

IS THE AIR WE BREATHE WHILE SLEEPING CONDITIONING OUR SLEEP QUALITY?

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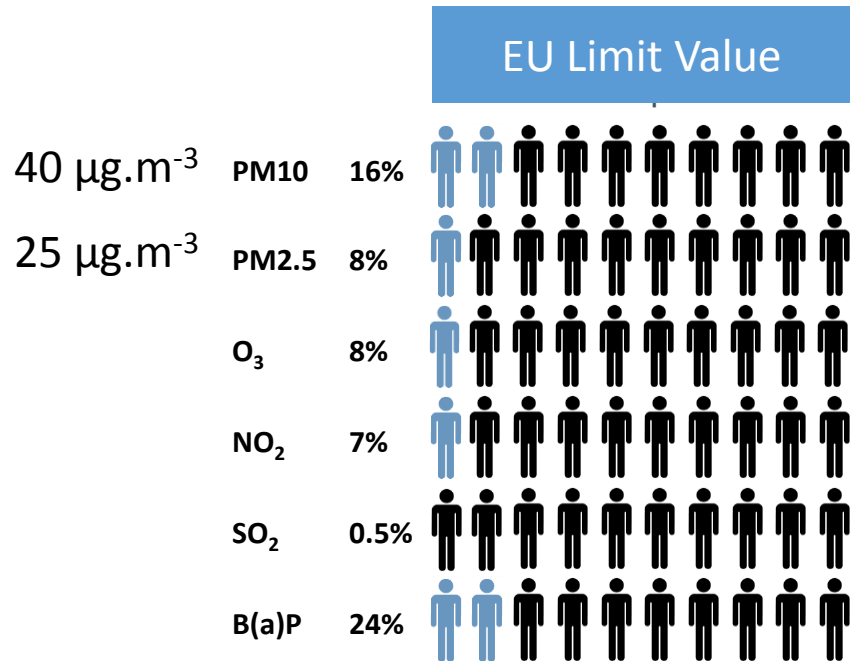
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1. Background
2. Goals
3. Methodology
4. Preliminary Results
5. Conclusions and future work

Human exposure to air pollution

Europe
2014

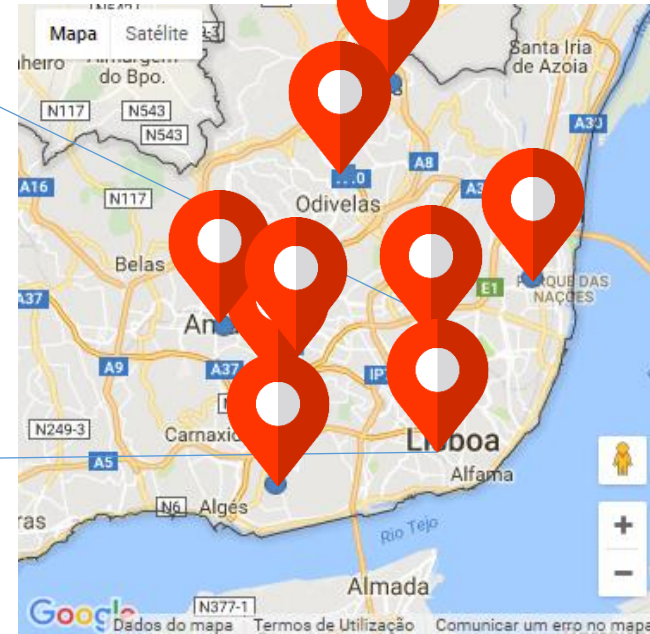


Human exposure to air pollution

Europe
2014



Air quality monitoring station



Is this strategy representative of the human exposure?

Human exposure to air pollution

Is this strategy representative of the human exposure?

No

1

High variability of air pollutants concentration within a city

No

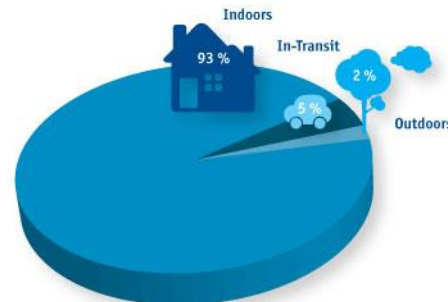
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People spend more than 90% of their time at indoor environments

No

3

High variability of pattern of occupation within the population

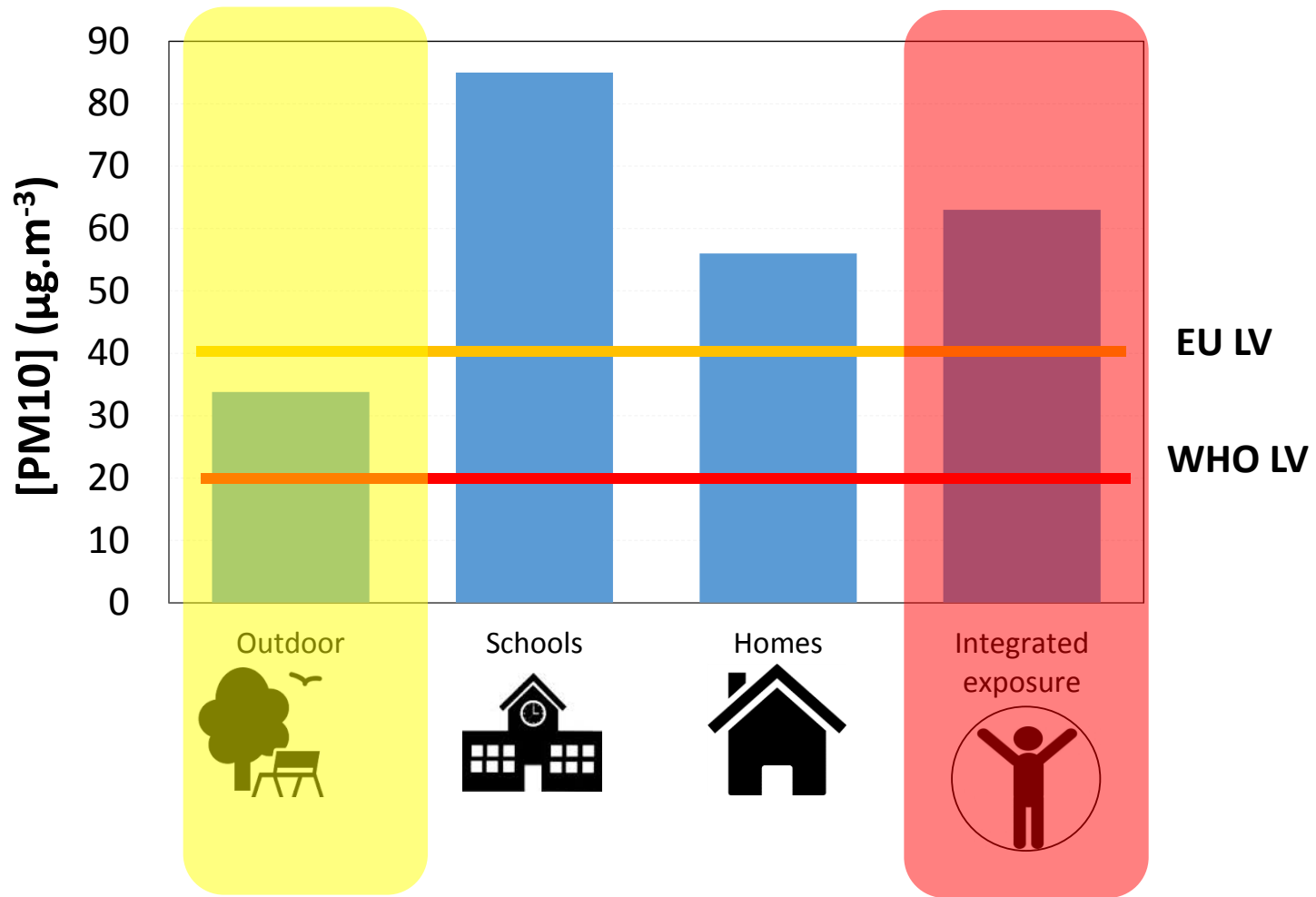


Human exposure to air pollution



1. BACKGROUND

ICUH





Around 1/3 of our life is spent sleeping



**WHAT DO WE
KNOW NOW?**



Around 1/3 of our life is spent sleeping

1

Sleep has a vital role in human welfare

Low ventilation rates

2

3

Breathing area closer to potential sources of pollutants

Lack of studies about exposure during sleep

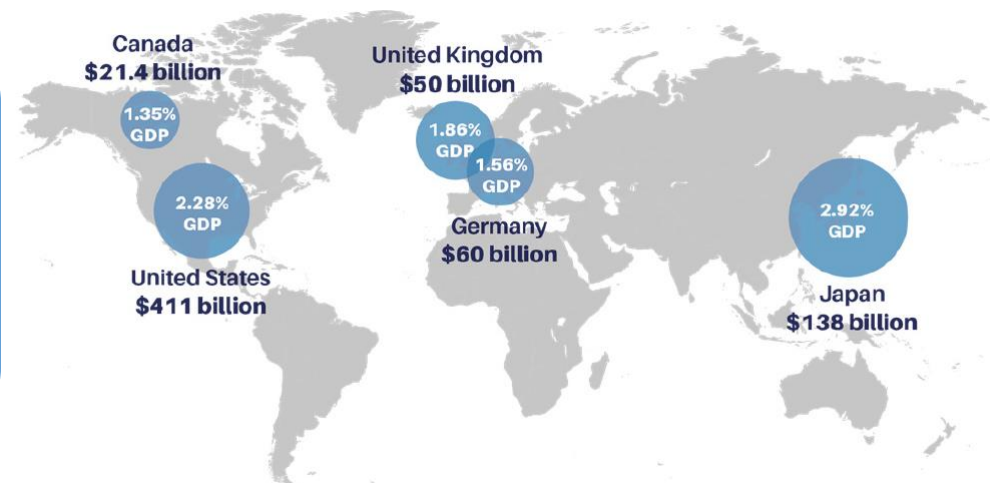
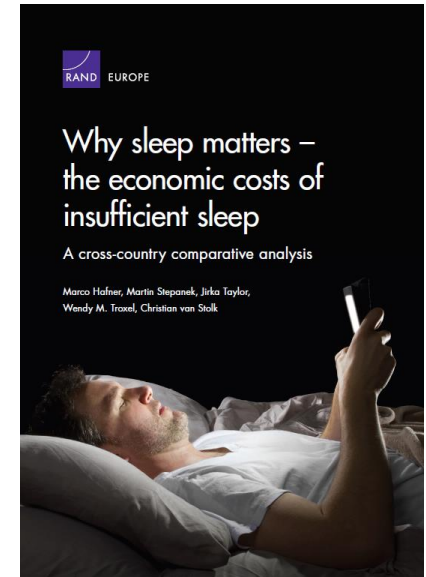
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Why sleep matters – the economic costs of insufficient sleep [2016]

1 Sleep has an overall **impact** on the **countries' richness**

2 Lower **productivity levels** and **higher mortality risks** related to insufficient sleep can result in **substantial economic losses** to modern economies

3 **Insufficient sleep** among its populations cost the **5 OECD countries** under consideration (USA, UK, Japan, Germany and Canada) **up to \$680 billion** of economic output lost every year.

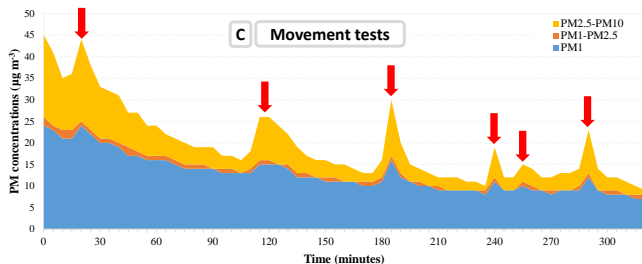
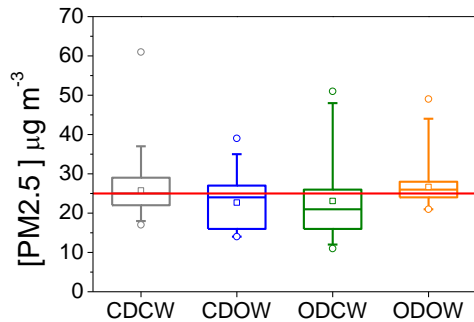


1. BACKGROUND



Preliminary study

- Multi-pollutant approach
- Values above guidelines were found for VOC, formaldehyde and **PM2.5**



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Indoor air quality during sleep under different ventilation patterns

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ABSTRACT

Sleep plays a crucial role in the human welfare. This preliminary study aimed to characterise the indoor air quality (IAQ) during sleep, which has been scarcely studied, to better understand the occupant's exposure. Comfort parameters along with indoor air pollutants were assessed in one bedroom during the sleeping period of the occupant. Four scenarios of natural ventilation in the bedroom were studied regarding IAQ. The ventilation setting with door and window closed (CDCW) promoted the lowest air change rate ($0.67 \pm 0.28 \text{ h}^{-1}$) and the highest levels of carbon dioxide (CO_2), carbon monoxide (CO) and volatile organic compounds (VOCs). Irrespective of ventilation condition, particulate matter levels (PM10, PM2.5) were always high, although maximum values were recorded under CDOW. The simultaneous opening of door and window supplied the highest air change rate ($4.85 \pm 0.57 \text{ h}^{-1}$). Several pollutants

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**DOES INDOOR AIR QUALITY
INFLUENCES SLEEP QUALITY?**



DOES INDOOR AIR QUALITY INFLUENCES SLEEP QUALITY?

Multi-disciplinary team

IAQ monitoring
(multi-pollutant approach)



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e do mar

Sleep quality assessment



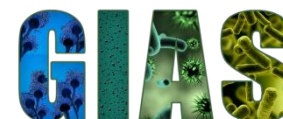
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DOES INDOOR AIR QUALITY INFLUENCES SLEEP QUALITY?

Strategy

Assessment of IAQ at bedrooms and sleep parameters

IAQ monitoring

- Minimize noise interference

In situ apparatus (black box)



Assessment of Sleep Quality

Actigraphy – 10 days

- SomnoWacht® actigraph
- Sleep/wake rhythm monitoring

Individual questionnaires

- Pittsburgh Sleep Quality Index (PSQI)
- Berlim Questionnaire (BQ)
- Sleep diary

Polysomnography – 2 nights

- Polysomnography- level II was used in volunteers
- Sleep parameters:
 - Total sleep time
 - Sleep latency
 - REM sleep latency
 - Sleep efficiency
 - Heart rate variability
 - Respiratory disturbance index
 - Oxygen desaturation index
 - and others

Assessment of Sleep Quality

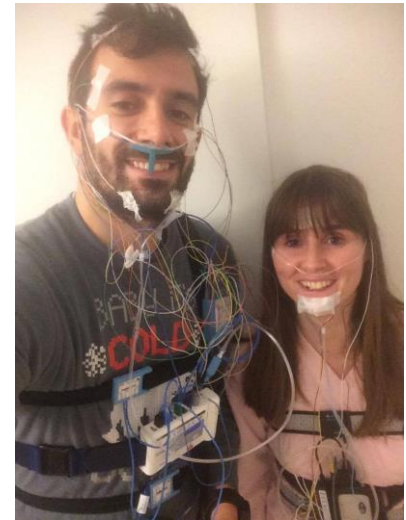
Actigraphy – 10 days

- SomnoWacht® actigraph
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Individual questionnaires

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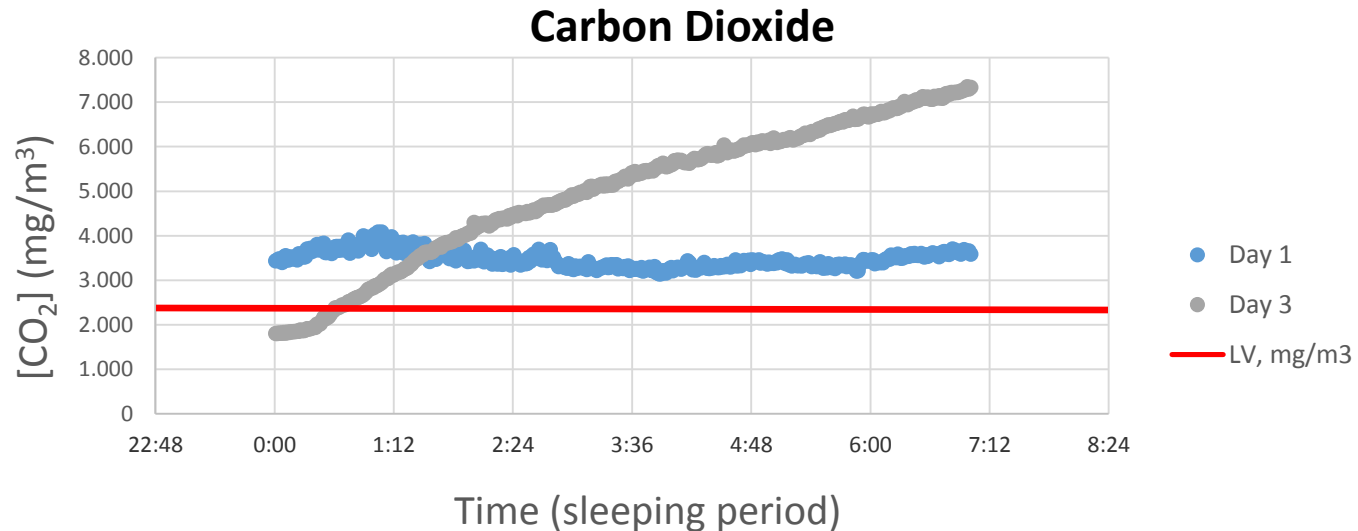
Polysomnography – 2 nights



Ongoing Work

- **Sleeping period** lasted for 7 hours (eg. Couple 5)

CO₂ Concentrations

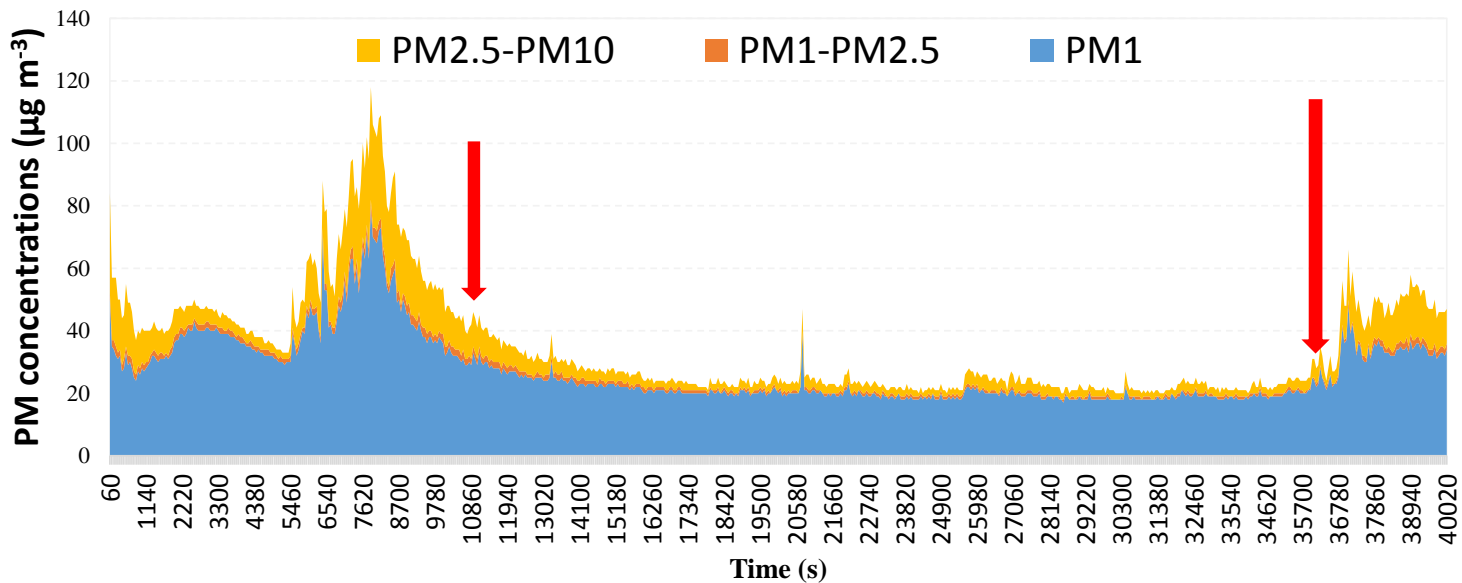


- **Sleeping period always had** mean CO₂ values higher than LV of 2250mg.m⁻³ (Portuguese legislation)

Particulate Matter during sleep

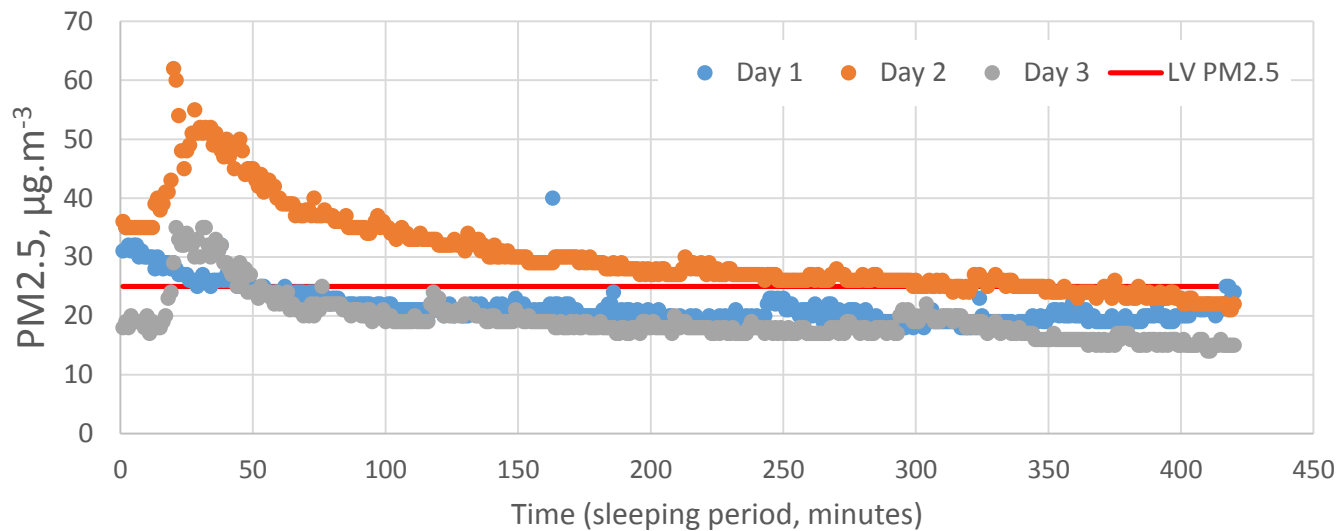
Day 1

Example: Couple 5



Particulate Matter during sleep

Example: Couple 5



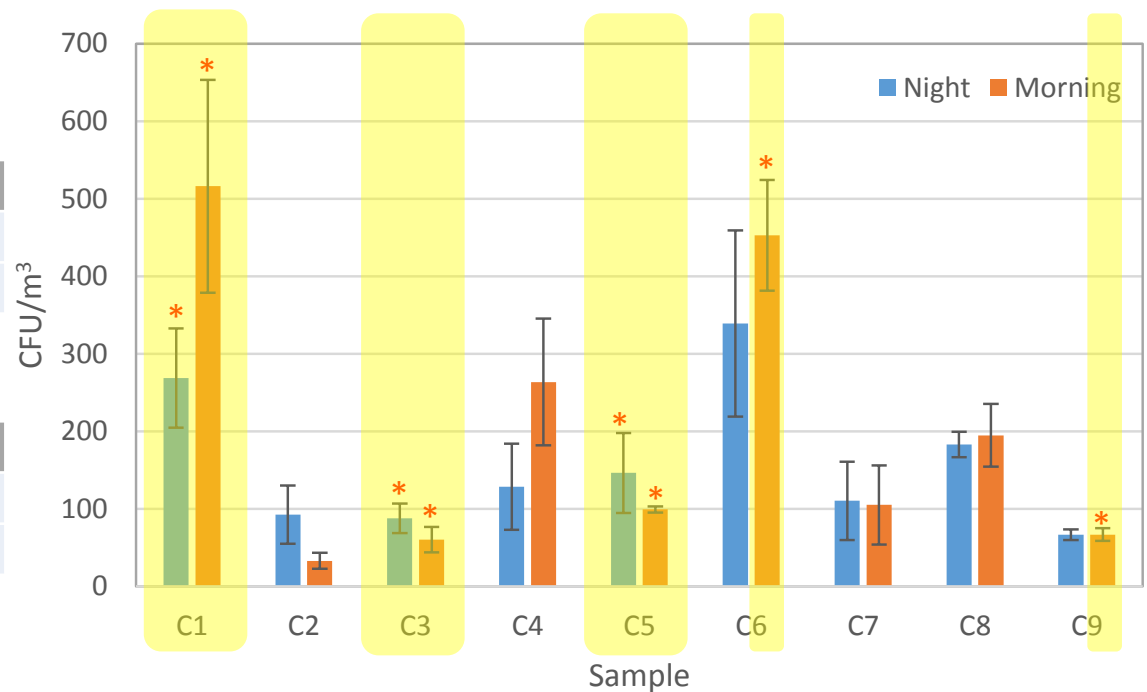
	PM2.5 (µg.m ⁻³)	PM10 (µg.m ⁻³)
Indoor	31.0 ± 9.5 [17.0 – 62.0]	39.0 ± 13.2 [20.0 – 90.0]
LV	25	50

4. PRELIMINARY RESULTS

Fungi

	Fungi (CFU/m ³)
Night	158 ± 91
Morning	199 ± 178

	Indoor > Outdoor
Night	3
Morning	5

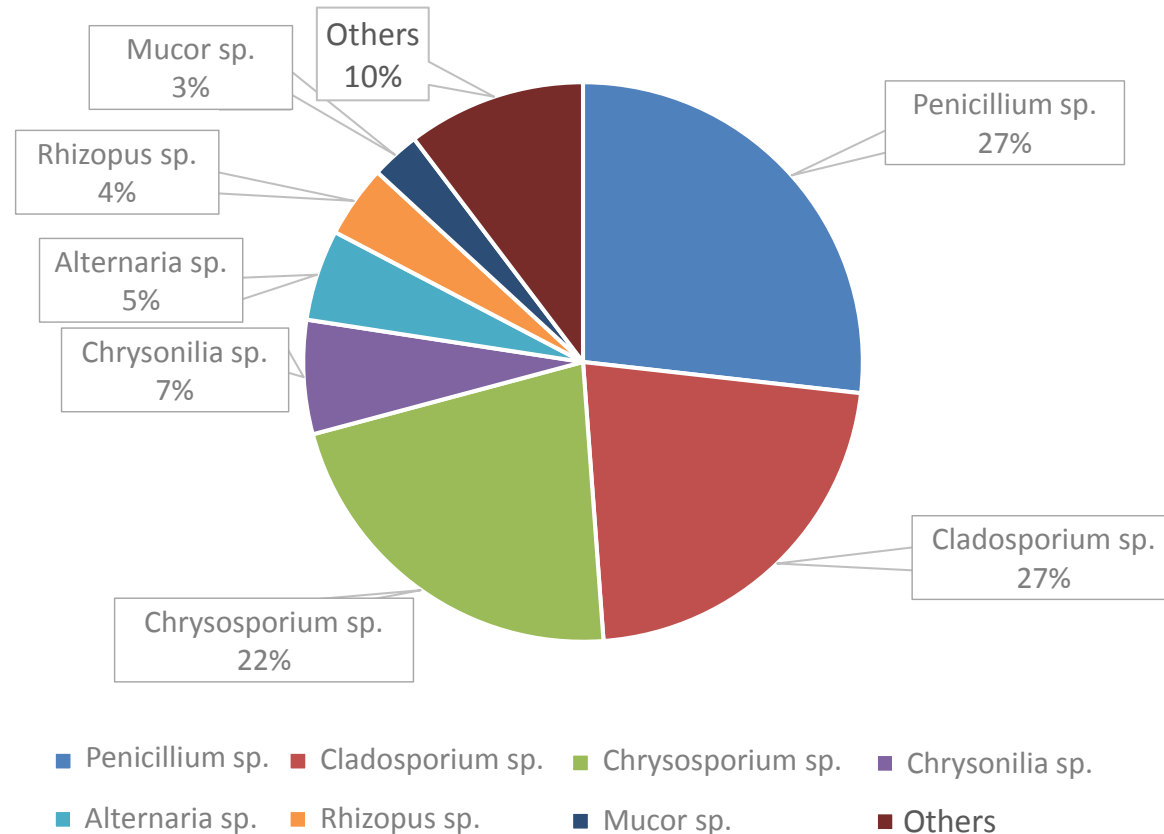


* Exceedance of Recommended Limit Value [Indoor > Outdoor]

Fungi

- **45 different** Fungi species found
- More prevalence of 3 Fungi species:
 - Penicillium sp. (27%)
 - Cladosporium sp. (22%)
 - Chrysosporium sp. (22%)

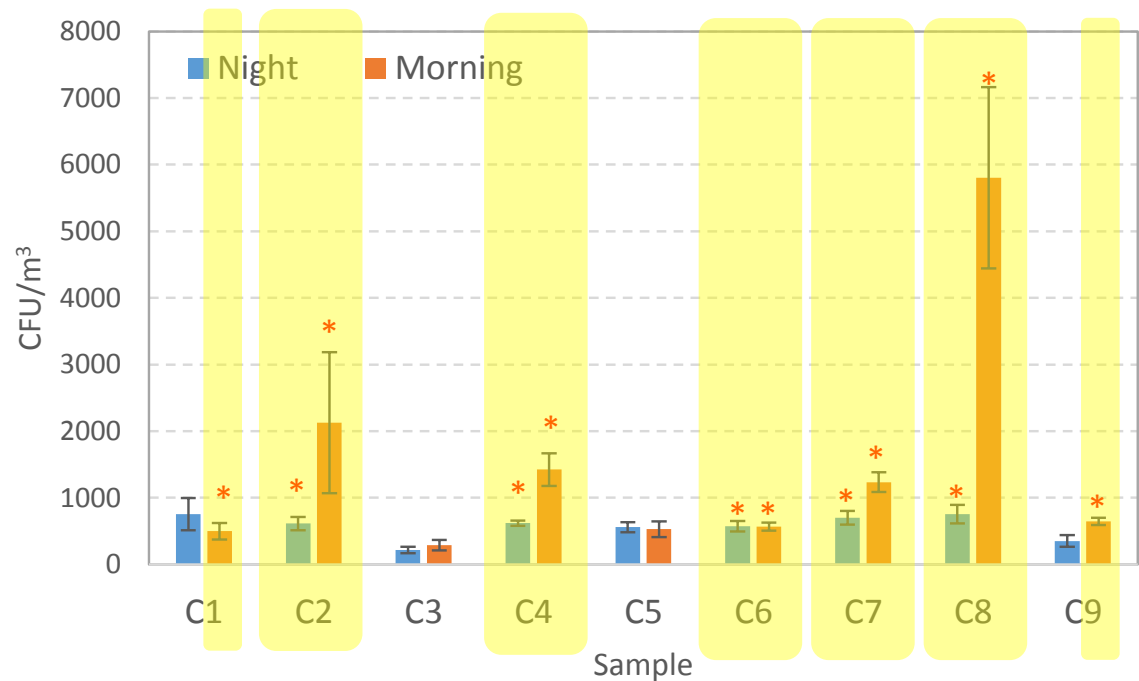
Prevalence of Fungi species at bedroom



Bacteria

	Bacteria (CFU/m ³)
Night	571 ± 181
Morning	1458 ± 1732

	Indoor > LV
Night	5
Morning	7

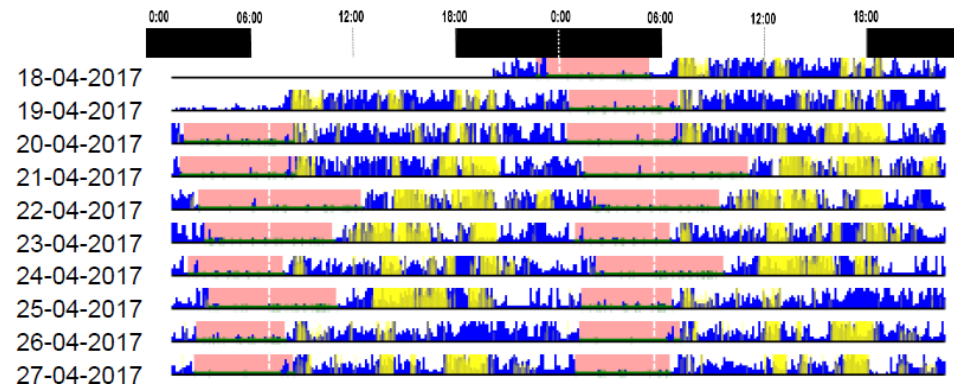


* Exceedance of Recommended Limit Value [Outdoor + 350 CFU/m³]

Actigraphy

Example: Couple 5 - Man

Sleep Graphs

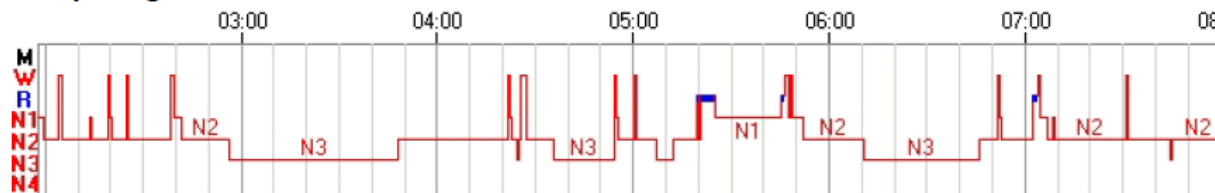


Polysomnography

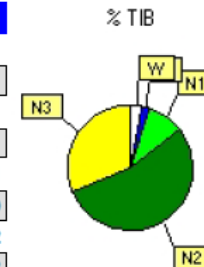
Example: Couple 5 - Man

	from	to	Artefact	Duration
Recorded Time	29-04-2017	29-04-2017 8:01:00		08:01:00
TIB	29-04-2017 1:57:34	29-04-2017 8:00:27	-	06:02:53

Sleep Stages



Total Sleep Time (TST)	05:53:23	Sleep Stage	Duration	(%) TIB	(%) Sleep
Sleep Efficiency [%]	97,4	Artefact	-	-	-
Sustained Sleep Eff. [%]	97,4	Movement	-	-	-
Sleep Latency [m]	0,0	Wake	00:09:30	2,6	-
Sleep Latency N1 [m]	0,0	REM	00:07:30	2,1	2,1
Sleep Latency N2 [m]	1,9	N1	00:34:56	9,6	9,9
Deep Sleep Latency [m]	58,4	N2	03:18:27	54,7	56,2
REM latency [m]	201,9	N3	01:52:30	31,0	31,8
Total Sleep Period (SPT)	06:02:53	N4	-	-	-
Sleep Stage Change (Index)	55 (9,1)	Light Sleep	03:53:23	64,3	66,0
# Wake (Index)	13 (2,2)	Deep Sleep	01:52:30	31,0	31,8
#Wake respiratory (Index)	0 (0,0)				



- **Several pollutants (PM_{2.5}, CO₂, VOCs, CH₂OH, bacteria and fungi) have been found to be above limit values established by Portuguese legislation**
- **Sleep quality** will be assessed in each case by **actigraphy** and **polysomnography** with the aim of using actigraphy as a sleep quality surrogate
- **Associations between sleep quality and indoor air quality during sleep will be assessed** in order to understand which are the main environmental factors that influence sleep quality
- **Future work will evaluate different settings** (type of area – urban/rural, seasons, type of household, others)

FCT

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THANK YOU!

