DANVAK DAGEN 2021

Ventilation and sleep quality

Sponsored by ASHRAE 1837-RP

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Introduction

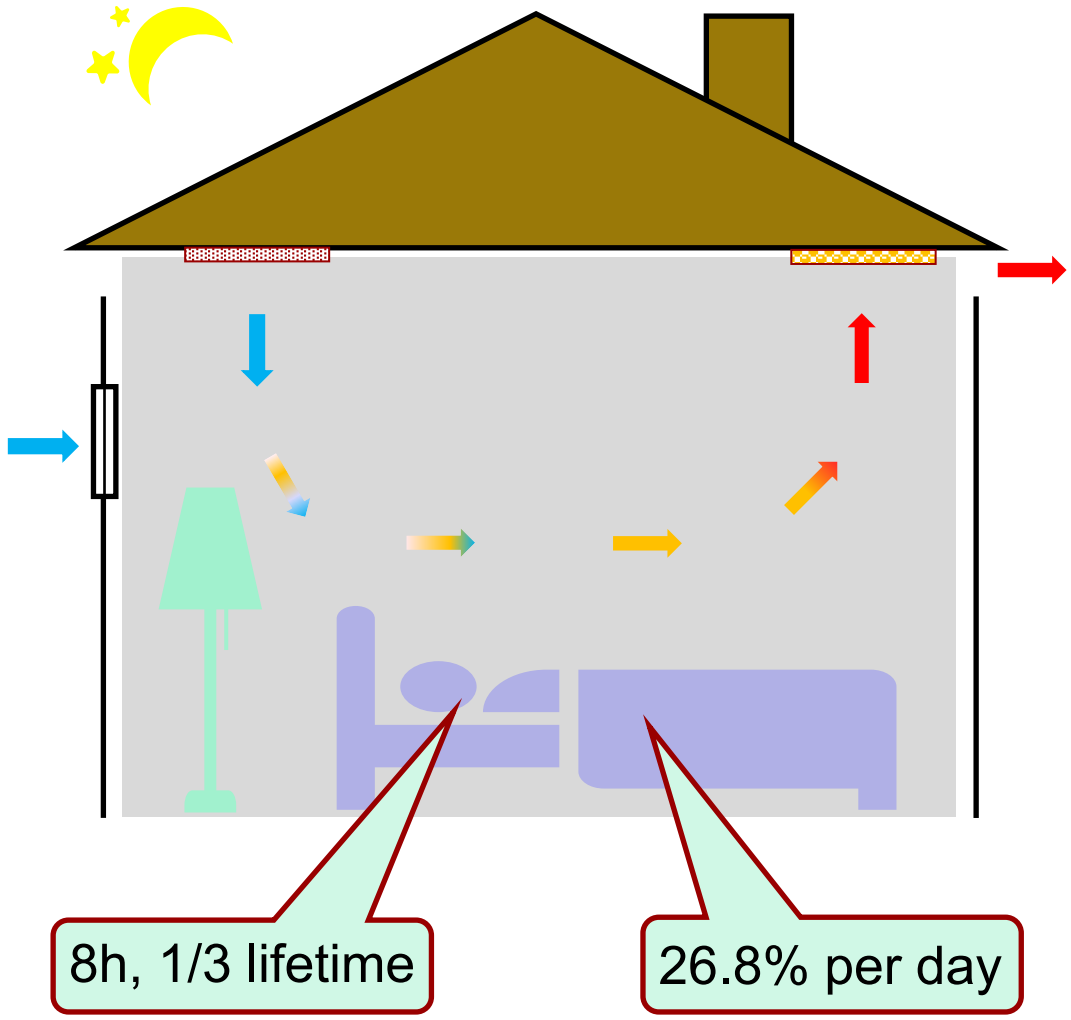
Why we sleep?

- Fundamental function of body
- Attributes to health issues: obesity, diabetes, etc.

How to sleep well?

- Keep sleep hygiene: good sleep route, etc.
- Good sleeping environment

TC *Noise* ***IAQ***



Standards review

Ventilation requirements for bedrooms in standards (8/17)

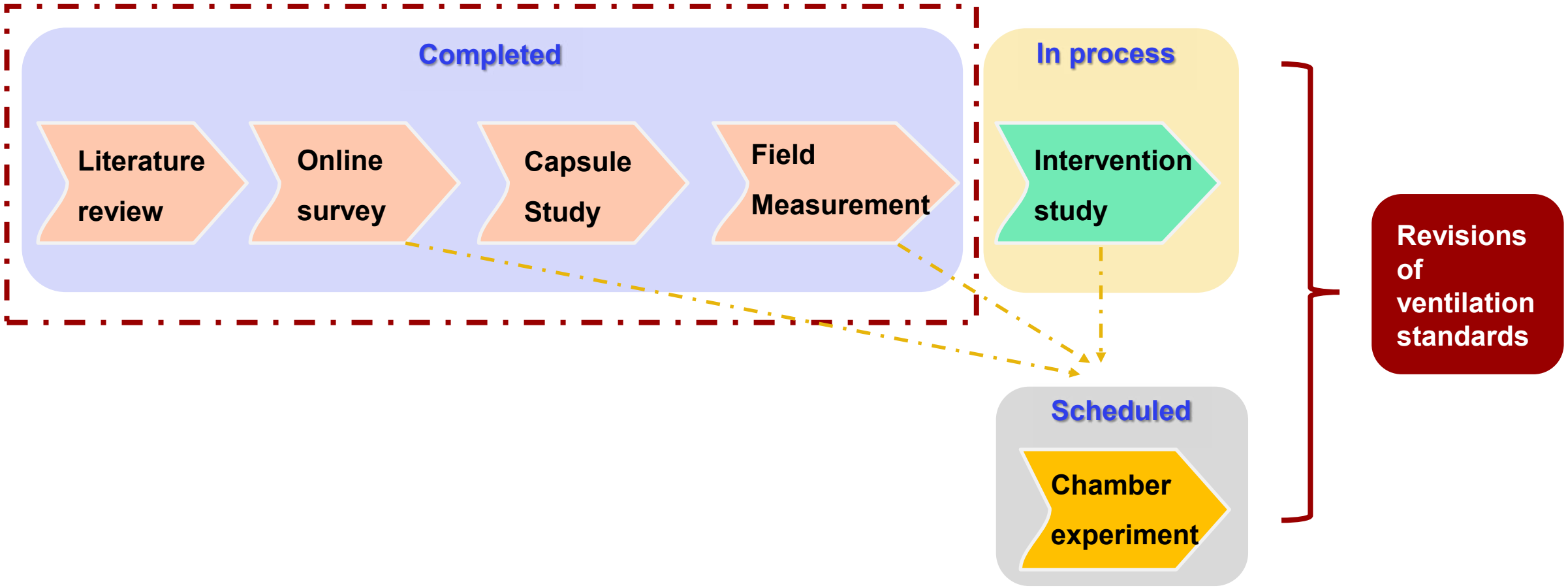
Country / Region	Standard	Air Flow Quantity / Air Change Rate				CO2 Level Above Ambient (ppm)
		L/s	L/S. m2	L/s. person	h -1	
CEN	EN 16798-1:2019				1.2-2.9	380-950
Belgium	NBN D-50-001 (1991)	7-20				
Norway	TEK17 (2017)			7.2		
Denmark	BR18 (2019)		0.3			
Austria	ONORM H 6038 (2014)			5.56		
Netherlands	NNI (2006)	7				
China	Design manual for heating and air conditioning (2008)				1	
Indian	IS 3362 (1977)				3	

Source: *Sekhar, C., et al., (2020). Bedroom ventilation: Review of existing evidence and current standards. Building and Environment, 107229.*

Objectives

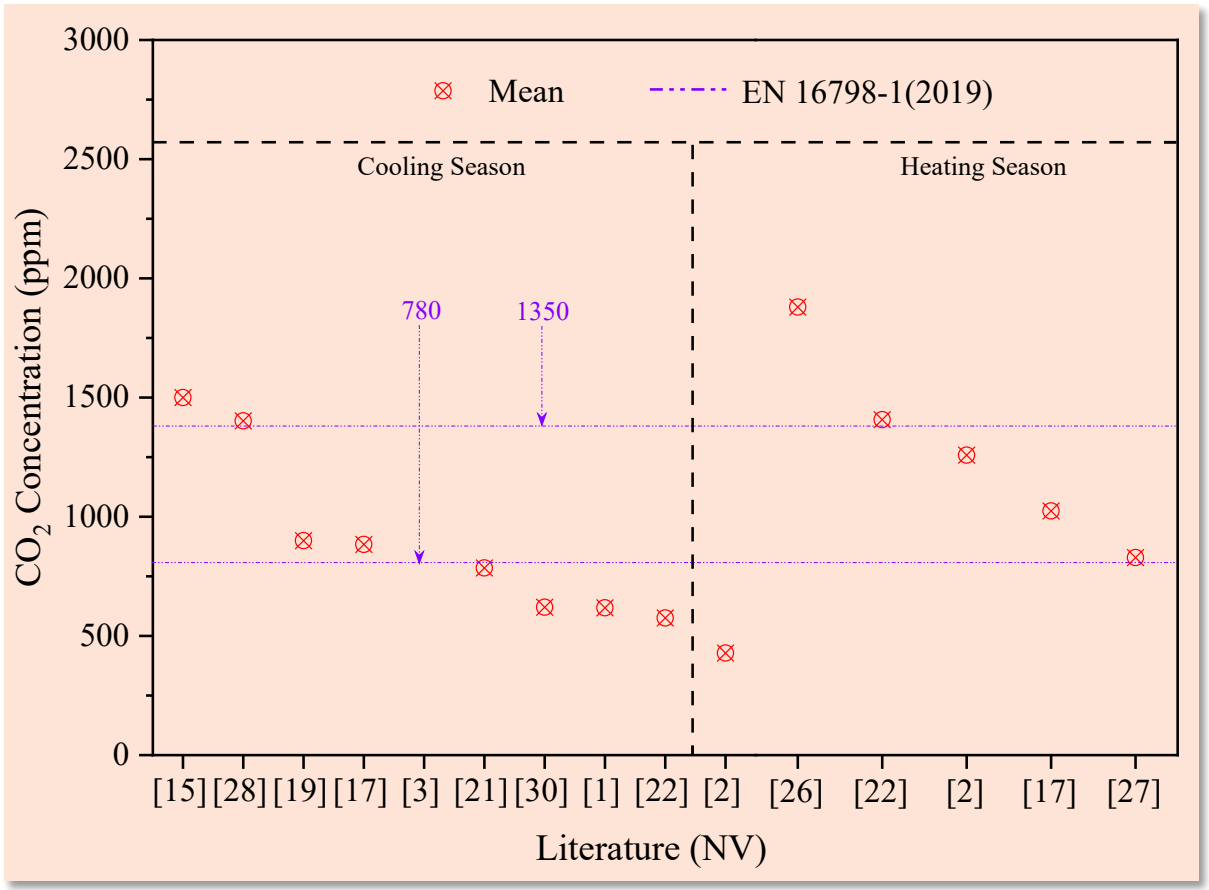
- What are the actual ventilation rates in bedrooms? Do these ventilation rates meet standard requirements?
- How does ventilation affect IAQ in bedrooms? How does it affect sleep quality, well-being and the next-day work performance?
- What is the minimum ventilation rate to avoid the adverse effects of bedroom IAQ on sleep quality?

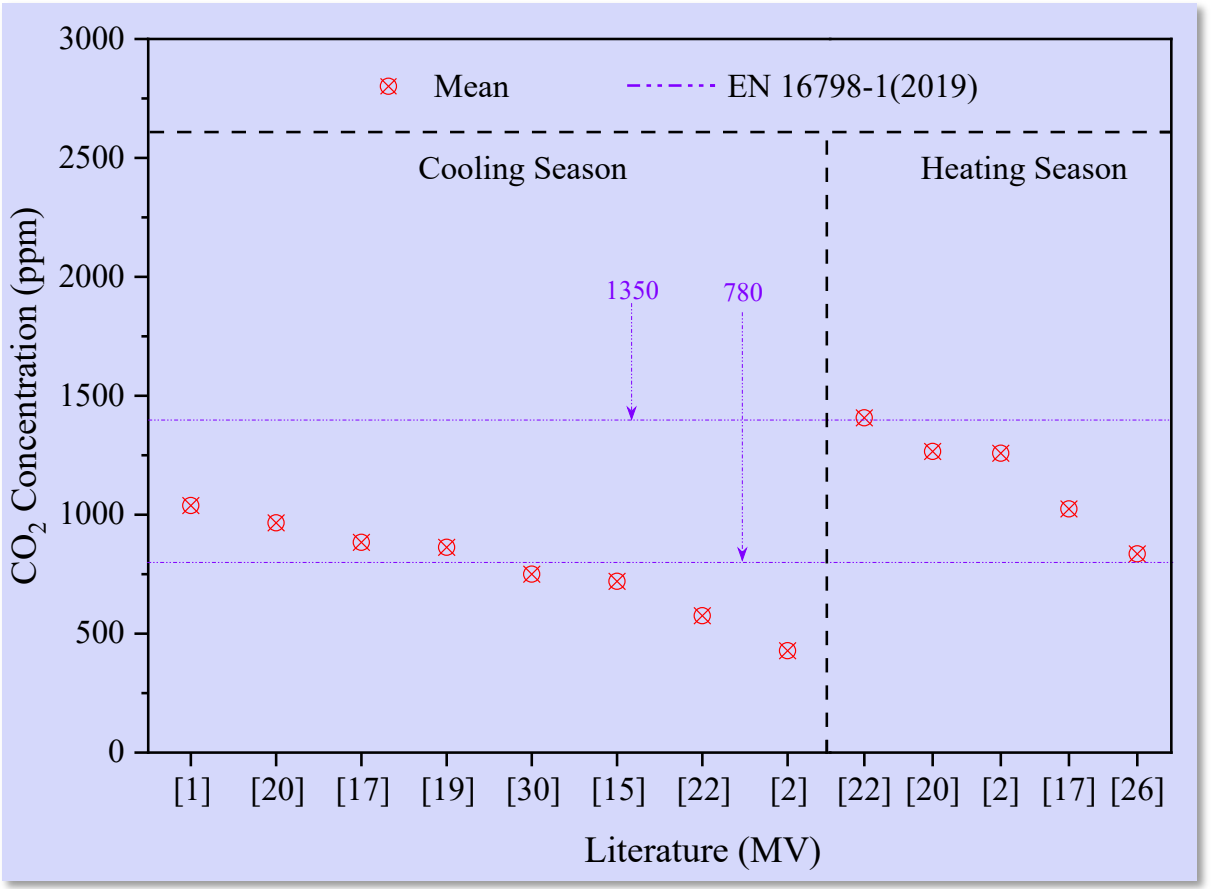
Process


Completed
Literature review
Online survey
Capsule Study
Field Measurement
In process
Intervention study
Scheduled
Chamber experiment
Revisions of ventilation standards

Literature review

Papers reviewed reporting CO2 concentration (46/200+)

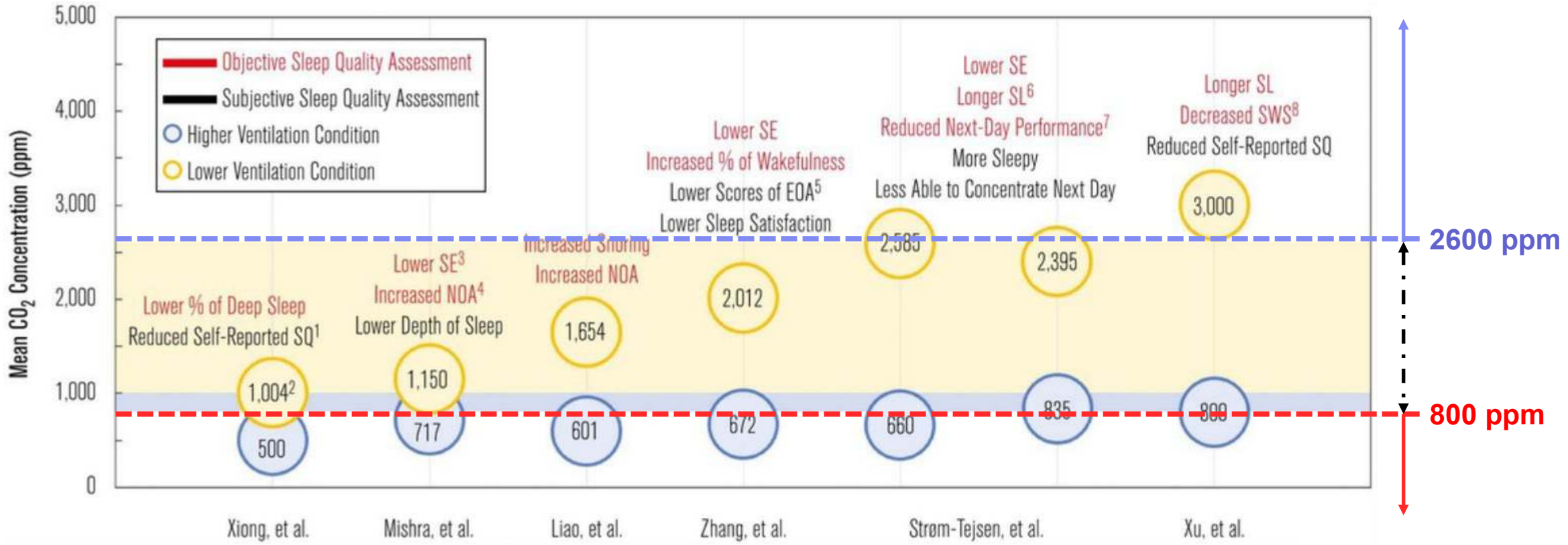




Source: *Sekhar, C., et al., (2020). Bedroom ventilation: Review of existing evidence and current standards. Building and Environment, 107229.*

Literature review

Tentative relationship between ventilation and sleep quality

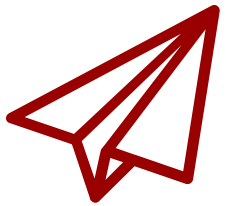


Source: *Sekhar, C., et al., (2020). Bedroom ventilation: Review of existing evidence and current standards. Building and Environment, 107229*

Akimoto, M., (2021). Reviewing how bedroom ventilation affects IAQ and sleep quality. *ASHRAE Journal*, *63*(4), 56-60.

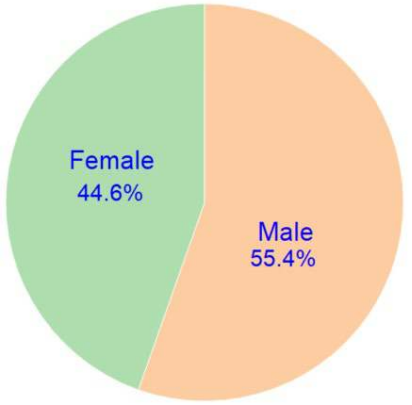
Findings

- Only a few ventilation standards prescribe ventilation requirements in bedrooms
- The measured ventilation rates during sleep
- Lower ventilation during heating season, especially in naturally ventilated bedrooms
- Establishing the tentative relationship between the ventilation and sleep quality

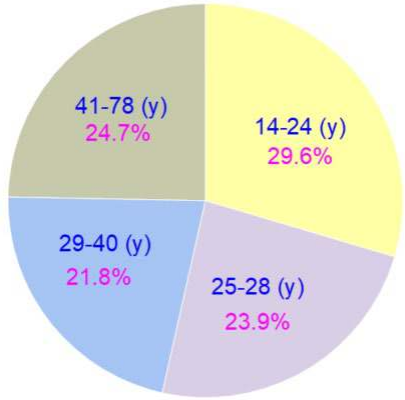


Online survey

517 respondents



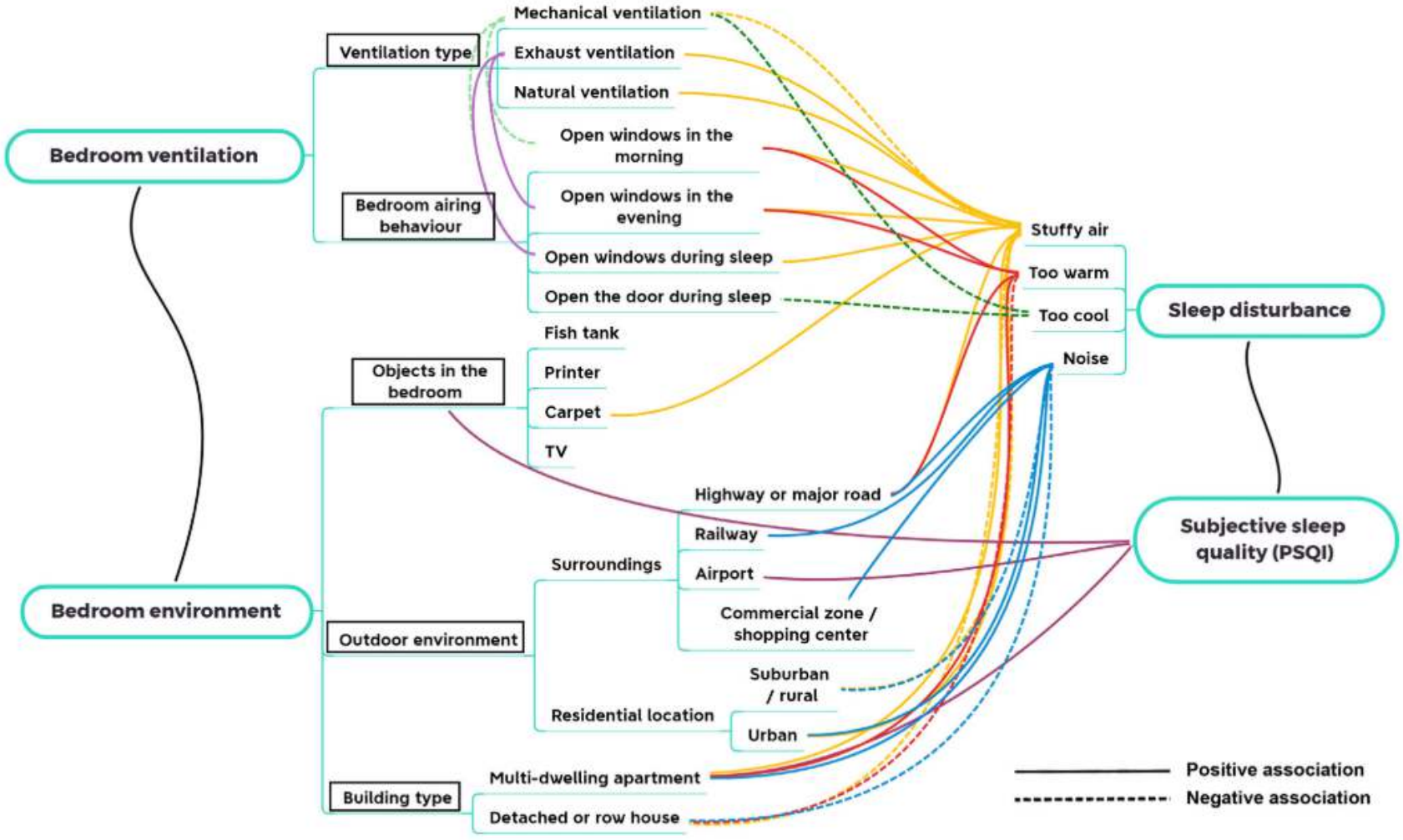
(Sex distribution)



(Age distribution)

Source: Liao, C., et al., (2021). A survey of bedroom ventilation types and the subjective sleep quality associated with them in Danish housing. *Science of The Total Environment*, *798*, 149209.

Online survey

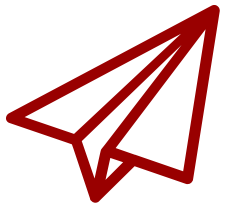


Source: Liao, C., et al., (2021). A survey of bedroom ventilation types and the subjective sleep quality associated with them in Danish housing. *Science of The Total Environment*, *798*, 149209.

Findings

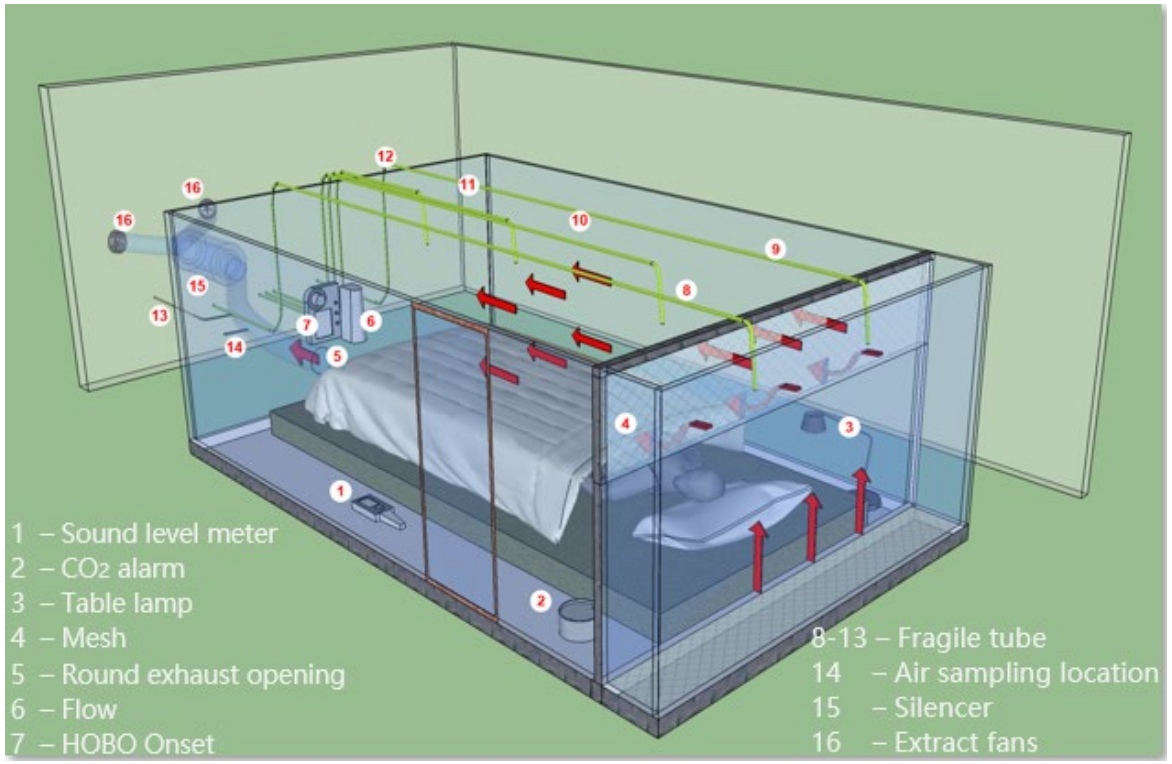
- Sleep quality was less disturbed when sleeping in mechanically ventilated bedrooms

- Sleep was disturbed by stuffy air, noise and thermal discomfort



Capsule study

Chemical measurements (CO2 and VOCs)



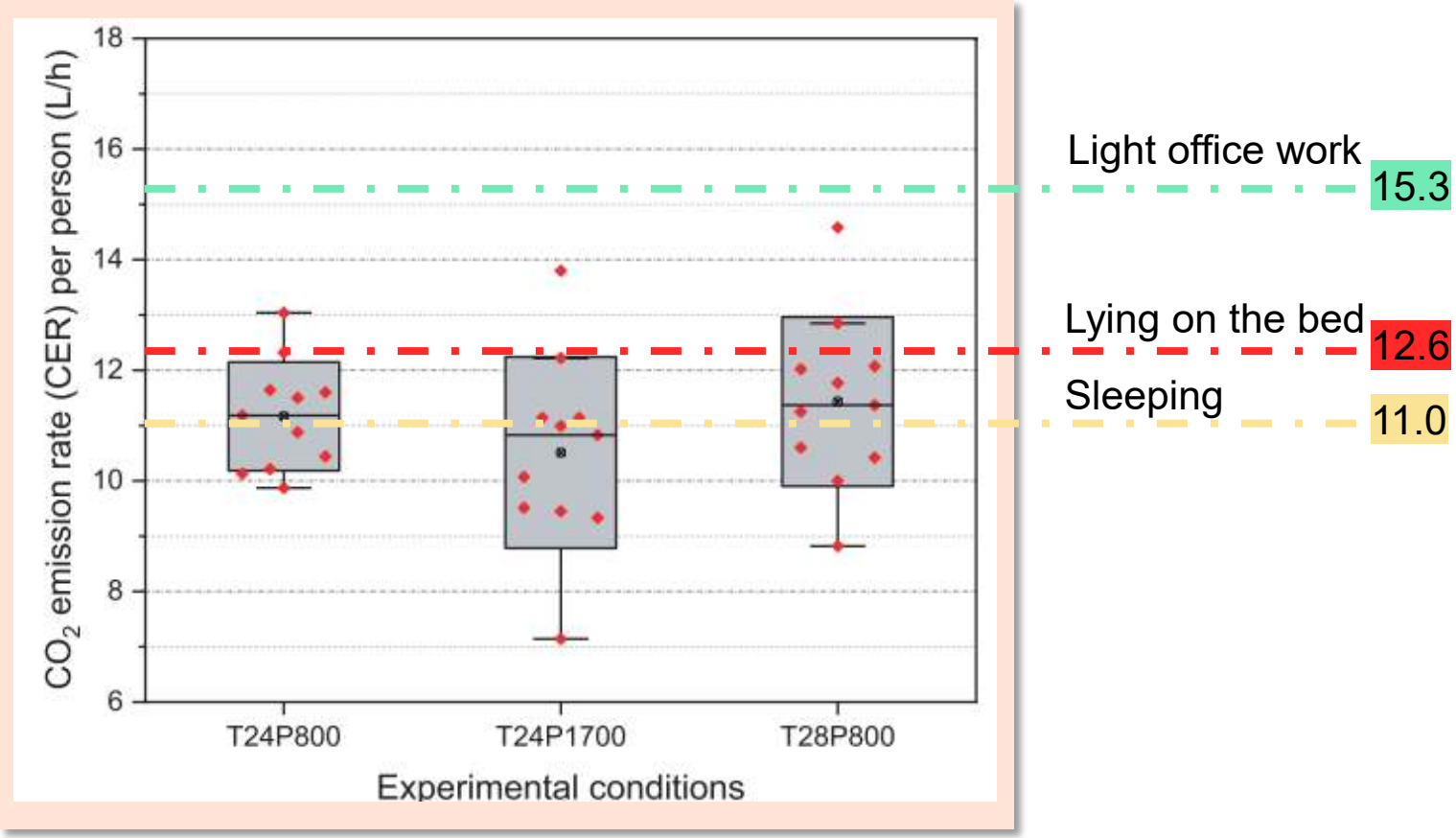
(Schematic diagram of the capsule)

(Snapshot)

Source: Fan, X., et al., (2021). Emission rate of carbon dioxide while sleeping. *Indoor air*.

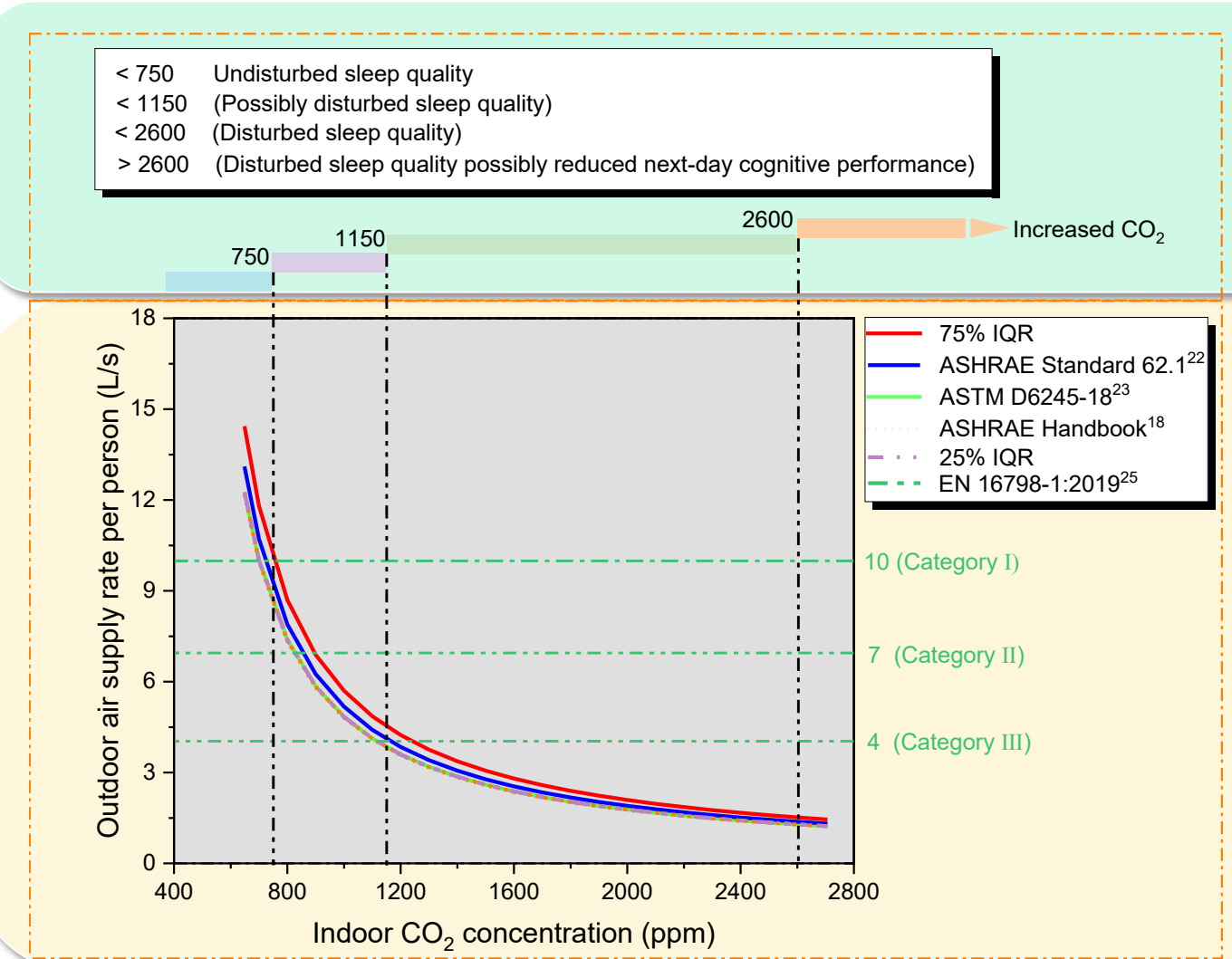
Capsule study

Emission rates of CO2 while sleeping



Source: Fan, X., et al., (2021). Emission rate of carbon dioxide while sleeping. *Indoor air*.

Capsule study



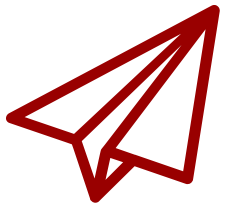
Tentative relationship between the ventilation and sleep quality and thus next-day work performance

Calculated ventilation rate against CO2 concentration under different emission rates

Source: Fan, X., et al., (2021). Emission rate of carbon dioxide while sleeping. *Indoor air*.

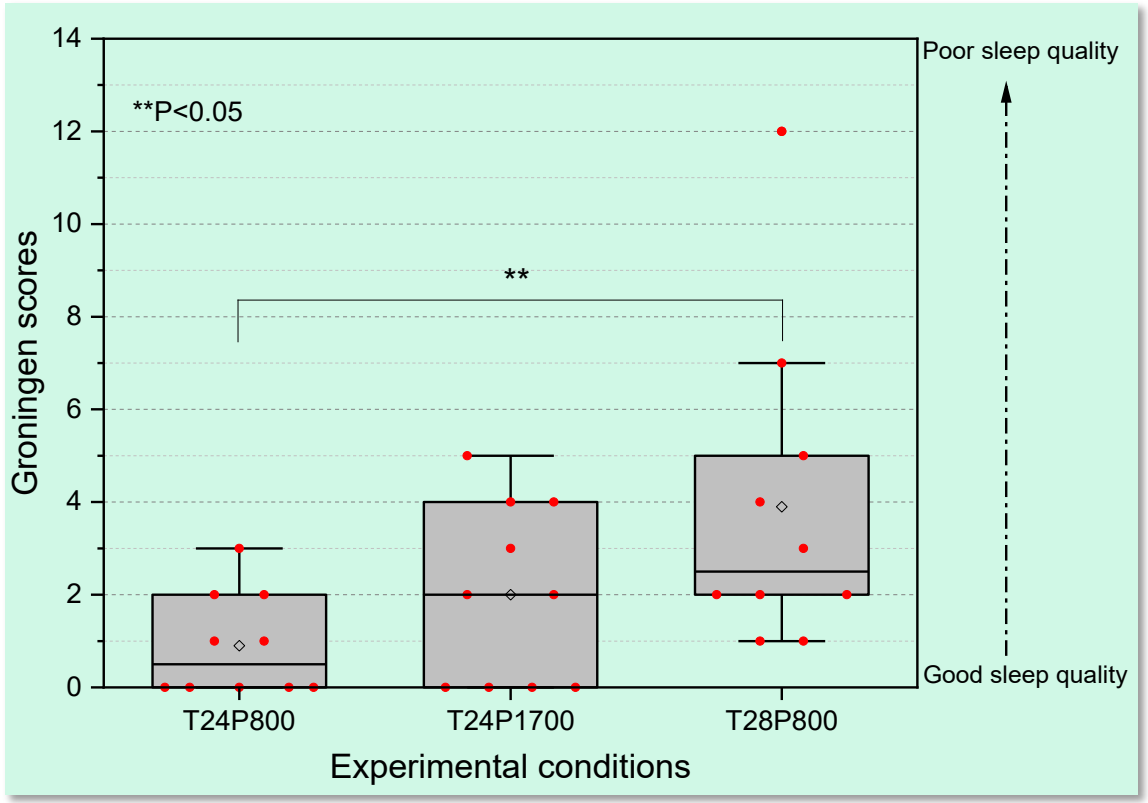
Findings

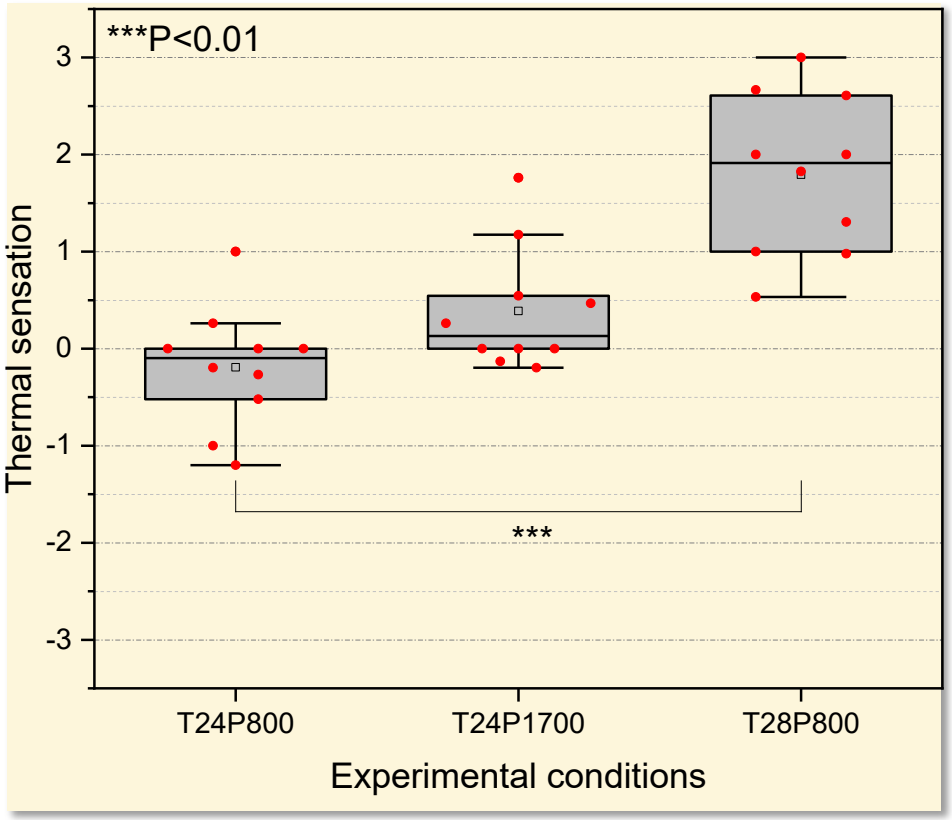
- Average CO_2 emission rates while sleeping was found to be around 11.0 L/h per person
- Increasing temperature or reducing ventilation did not change the CO_2 emission rates during sleep



Capsule study

Temperature effects on sleep quality

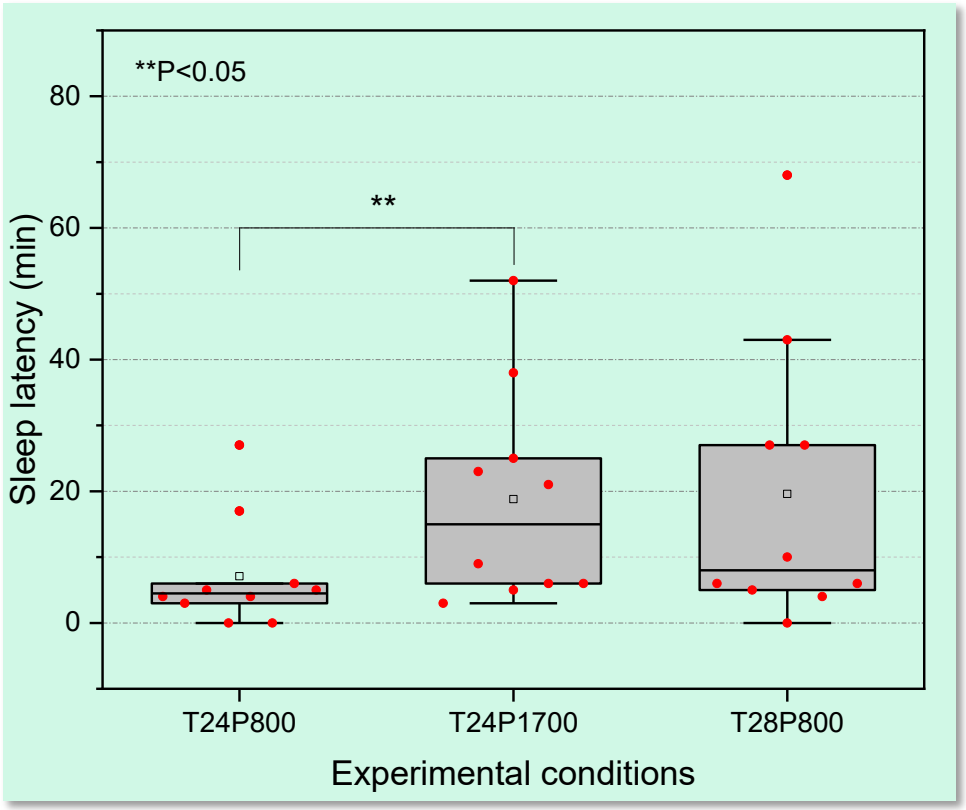


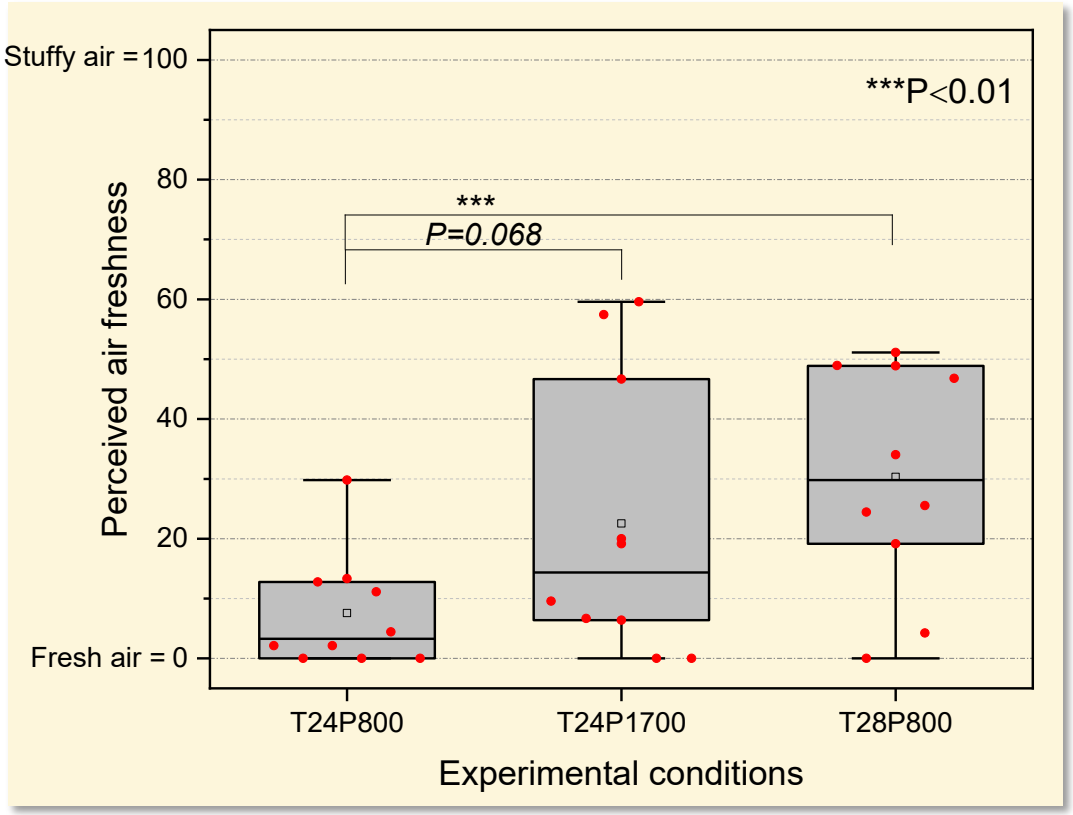


Source: Fan, X., et al., (2021). The effects of ventilation and temperature on sleep quality and next-day work performance: pilot measurements in a climate chamber, Building and Environment (submitted)

Capsule study

Ventilation effects on sleep quality



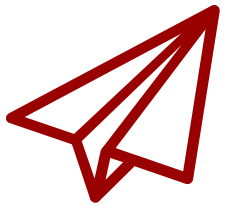


Source: Fan, X., et al., (2021). The effects of ventilation and temperature on sleep quality and next-day work performance: pilot measurements in a climate chamber, Building and Environment (submitted)

Findings

- Increasing temperature negatively affected the subjectively rated sleep quality

- Reducing ventilation delayed the sleep onset



Field measurements

Measurements

- Temperature, relative humidity, CO2 level, illumination level

Data is being analysed……

- Sleep quality (subjectively and objectively)
- Skin temperature
- Subjective ratings and perceptions

Thank you !

Questions, comments and suggestions?

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