

Study of room acoustics and noise at Bispebjerg & Frederiksberg Hospital

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Motivation and Objectives

Noise in hospitals has been a well known issue for years evidenced by a statement from Florence Nightingale in 1859: "Unnecessary noise is the most cruel absence of care which can be inflicted on either sick or well". It has been found that noise in hospitals is increasing, Busch-Vishniac (2005) made a collection of noise studies from hospitals from the 1960s until 2005 which showed an increase in A-weighted equivalent sound pressure levels measured in hospitals during daytime hours.

High sound levels are known to be linked to room acoustics including reverberation time (Rindel 2010) and therefore limits for reverberation time in hospitals have been stated in The Danish Building Code 2015 (BC15). It states a reverberation time of 0.6 s in examination rooms and treatment rooms and 0.8 s in patient rooms. This study investigates the hospital acoustics in two different hospitals in Copenhagen. The objectives of the project are:

- What kinds of issues do the hospitals Bispebjerg and Frederiksberg have regarding acoustics and noise?
- How are these issues linked to room acoustics and can they be solved by improving room acoustics in hospitals?
- How do these issues influence staff members?

Method

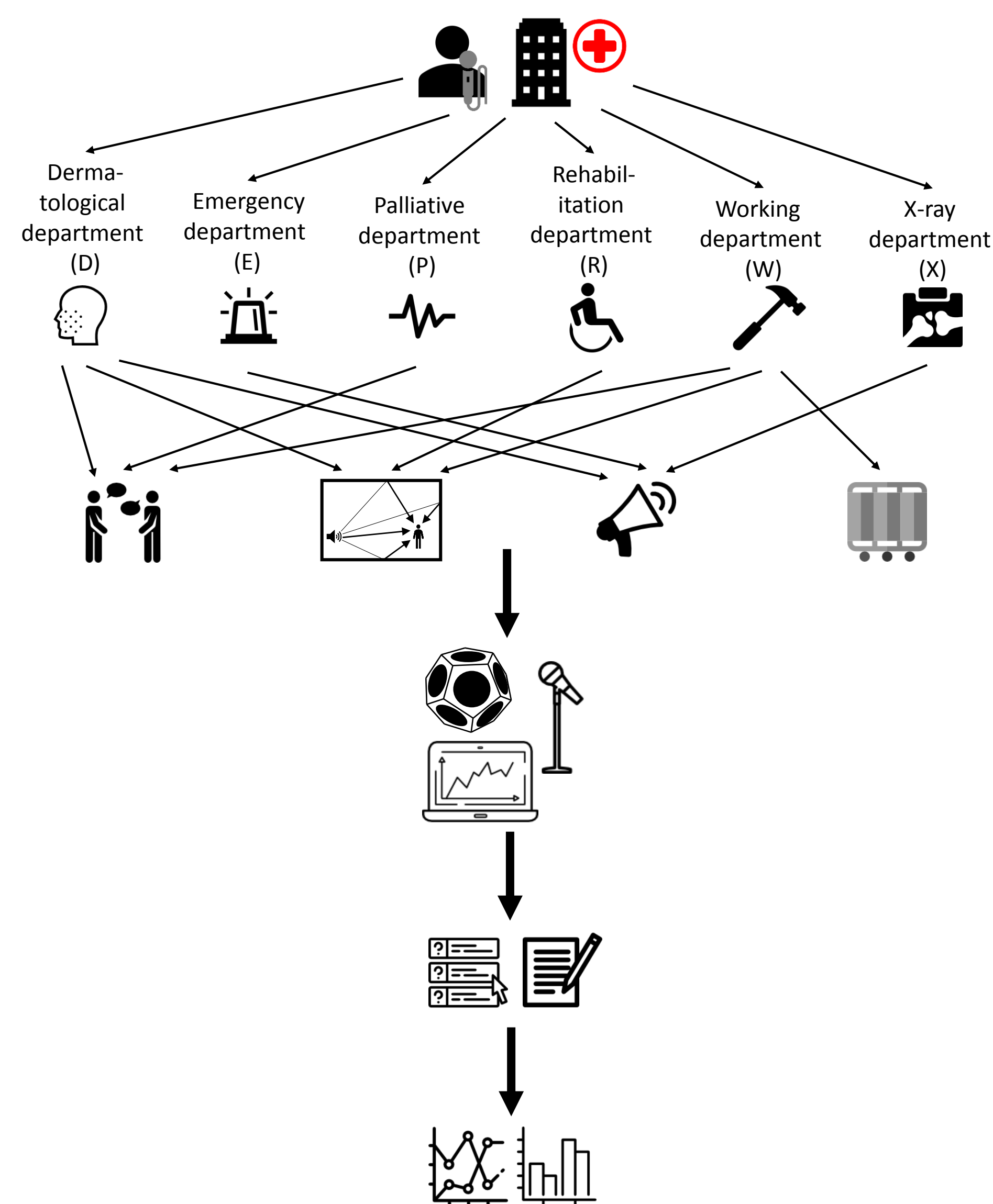


Fig. 1: Flow chart of method. Different departments at hospitals were interviewed about acoustic/noise problems. Six departments were included in the project and sorted into for different types of issues, Lombard effect, Reverberation, Noisy/hectic environment and Speech privacy. Rooms with issues were measured and surveys were handed out.

Measurements

- Room acoustics in 20 rooms at six different hospital departments were measured.
- Measurements were carried out with with an omnidirectional speaker, a Brüel & Kjær Microphone Supply type 5935 L, Lab gruppen Amplifier LAB 300, Brüel & Kjær Microphone Unit Type 4192-L-001 and a Dell laptop with Brüel & Kjær DIRAC program.
- All measurements were made in accordance with DS/EN 3382 - 1 and 2.
- Two speaker positions with five microphone positions per speaker position.
- Measurements were performed between the 22nd of February and 4th of April 2017.

Surveys

- Surveys were handed out to staff members at each department either electronically or on paper.
- In total 64 staff members filled out the surveys. D: 15, E: 3, P: 7, R: 4, W: 16, X: 16, undefined: 3
- The surveys included three qualitative questions:
 - Disturbed by noise: "When you think about the past 6 months, how disturbed have you been by noise when you have been at work?",
 - Participant cannot hear/understand: "When you think about the past six months how often have you experienced you could not hear or understand what a colleague and/or a patient said because of noise?",
 - No privacy when speaking with patient: "When thinking about the past six months how often have you experienced that you could not speak confidentially with a patient without other patients hearing you?",
 - D and R were additionally questioned about patients saying (s)he cannot hear/understand participant: "When thinking about the past six months cross out up to five noise sources you found disturbing at your work place?".
 - All four questions had five possible answer possibilities.
- Each qualitative question had one quantitative question linked of what rooms they thought the phenomenon appeared, with the possibility of answering up to three different room types.
- One stand alone quantitative question regarding which noise sources participants found disturbing.

References:
 Busch-Vishniac, I. J. et al., *Noise levels in John Hopkins Hospital*, J. Acoust. Soc. Am., Vol 118, No 6, December 2005
 Nightingale, F., *Notes on Nursing* (Dover, New York, 1860)
 Rindel, J. H., *Verbal communication and noise in eating establishments*, Applied Acoustics 71 (2010) 1156-1161
 Dansk Standard, *Acoustics – Measurement of room acoustic parameters – Part 2: Reverberation time in ordinary rooms*, DS/EN ISO 3382-2 (2008)
 Dansk Standard, *Acoustics – Measurement of room acoustic parameters – Part 3: Open plan offices*, DS/EN ISO 3382-3:2012 (2012)
 Energistyrelsen, *Vejledning om lydbestemmelser i bygningsreglementet 2010 (akustisk indeklima)*, September 2013

Results

Measurements

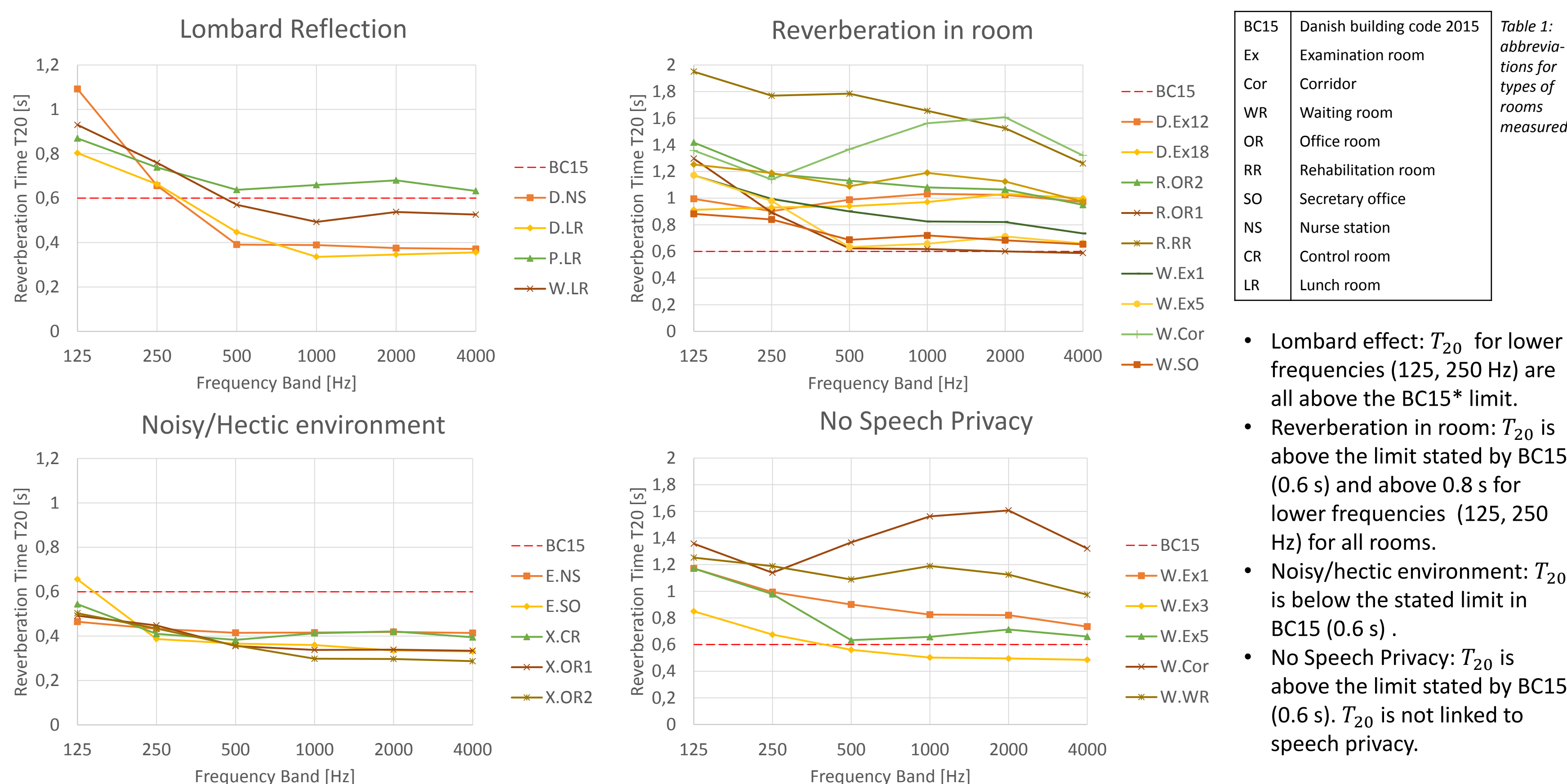


Fig 2: Reverberation time T₂₀ for each category of acoustic issues. First letter in label is for department (explanation in fig. 1), abbreviation after the dot is for the type of room measured, given in table 1. BC15 is the limit stated by The Danish building Code 2015.

Surveys

- 64 % moderately to extremely disturbed by noise.
- 54 % sometimes to always cannot speak privately with a patient
- 60 % sometimes to always cannot hear/understand patients or colleagues.
- 39 % sometimes or often patients say that they cannot hear/understand participants.
- 21% noise disturbance in Lunch/meeting room
- 46% No privacy when speaking to patient in patient room .
- 42% participants cannot hear/understand others in meeting/lunch room.
- 38% patients cannot hear/understand participants in patient rooms and examination room.
- 28% find talking in rooms were participants are in is the most annoying noise source.

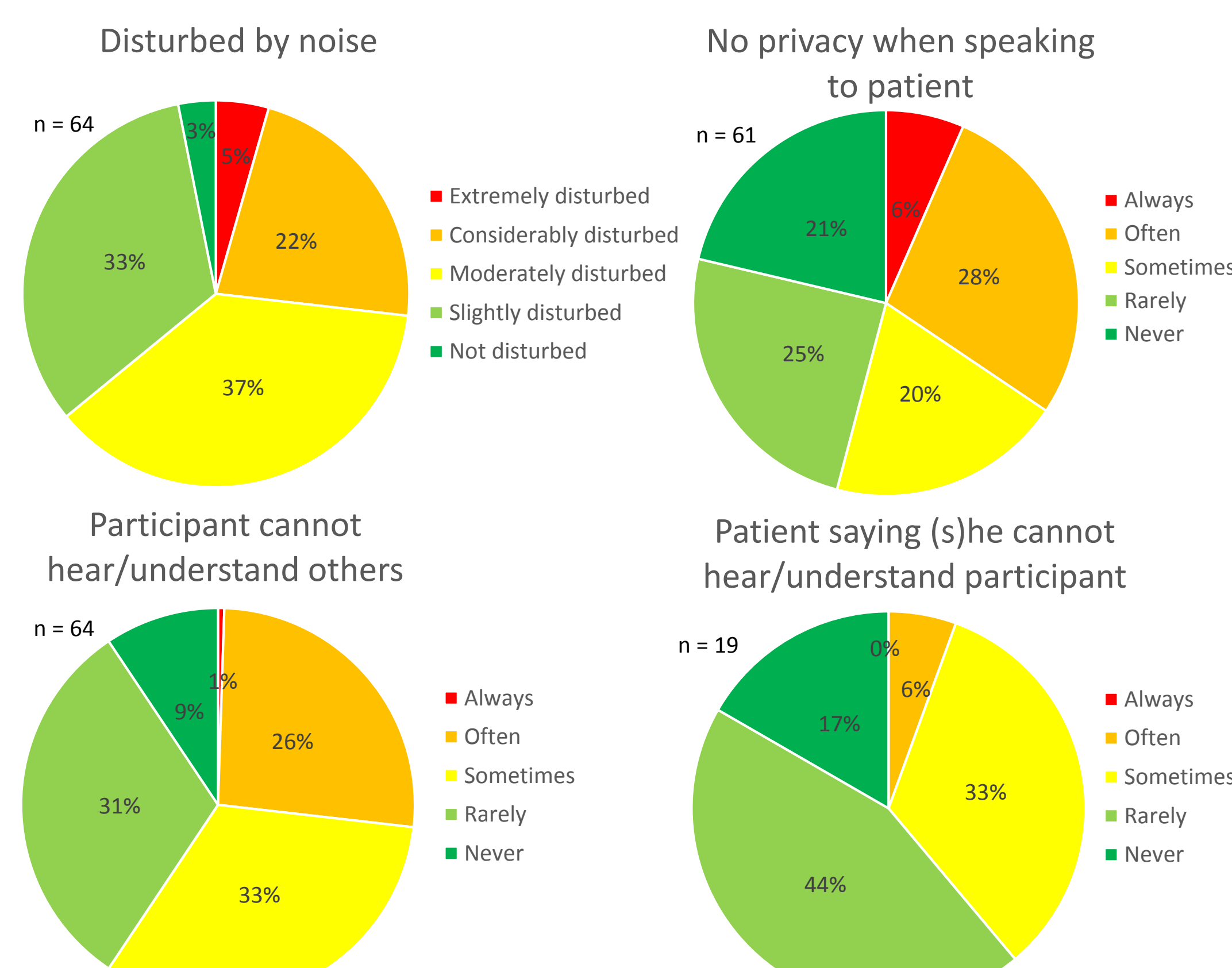


Fig. 4: Participants answer to four different questions regarding acoustics and noise. Disturbed by noise, No privacy when speaking to patient, staff member cannot hear/understand patients or colleagues and patients saying (s)he cannot hear/understand staff members. n states the number of participants who answered the question. The number of answers within each degree is given in percent.

Table 2: Distribution of participants in total and at each department, the explanation of each letter in left column can be found in fig 1, distribution of women, men, hearing impairment and whether they found them selves sensitive to noise.

	All	W	M	H	S
Total participants	64	80	16	13	17
D	15	93	7	20	13
E	3	100	0	0	0
P	6	100	0	0	33
R	4	100	0	25	25
W	16	94	6	6	19
X	17	53	47	18	18
Undefined	3				

Noise Sources

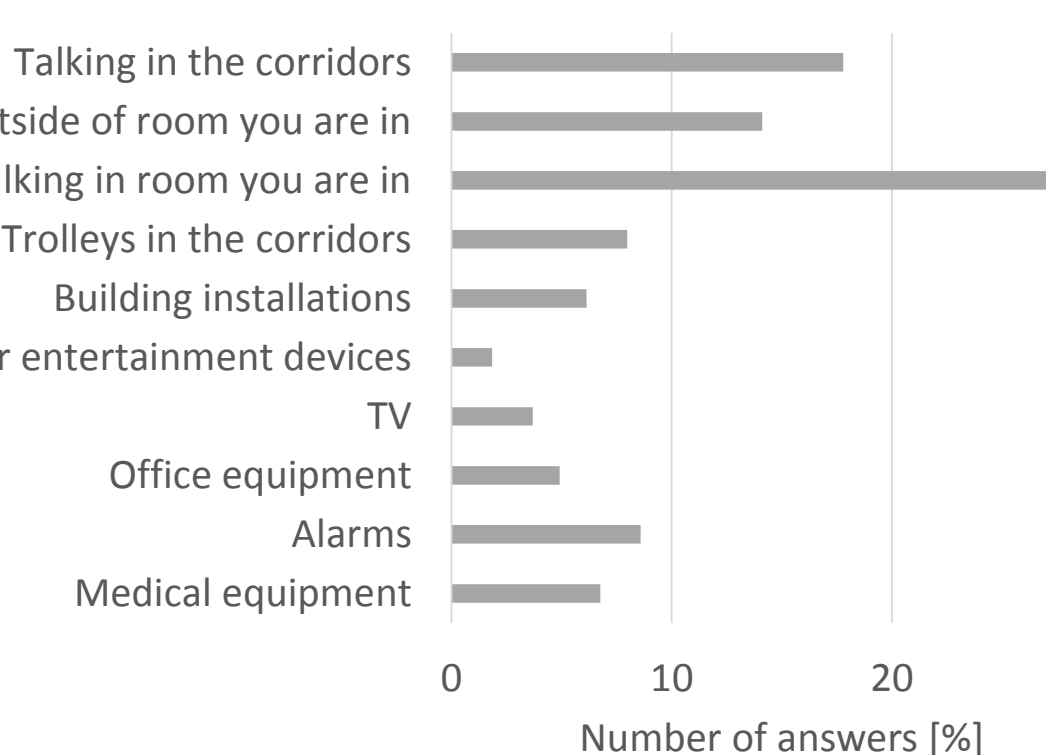


Fig. 5: The number of answers of noise sources the participants found disturbing at work. The participants could choose up to five noise sources they found disturbing.

Types of rooms with issues

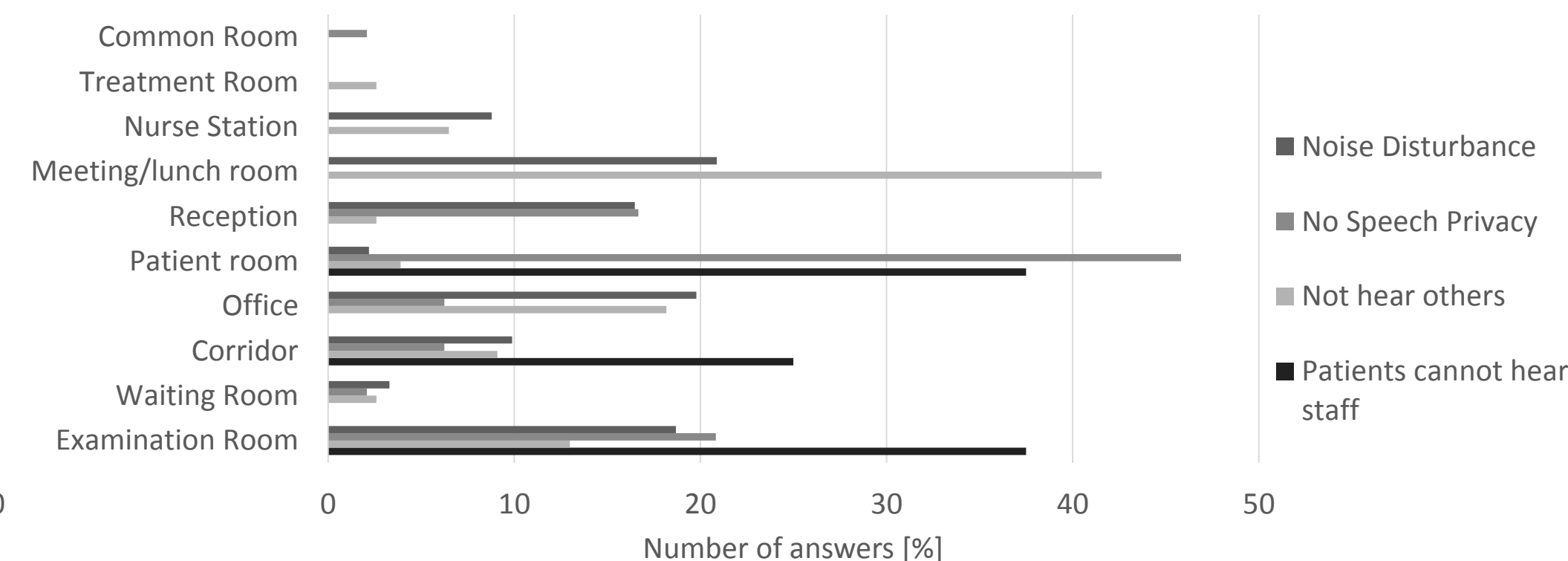


Fig. 6: The types of rooms where the participants found that the four different types of problems occurred. Participants could pick up to three rooms where they found each problem occurred. No differentiation has been made to what degree they found the problem occurred.

Initial Conclusions and Future work

Initial Conclusions

- Mainly five different issues regarding acoustics and noise were found present at Bispebjerg and Frederiksberg hospital:
 - Lombard effect
 - Reverberation in rooms
 - Noisy/hectic environment
 - No speech privacy
 - Noise from alarms and hospital equipment (not investigated).
- Four kinds of issues investigated. T₂₀ measured for each octave band was found to follow somewhat the same pattern for rooms within the four kinds of issues. However speech privacy needs more investigation.
- The Danish Building Code alone is not enough to ensure good hospital acoustics.
- The surveys show that
 - Only 3 % of participants don't feel disturbed at all by noise at work,
 - More than halves of the participants sometimes to always find that they cannot hear/understand a patient or colleagues due to noise and speak privately with patients.
 - More than 1/2 experience sometimes or often that patients complain that they cannot hear/understand important information the participant is giving.
 - The participants find that they are mostly disturbed by talking in the rooms they are in.
 - Speech privacy and patients not hearing/understand staff members mostly occur in patient rooms and noise disturbance and participant not hearing/understand a colleague or patient happens in meeting/lunch rooms.

Future work in project

- Try and link measured rooms with rooms stated with issues in surveys.
- Find significant results.
- Investigate noise levels in Examination room 12 at Dermatological ward (D.Ex12) which has reverberation issues.
- Come up with a solution for the D.Ex12 to improve the acoustics and calculate reduction in noise.
- Discuss how these issues potentially can influence patients based on literature.
- (Investigate Speech Privacy between rooms further.)

$$\frac{\partial T}{\partial t} = \frac{\lambda}{\rho c_p} \frac{\partial^2 T}{\partial x^2}$$