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Published in:
Proceedings of Forum Acusticum 2023

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Publication date:
2023

Document Version
Early version, also known as pre-print

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Sentop Dümen, A., & Rasmussen, B. (2023). Neighbour noise in multi-storey housing with poor sound insulation - Facts and occupants' viewpoints. In A. Astolfi, F. Asdrubali, & L. Shtrepi (Eds.), *Proceedings of Forum Acusticum 2023 : 10th Convention of EAA* (pp. 3731-3738). European Acoustics Association - EAA.

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NEIGHBOUR NOISE IN MULTI-STOREY HOUSING WITH POOR SOUND INSULATION - FACTS AND OCCUPANTS' VIEWPOINTS

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ABSTRACT

Neighbour noise has a significant role in acoustic privacy, protection and indoor environmental quality in residential buildings. Estimation of annoyance due to neighbour noise and concluding dose-response relationships are challenging due to variety in noise characteristics, occupant perceptions and other individual factors such as attitudes against the noise sources. This study uses qualitative analysis to examine complaints, attitudes and viewpoints on neighbour noise. In February 2021, an article was published in a national newspaper (Jyllands-Posten) of Denmark on the topics of implementation of acoustic labelling and sound insulation improvement. The article was also shared as social media posts in newspaper's official account and it received high public interest and several comments. People's reactions were gathered from the Facebook pages and analysed qualitatively. More than 500 comments were received in total, and these were grouped according to agreement/disagreement with classification, noise complaints (noise sources/activities, building definition, exposure timeframe, measures taken) accountable parties, emotions, beliefs and suggested measures and/or actions.

Keywords: *Neighbour noise annoyance, Acoustic labeling, Classification, Residential buildings, Noise attitude.*

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1. INTRODUCTION

Neighbour noise is a nuisance for many, who live in cities in multi-storey buildings. It has severe effect on occupants' wellbeing, social relations and health [1-10]. Especially during the first wave of Covid-19, it became evident that buildings could not protect their occupants against noise, and did not provide enough privacy [11-15]. Although regulations define limit values for sound insulation in new-build, compliance is unknown for many buildings, firstly because a high percentage of building stock was constructed before regulations and secondly because adverse field conditions and construction errors can weaken the performance. This brings the necessity of post-construction measurements and a labelling system.

COST Action TU0901, 'Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions' aimed at developing joint sound insulation descriptors and a common scheme with acoustic classes for housing to be applied throughout Europe. The Action had participation of 29 European countries and 3 overseas countries [16]. The results were expanded into a technical specification: ISO/TS 19488 [17]. The proposed acoustic classification system includes 6 classes ranging from A to F, class A indicating the highest performance and F the lowest. In Denmark, Danish standard DS 490:2018 defines the limits for each class as given in Figure 1 [18-20]. Figure 2 shows the estimated performance of Danish dwellings in multi-storey housing according to the construction year. A major part of the existing buildings was constructed before the building regulation, and has insufficient sound insulation.

Sound insulation between dwellings Main class criteria A-F in DS 490:2018			Occupants' expected evaluation	
Class	Airborne	Impact	Good or very good	Poor
A	$R'_w + C_{50-3150} \geq 63$ dB	$L'_{n,w} \leq 43$ dB and $L'_{n,w} + C_{1,50-2500} \leq 43$ dB	> 90 %	
B	$R'_w + C_{50-3150} \geq 58$ dB	$L'_{n,w} \leq 48$ dB and $L'_{n,w} + C_{1,50-2500} \leq 48$ dB	70-85 %	< 10 %
C	$R'_w \geq 55$ dB	$L'_{n,w} \leq 53$ dB	50-65 %	< 20 %
D	$R'_w \geq 50$ dB	$L'_{n,w} \leq 58$ dB	30-45 %	25-40 %
E	$R'_w \geq 45$ dB	$L'_{n,w} \leq 63$ dB	10-25 %	45-60 %
F	$R'_w \geq 40$ dB	$L'_{n,w} \leq 68$ dB	< 5 %	65-80 %

Figure 1. Sound insulation classes A-F according to DS490:2018 [18]. More information: See [18], [20].

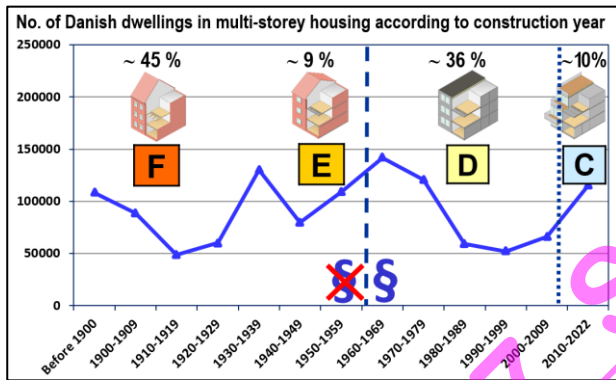


Figure 2. Number of Danish dwellings 1900-2022 according to construction year and estimated acoustic class. Periods 10 years, except the first & last column. The dashed line indicates year 1961 with the first national building regulations. The dotted line indicates year 2008 with stricter sound insulation limit values. Figure updated from [20].

2. METHODS

In 2021, an article was published in Jyllands-Posten [21], a national newspaper of Denmark on the topics of implementation of acoustic labelling and sound insulation improvement. The article was also shared as social media posts in newspaper's official account and it received high public interest and several comments. People's reactions were gathered from the Facebook page and analyzed qualitatively.

Overall, 511 comments were received in this post. There were 394 valid comments and 117 irrelevant (either only tagging friends or the context was not clear enough to

interpret the comment). Some of the comments belonged to the same person and these were merged to avoid bias. Overall 277 people's opinions were analyzed in this study. Firstly, statements of agreement or disagreement with the classification system were searched. Secondly, contents of the comments were analyzed to categorise people according to whom they held responsible for noise issues.

136 of the people commented about their noise related experiences. These were categorized according to noise source type, time frame referred for the noise, neighbouring conditions as reported, building conditions as reported, noise effects/activity disturbances and implemented coping strategy.

The content of all 277 people's comments were also analyzed to reveal suggested measures / actions, preconceptions / beliefs / statements and other complaints. Emotion expressions were also analyzed both through people's direct statements and through content analysis. Emotional typology proposed by Delft Institute of Positive Design [22] was implemented for categorizing emotion expressions.

All data was coded manually, thematically analyzed, checked and re-checked by authors and cross relations were analyzed using pivot tables in Excel.

3. RESULTS

3.1 Sample characteristics

Of 277 people who shared their comments, 178 were women corresponding to 64% of the sample and 93 were men corresponding to 34% of the sample. Genders of 6 profiles were unknown.

The content of the comments were analysed to reveal building typology distribution of sample (multi-storey apartment residents vs detached house residents). Some comments included clear description of building typology, while in other comments it was rather implicit (e.g. 'we have the same problem here') or could be deduced from specific descriptions, (e.g. 'Happiness is not guaranteed to be found by moving into a villa, where you have the "joy" of the neighbours' dogs, screaming children and lawnmowers'). Approximately 52% lived in multi-storey housing, 5% lived in detached houses and 7% moved from a noisy apartment. 36% could not be classified due to lack of information. Regarding the age of the building, most comments lacked details. Only 34

people mentioned their dwellings' age. 26 reported noise issues in old buildings, while 8 reported that neighbour noise problem was also present in new buildings. The geographical distribution of comments was also checked. Some comments mentioned the location of dwelling in question. For others, publicly shared information of living / working / hometown locations on Facebook profiles were used. Since the comments belonged to 2021 and analysis was made in 2023, some of those people may have changed location. However, data presents the general insight in geographical distribution of comments (Figure 3). For 73 comments location data was not available. Most of the comments were from three big cities of Denmark, i.e. Copenhagen (44 comments), Aarhus (23 comments), and Odense (13 comments).

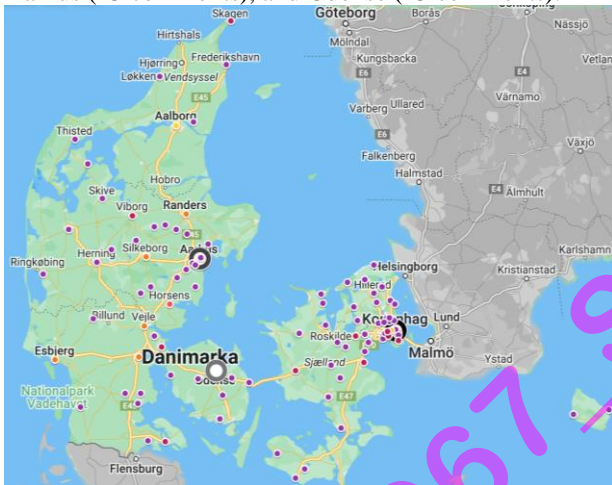


Figure 3. Geographical distribution of comments

3.2 Support for classification system

Out of 277 people, whose comments were analysed, 50 people actively agreed to implementation of a classification system (all others mainly explained their own neighbour noise experience and/or viewpoints). They defended that an informed choice must be provided to people, and that the classification system can direct the demand towards better dwellings and encourage housing associations/owners to invest in improvements.

"Finally, a professional input on this problem. (...) Millions of kroner are spent on renewal all around the housing associations - elevators, balconies, kitchens that are not run-down but just old, roofs that need maintenance, etc., - but no one wants to use money on improving sound insulation. Especially in old dwellings. It is completely wrong. Why the subject is not prioritized or treated with great carelessness is a

very good question. Especially when you look at how big a stress element noise is, both unconsciously and consciously for most or many people. - I'm just happy to live at the top and I could never think of moving to anything other than the top floor."

"(...) the idea of classification would make most people not want to rent dwellings, where the noise is clearly heard, that way the owner would quickly have the property renovated."

8 people partially agreed to implementation of a classification system. In these comments expression of support was followed by additional comments and suggested improvements:

"Good idea, but let's not stop there. (...) Poor sound insulation is a huge burden, not just for individual families, but also for society."

"Is it not possible to carry out subsequent sound insulation improvement of dwellings? Although it doesn't remove all the noise, it might help a little. In that case, a requirement for additional insulation would probably be more effective than a sound class scheme."

8 people stated disagreement with a classification system. Most concerns were related with the economical burden of sound insulation or that increased tolerance and social relations was the answer to noise problem. Some also expressed technical difficulties that can be faced while classifying buildings.

"Demanding sound insulation would be of no use at all, as the apartment becomes smaller and loses value."

"No, we must start talking together and show good neighbour relations. When you choose to live in an apartment, then you must also be able to tolerate having neighbours close by. Maybe we need to work a little on developing greater tolerance."

3.3 Party accountable for noise related nuisance – who is to blame?

Based on the content, comments were grouped according to which part was indicated as main accountable for noise annoyances. Some people blamed the building for the experienced noise, while others blamed neighbours or complainers.

Buildings were held accountable due to the observed low performance, age of construction (old vs. new), the typology (apartments vs. detached houses), or unfavourable plan layout that included adjacent noisy and noise sensitive rooms.



"My bedroom is under upstairs neighbour's kitchen-dining room. It sounds like the furniture is being rearranged every evening from 22 to 01. It's soooo boring."

People, who held neighbours accountable for noise, blamed them for being reckless (not considering others), being unaware of their noise, behaving excessively, or belonging to a marginalized group (young / old / immigrant). When the noise source was children, often parents were held accountable for not educating their children, for being reckless and for contradicting the demand of silence from others. Upon continuous exposure to a neighbour noise and not being able to solve it with the neighbour, some people made complaints to housing association. For a few, this resulted in the neighbours being kicked out, but for others, unsuccessful complaint resulted in frustration. These respondents blamed housing associations for not taking action against noisy neighbours, not monitoring house rules and not investing in improvement of sound insulation.

"We have an upstairs neighbour with 4 children, 0-5 years. That one infant cries we all know, but the other 3 are noisy until 10.00pm - 11.00pm most evenings. We have spoken to the family, and it helps for a few days. We have approached the housing association and the complaint must be in writing and signed by other residents, who are also annoyed by the noise, so it is uphill."

Lastly, some people blamed the complainers, who reacted on their noise annoyance either by directly warning the neighbour or by writing a comment about it. They were accused of being intolerant, hypersensitive and excessive. Making a complaint was inappropriate because people needed to return the tolerance that was shown to them. Furthermore, many argued that people needed to accept living with noise, if they had chosen to live in an apartment and/or in a city. For those people, cities were synonyms of noise due to living close; and people living on top of each other were similar to "rabbits/chickens in cages".

"It is easier to blame others for your own situation, you are free to do something yourself..."

3.4 Noise complaints

3.4.1 Noise sources

74 different noise sources were mentioned in the comments. These were grouped according to generator of noise and activities (Table 1). Most mentioned sound sources were loud music, speech, toilet activities, bedroom activities, children and vacuuming. (Vacuuming sound was referred in the article in question, therefore leading). A few people

referred some noise sources typical to suburban houses to express that neighbour noise is a burden also in this typology. These sources were children screaming, lawn mowing, dog barking, trampoline and its squeals, music from teenage sheds, hammering, traffic, and truck visits.

Table 1. Noise sources in multi-storey buildings

Category	Noise source
Neighbour voice	Talking, conversation, laughing Singing Sneezing, coughing, yawning Snoring Farting Fighting, arguing Shouting, screaming, cheering Children screaming, baby crying
Sounds of neighbour activities	Moving in Eating, cutlery, can opening Cooking, washing dishes Cleaning Bedroom activities Watching TV Listening to music Playing instrument Playing computer / board game Having guests Party Gymnastic, dropping exercise tools Playing football DIY Children riding a bicycle
Sounds of household devices	Vacuuming Washing machine, dishwasher Machinery buzz
Sounds of building installation	Toilet activities, flush Bath, shower Rainwater drain Electrical switch Heating system
Signal sounds	Doorbell Alarm clock Telephone message sound, vibration
Sounds of hallway activities	Getting inside / opening front door Climbing stairs Children in apartment hallway
Impact sounds	Walking (on heels/boots/without shoes) Closing/ slamming doors, drawers etc. Dragging chairs, furniture Children running, jumping, tumbling Running Items dropping on floor/hitting wall
Animal sounds	House pets (cat, dog, bird)
Outdoor sounds	Car traffic, railway Pub

3.4.2 Time frame

Some of the comments included information of the time frame for nuisance (Figure 4). Almost all of them were indicating night-time. Noises at that time caused sleeping irregularities as people had difficulties in falling into sleep, woken up by noise or deliberately changed their sleeping pattern in order to avoid noise. Others also referred to morning-time annoyance. One comment was written by a night-worker who had difficulties both due to noise in mornings and due to not being able to manage everyday tasks in their apartment without neighbour's complaining.

3.4.3 Building definition

Most of the complaints were associated with old buildings, and building construction was defined as 'thin', 'like cardboard', 'hard (wood) floor instead of carpet'. However there were also a few who reported that new buildings also performed badly. These respondents were feeling like 'they had been cheated' because performance of recently bought apartment didn't meet their expectations. Since the sample distribution could not be controlled in this research, the topic needs to be further addressed with socio-acoustic surveys.



Figure 4. Time frame of (a) nuisance and (b) recommended house rule

3.4.4 Sound source / sound definition

Complaints showed that sounds are especially annoying when they are clear, intelligible, violent, heard as if coming from their own dwelling, private (toilet/bedroom) and when it is repeated several times and at an inappropriate time. Those who hold their neighbours responsible for experienced noise issue, also have a hostile attitude towards them.

While most of the comments were related with people's noise annoyance experiences and judgments, some comments indicated neutral or positive response to hearing neighbour sounds. 4 groups emerged from these positive comments:

1. People who were content by hearing others, felt safe and associated sounds with life and human contact.
2. People who weren't bothered unless the noise was not at an inappropriate time.
3. People who adapted / got used to noise.
4. People who tolerate noise for neighbourly relations.

3.4.5 Actions taken

Most noise problems resulted in moving from the apartment. Several people made a complaint to the neighbour or the authorities. Seldom their problem was resolved. Unsuccessful coping resulted in desperation and frustration towards the neighbours and the housing associations.

3.5 Suggested measures, preconception and beliefs

People's suggested measures, preconceptions and beliefs were focused around (1) responsibility and economic burden, (2) classification, (3) sound insulation, (4) other physical measures, (5) social and personal measures, (6) house rules.

A great un-clarity exists related to who should be financially responsible for sound insulation. Responses pointed to all three of residents, owners, and housing association. Government funding was also recommended.

With regards to classification, most asserted that informed choice was necessary and some expressed that they would not had moved in their apartment if they had known the performance. Some see classification system as an encouragement since it would lead to demand on better performance and owners / housing association

would have to consider improvement. Some people underline the necessity of implementing classification system to both tenant and owner-occupied buildings. Sound insulation must be mandatory and limits for improvement should be defined separately (even small improvement can help). Others think that it is not possible to demand changes to existing buildings, and existing buildings constitute a large proportion of the housing stock. The most important reason for objection to the classification is the economic burden of sound insulation. Although renovation of dwellings has increased, noise is most often not considered and no investment is made in these works. Sound insulation is considered to be very expensive and improvement of existing buildings is hard or impossible. Accordingly, social measures constitute the largest part of the proposals. Being tolerant, accepting noise if living in apartment, mutual respect among neighbours, being considerate, conversation with kindness, and educating children are listed as social measures. Several house rules are recommended as well, stating time frame for activities and other considerations (Figure 3).

There are many preconceptions regarding the construction knowledge and improvements but they are shallow and sometimes incorrect. Most common preconception was seen in accepting the apartments (19 comments), cities (8 comments) and old buildings (10 comments) as inevitably noisy and that people should 'either take it or leave it'. Correspondingly, most common suggestion was moving to another dwelling / to a house / to a countryside (20 comments).

As observed from the amount of details given in comments, hearing each other in multi-storey buildings is a violation of privacy and a threat to dignity. Too much information related to one's life, sensitive activities, communication and parenting practices are exchanged through noise. Both sides feel reluctant and uncomfortable with sharing this amount of information. This constitutes the second facet of noise problem.

3.6 Emotional response

When the comment was referring a noise episode, the terms referring an emotion were determined as:

"Annoying", "boring", "horrifying", "terrible", "burdensome", "stressful", "makes crazy", "concern for health", "ugly sounds", "hatred", "tired", "un-peaceful", "unlucky", "affects the quality of life", "ruins lives", "makes life hell".

Emotion expressions were also analyzed through content analysis. Emotional typology proposed by Delft Institute of Positive Design [22] was implemented for categorizing emotion expressions. According to this analysis noise induced following emotions:

- Contempt and hate (against the noisy neighbour)
- Indignation (when the behaviour is against moral values)
- Resentment (when they believe neighbours has treated unfairly)
- Frustration (upon not finding a solution or performance not meeting the expectation)
- Longing (to silent dwelling)
- Shame / uncomfortable feeling (due to private activities being heard)
- Startle (against sudden noise)
- Worry and anxiety (for their health, for next noise issue, for neighbours' reaction)
- Desperation (upon not finding a solution)
- Schadenfreude (revengeful feeling to annoy the neighbour with own noise)
- Pleasure (those who were content of hearing others)
- Tenderness (an understanding to children and disabled children)

When the comment was about 'being heard' the emotion terms were found as:

"Boring", "burdensome"

The following emotions were detected through content analysis:

- Worry and anxiety (of receiving complaints)
- Embarrassment (by being exposed and revealed to their neighbour)
- Resentment (when they believe neighbours has treated unfairly by complaining)

4. CONCLUSION

Most people agree with an acoustic classification scheme and labelling. This would give people the right to make informed choice while renting/buying apartments. Also implementation of a classification scheme would encourage construction sector / housing associations / house owners to improve the performance.

Results show that noise is a burden on social relations, causing disorder in society. People respond aggressively

when they see neighbour or the complainer as the problem. Unsuccessful complaints result in further anger and even threats and harassments. In cases of conflict, moderator teams are of importance.

As seen from the responses, most common coping strategy was moving to another dwelling. However, considering that without a classification system, for most people there is no way of knowing the sound insulation before moving in or buying the property, thus moving is not the optimal solution. Nevertheless, if people are aware of the typical relation between the construction year/type and the acoustic class, cf. Figures 1-2, they get a first estimate.

Most people consider apartments and cities as inevitably noisy. The construction sector should put noise into the agenda and improve construction quality. Social awareness should be raised in order to direct people's opinion from seeing noise as a destiny to knowing alternative solutions and demanding better performance. Good practices, success stories of improvements should be promoted to change opinion about improvement being impossible. Most urgent questions are 'who are responsible for improvement?' and 'which funds can be applied?'

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forumacusticum 2023

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