Neighbour noise questions in national surveys

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Summary

The impact of built environment on residents' health and wellbeing is often assessed through national surveys on residential satisfaction and on health and morbidity. These surveys typically cover a wide range of environmental factors. Thus, noise is addressed only briefly through a few questions dedicated to for example "noise in general" or "traffic noise". This makes it difficult to measure neighbour noise impacts and develop useful insights for sound insulation policies. Nevertheless, some national survey schemes effectively address neighbour noise and serve as good examples. Additionally, some socio-acoustic surveys provide detailed assessments of various indoor and outdoor noise aspects, though their sample size and representativeness vary.

This study analyses the noise annoyance questions in national surveys in two countries, i.e. Denmark and Norway, and makes a comparative analysis of methodologies and results. The results provide recommendations on questions to address neighbour noise in national surveys.

Introduction

Neighbour noise is a significant problem in multi-storey housing (MSH), violating consumer rights [1] and evoking negative emotions [2]. Noise induced annoyance is typically measured as a reaction variable in surveys. In order to standardize noise annoyance studies, "Community Response to Noise Team" of ICBEN made important efforts [3, 4], and final contributions were published as a technical standard, ISO/TS 15666, in 2003 and revised in 2021 [5]. The document provides criteria to be considered in a socio-acoustic survey, recommends response scales, standardized question formulations as well as translations to 17 languages. In 2013 an international study, COST TU0901: Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions was completed and a standardized questionnaire form was published as one of the outcomes [6]. This template is intended to assess the noise annoyance in residential buildings to compare with acoustic measurements. The EU-Survey on Living Conditions (EU-SILC) is conducted annually using standardized methods, allowing for the collection of comparable data across European countries [7]. However, the questionnaire includes only a single-item question on noise annoyance, which combines environmental and neighbour noise into one category, while these were separated in 2007 and earlier versions. Countries administer other representative surveys where they elaborate noise aspects further, however methodological differences complicate interpretation of results in cross-studies. This study reviews the noise annoyance questions in national surveys in Denmark and Norway. It will be considered to extend to more countries later.

Methods

The surveys included in the analysis are listed in Table 1. Methodological recommendations for developing questionnaires and socio-acoustic surveys were gathered from relevant literature [3-6, 8-11]. After defining the analytical dimensions, questionnaire designs were examined across different studies. Annoyance findings were collected from published reports and open-access databases. The results were mainly presented as the total percentage of respondents who reported annoyance. Where data were available, the percentage of "high annoyance" was also reported. The cutoff point for "high annoyance" was defined in accordance with the literature as the percentage of respondents who reported 8 or more on an 11-point scale, "very" or "extremely" annoyed on a 5-point scale and "very annoyed" on a 3-point scale. Sample size, response rate and sample representativeness were also reported. Questions on sleep disturbance are not included in this paper.

Table 1: Information about the analysed surveys. Letters in codes for surveys are abbreviation of countries and numbers indicate year.

Code	Country	Year	Institute	Survey name	Aim of survey	Reference
NO23 DK23	EU	2023	EUROSTAT & National statistics institutes	EU-SILC: Survey on Living Conditions	To collect timely and comparable data on living conditions.	[12]
NO07	NO	2007	NIBR - The Norwegian Institute for Urban and Regional Research	Survey among residents of new housing	To analyse resident's experiences and satisfaction with recently built residential buildings.	[13]
NO15	NO	2015	Sintef / TØI / Multiconsult (for DIBK-Norwegian Building Authority)	Acoustic conditions in dwellings: Evaluation of building technical requirements for acoustic conditions	To analyse residents' self-reported experience in relation to objective sound insulation measurements.	[14-15]
NO19	NO	2019	HUNT Research Centre	HUNT 4 - sør Trøndelag Health Study	To analyse factors of health and quality of life	[16-17]
DK17	DK	2017	SIF - National Institute of Public Health	SUSY 2017 - The National Representative Health and Morbidity Studies	To measure wellbeing, health and morbidity	[18-20]
DK21	DK	2021	SIF	SUSY 2021	To measure wellbeing, health and morbidity	[22-23]
DK24	DK	2024	Videncentret Bolius (Realdania)	The Danes in the built environment	To analyse residents' life quality in residential buildings.	[24]

Comparison of questionnaire designs

Table 2 presents the comparison of questionnaire designs.

a. Noise sources: COST TU0901 questionnaire includes 1 question on overall annoyance, 11 questions on annoyances due to specific indoor noises, and 2 questions about environmental noise indoors. While NO15 follows this scheme, other surveys vary in granularity (number of source types), wording (e.g. neighbour / other and outdoor / traffic) and content (noise inside one's own home is addressed as own family / sound insulation / devices).

b. Question wording: Questions meet the four elements of good practice, namely, brevity (both by length and conceptually), objectiveness (neutrality), simplicity (words that are familiar to all and require less cognitive effort), specificity (by avoiding too general or ambiguous questions, e.g. using the word 'often', questioning two issues at once) [9]. While ISO/TS 15666:2021 uses "at home" inclusively, covering both indoor and outdoor spaces (gardens, balconies etc), COST TU0901 specifies traffic noise under closed-window conditions to facilitate comparability with sound insulation measurements. Following ISO/TS 15666:2021 recommendations, the time frame of annoyance is defined as 12 months only in NO19 and NO15.

c. Response scale: Bipolar scales (positive to negative) and agree/disagree evaluations can introduce bias as respondents often lean towards positivity and agreement [8,10]. Almost all surveys used unipolar (neutral to negative) scale, except NO07 which measured satisfaction. 'NA (not applicable)' option (e.g. NO15), can reduce bias especially when a source doesn't exist, but may lead to incomplete data [8].

Table 2: Analysis of questionnaire design in selected studies (PS: point scale, CB: Checkbox)

Code	Noise source	Question wording	Response scale wording
ISO / TS 15666	–	Thinking about the **last (12 months or so)**, when you are ***here at home***, how much does noise from (noise source) bother, disturb or annoy you? [4]	5 PS: Not at all; Slightly; Moderately; Very; Extremely
		Thinking about the **last (12 months or so)**, when you are ***here at home***, what number from 0 to 10 best shows how much you are bothered, disturbed or annoyed by (source) noise? [4]	11 PS:0-Not at all - 10-Extremely annoyed
COST TU0901	*14 types* [1]	Thinking about the **last 12 months** ***here at home***, what number from 0 to 10 best shows how much you are bothered, disturbed or annoyed by these sources of noise?	11 PS:0-Not at all - 10-Extremely annoyed
NO23 DK23	*1 type* [2]	When you are ***inside your dwelling***, do you have problems with noise from neighbours or other noise from outside, e.g. traffic, industry or construction work?	2 PS: Yes / No
		(If the respondent answered yes) Is this noise …	4 PS: Very annoying; Somewhat annoying; A little annoying; Not annoying
NO07	*3 types*	How satisfied are you with the sound insulation in relation to noise outdoors? (*Hvor fornøyd er du/dere med Lydisolering i forhold til støy utenfra?)*	5 PS: Very dissatisfied *(Svært misfornøyd);* Quite dissatisfied *(Nokså misfornøyd);* Neither satisfied nor dissatisfied *(Verken fornøyd eller misfornøyd);* Quiet satisfied *(Nokså fornøyd);* Very satisfied *(Svært fornøyd)*
		How satisfied are you with the sound insulation in relation to neighbouring dwellings? (*Hvor fornøyd er du/dere med lydisolering i forhold til naboleiligheter?)*	
		How satisfied are you with: Sound insulation between rooms in the dwelling? (*Hvor fornøyd er du/dere med: Lydisolering mellom rommene i boligen?)*	
NO15	*12 types* [3]	Thinking about the **last 12 months** ***when you are at home***, how much are you bothered by noise from each specific noise source? *(Tenk på de siste 12 månedene når du er hjemme, hvor mye er du plaget av støy fra hver spesifikke støykilde?)*	5 PS: Extremely *(Voldsomt);* Very *(Mye);* Moderately *(Middels);* Slightly *(Litt);* Not at all *(Ikke plaget);* NA *(Ikke relevant)*
NO19	*1 type + other*	Consider the **last 12 month**s, how bothered are you by noise from traffic ***when you're at home***? *(Hvis du tenker på de siste 12 månedene, hvor plaget er du av støy fra veitrafikk når du er hjemme?)*	5 PS: Extremely *(Svært mye);* Very *(Mye);* Moderately *(Middels);* Somewhat *(Litt);* Not at all *(Ikke)*
		Consider the **last 12 months**, how bothered are you by noise from other sources ***when you're at home***? (*Hvis du tenker på de siste 12 månedene, hvor plaget er du av støy fra andre kilder når du er hjemme?)*	
DK17	*2 types +9sub-types in CB*	Have you been bothered by any of the following conditions ***inside your home*** within the **past 14 days**? *(Har du inden for de seneste 14 dage været generet af nogen af følgende forhold inde i din bolig?)* _ Traffic noise *(Støj fra trafikken)* _ Neighbour noise *(Støj fra naboer)*	3 PS: Yes, very annoyed *(Meget generet;* Yes, slightly annoyed *(Lidt generet);* No *(Nej)*
		If you have been bothered by noise from neighbors within the **past 14 days**, what kind of noise have you been bothered by? *(Hvis du har været generet af støj fra naboer inden for de seneste 14 dage, hvilken slags støj har du så været generet af?)*	9 CB: Footstep / Speech / Scream / Door closing / Pet / House appliances / Lift / Sanitary sys. / Other [5]
DK21	*5 types*	Have you been bothered by any of the following conditions ***inside your home*** within the **past 14 days**? *(Har du inden for de sidste 14 dage været generet af nogen af de følgende forhold i din bolig?)* _ Traffic noise *(Støj fra trafik)* _ Noise from toilet, drain or sewer *(Støj fra toilet, afløb eller kloak)* _ Noise from ventilation systems *(Støj fra ventilationsanlæg)* _ Neighbour noise *(Støj fra naboer)* _ Shaking in the home *(Rystelser i bloigen)*	3 PS: Yes, very annoyed (Meget generet; Yes, slightly annoyed (Lidt generet); No (Nej)
DK24	*1 type +7sub-types in CB*	Are you having problems with the indoor climate ***in your current home***? *(Har du problemer med indeklimaet i din nuværende bolig?)*	10 CB including: Noise (Støj)
		What noise source bothers you the most? *(Hvilken støjkilde er du mest generet af?)*	7 CB: Traffic / Neighbour / Inside home (e.g. devices) / City life / Industry / Wind turbine / Other

Notes:
[1] General, Neighbour (speech, music, footstep), Common areas (speech, footstep), Service systems (sanitary, mech.), Traffic (***closed windows***), Inside home (own family) [5]
[2] 2007 and earlier surveys separated road and neighbour noises
[3] Same as [1] except general and inside own house
[4] 'at home' covers inside the home or outdoors at home
[5] see the complete descriptions in original reference

Continuous scales (e.g. numerical scale) allow respondents to mark a point along a continuum, whereas categorical scales provide predefined choices: (1) dichotomous scales: simple but lack granularity, (2) rating scales: more cognitive effort but offer greater accuracy, (3) quantifier scales: preferred for frequency-based questions (e.g., sleep disturbances) [8]. Too long scales risk reducing distinctions between options, increase cognitive load and cause tendency towards first or last options in self-administered questions and interviews respectively [9]. For standardization, a 5-point verbal scale (categorical) and an 11-point numeric scale (continuous) are recommended in noise annoyance research [4-5]. COST TU0901 questions included a numeric scale, but some researchers adapted it to a 5-point verbal scale for consistency with previous studies (NO15). 3 and 4-point scales were also used.

Order of scale (positive to negative or vice versa) and the display format of the scale (vertical or horizontal) may affect data quality [8], however this review did not have access to presentation format in the online survey medium.

Comparison of findings

Table 3 presents the comparison of findings across studies. However, it is important to note that due to methodological differences, direct comparisons are subject to bias. The EU-SILC enables cross-national comparisons as well as longitudinal analysis to see changes in time. However, it evaluates general noise annoyance rather than specific sources.

a) Annoyance findings: Nonetheless, the results show that neighbour noise complaints were similar or more common than traffic noise complaints when these issues were addressed separately in surveys. Annoyances are higher in MSH. NO07 indicates that MSH with 3 floors or less might experience more problems in Norway (might indicate converted houses). In a study that analysed various indoor noise sources separately (NO15), footstep noise was identified as the most annoying among various indoor noises as also found in [25, 26]. Additionally, noise problems increase in cities and when poverty is accounted (NO23 and DK23), and life satisfaction is lowest among those with noise problems (DK24).

All the surveys, except NO15, had representative samples, therefore reflect the experiences of the broader population.

b) Limitation to annoyance characterization: It is challenging to fully understand the dimension of neighbour noise problems based on only statistical findings. Due to the multi-parameter nature of neighbour noise the percentages or mean annoyance scores obtained in surveys are often low, while complaints of singular respondents can be very strong and significantly affect their wellbeing.

A particular challenge arises when coding responses from residents who do not hear the noise. One solution is to code their annoyances as '0' since their evaluation is also representative of the population and '*not hearing'* can imply that the sound insulation is satisfying. However, this can lead to an underestimation of noise issues when the source is absent for some of the respondents (e.g. no elevator or upper neighbour). This could be addressed by introducing NA option, or questioning / examining the building layout. Lastly construction year should also be questioned to assess noise conditions in housing from different periods.

Table 3: Summary of results (MSH: Multi-storey housing)

Code	Sampling	No. Respondent	Resp.per Question	Noise source	Annoyance finding	Other findings
NO07	Representative. In all types of new buildings (2005) (NIBR)	1553 (39% response rate)	1070	outdoor	**13%** unsatisfied, 69% satisfied MSH: **12%**, 69% MSH <3floors: **17%**, 59%	_ Among all the physical aspects of buildings, residents are least satisfied with sound insulation between rooms in the home and to the neighbouring apartment
			1498	neighbour	**17%** unsatisfied, 69% satisfied MSH: **14%**, 74% MSH <3floors: **27%**, 54%	
			1470	own home	**17%** unsatisfied, 63% satisfied	
NO15	Not representative. In MSH (%97) with different insulation properties (DIBK)	702 (18% response rate)	_	traffic	**~ %43** annoyed, ~ 10% highly annoyed	~65% of the respondents are annoyed Concern of bothering others: ~33% visitors / child sound, ~37% music/tv, ~17% footsteps
			_	speech	**~ %23** annoyed, ~ 4% highly annoyed	
			_	music	**~ %29** annoyed, ~ 4% highly annoyed	
			_	footstep	**~ %44** annoyed, ~ 10% highly annoyed	
NO19	Representative. In Trøndelag (HUNT)	106000 (43% response rate)	98795	traffic	**31%** annoyed, 4% highly annoyed	
			98848	other	**29%** annoyed, 3% highly annoyed	
NO23	Representative (EU-SILC)	5531 (48% response rate)	–	traffic + neighbour	**14%** have problems Single household: **18%** In cities: **16%** In cities & poverty: **23%**	49% of dwellings are 2 or more family residential buildings
DK17	Representative (SUSY2017)	14022 (? response rate)	12691	traffic	**14%** annoyed, 2% highly annoyed MSH: **22%**	apartments built after 2010 have 0.46 times lower odds of annoyance by footsteps and 0.21 times lower odds of annoyance by speech than those built in 1960-1969.
			12683	neighbour	**17%** annoyed, 3% highly annoyed MSH: **36%**	
DK21	Representative (SUSY2021)	11346 (45% response rate)	10415	traffic	**14%** annoyed, 2% highly annoyed	
			10416	neighbour	**16%** annoyed, 3% highly annoyed MSH: **35%**	
DK23	Representative (EU-SILC)	6215 (~40% response rate)	–	traffic + neighbour	**16%** have problems Single household: **20%** In cities: **24%** In cities & poverty: **29%**	48% of dwellings are 2 or more family residential buildings
DK24	Representative (BOLIUS)	7108 (? response rate)	7108	general	**11%** have problems.	MSH after 2000: 13%,before 1920: 22% Satisfaction with life is lowest among who reported noise problems (6.55/10)
			773	traffic	**40%** most annoyed by MSH: **29%**	
			773	neighbour	**39%** most annoyed by MSH: **54%**	

c) Data accessibility: Access to results, data and information and communication with public needs further elaboration for contributing to open-science. Among the analysed surveys, DK24 database allowed making cross-comparison between questions. Besides the research reports NO15 data were used in dose-response analysis and DK17 in correlation with health symptoms both published in English. Although EU-SILC included both a bipolar Yes/No question and a more detailed 4-point rating scale, only the results of the Yes/No question were publicly available online, at least to the knowledge of the authors. While it was possible to access results of the health survey in Trøndelag county (HUNT), it was not possible to access the results of other health surveys (e.g. HELMILO, HUBRO) in Norway.

Conclusions and recommendations

Sharing experiences regarding annoyance and construction solutions can contribute to improving acoustic conditions in housing. This study highlights the challenges of comparing noise annoyance findings across studies due to the lack of harmonized approaches and methodologies. Furthermore, inconsistencies in methods over time complicate efforts to quantify and monitor noise annoyance. While EU-SILC provides comparable results indicating the overall noise problem, simplification to one-item question minimizes its effectiveness in developing noise mitigation policies and strategies, as measures to address traffic noise differ significantly from those targeting neighbour noise. Future efforts should include developing coordinated and standardized surveys.

Some national surveys address primarily environmental noise and include a general question for “other” sources. Survey findings show that neighbour noise causes as much or more annoyance and should be addressed in surveys alongside other building-related noise issues. Since neighbour noise annoyance varies considerably between housing types, surveys should provide results for both multi-storey housing, row houses and one-family homes. Annoyance relation to construction types is an important area for further investigations and communication, cf. e.g. [1], [25].

Besides giving projections to policy makers, science should inform society through open access reports, scientific papers and databases. Accessibility of the survey results needs improvements. Like for energy labelling, acoustic quality performance should be available for dwellings, cf. [1] and [25].

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