

Assessment of noise annoyance in medical facilities

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DOI: 10.54215/Noise_Control_2022_A_Digital_Monograph_Pleban_D

Abstract

Inadequate acoustic conditions at workplaces in medical facilities are the result of noise coming from outside of the room, noise from any apparatus or tools used and reverberation noise, resulting from room characteristics. The assessment of noise annoyance in workplaces at selected medical facilities in Poland was carried out. This assessment was conducted by means of a direct-personal interview technique using a categorized paper questionnaire interview among 301 people (physicians, nurses and diagnostic laboratory staff). The obtained results showed among others that noise is the biggest source of annoyance for nurses, less for employees of diagnostic laboratories and physicians. The average grading of noise annoyance in workplaces on a scale from 0 to 10 was 2.77, and therefore the noise annoyance was assessed as slightly.

Keywords: noise, medical facility, workplace, annoyance

1. Introduction

According to the latest data of the Statistics Poland [1], in 2020 Poland 542,186 persons were employed in the "Human health care and social work activities" section. Among this group of employees, 17,501 persons were exposed to the risks arising from work environment, i.e. they were exposed to hazards connected with the work environment, strenuous work or mechanical factors associated with particularly dangerous machinery and devices.

The risks arising from work environment concern exposure to chemicals, dusts, noise, mechanical vibrations, hot or cold microclimate, radiation, electromagnetic fields, biological agents, etc. On the other hand, the risks arising from strenuous work include excessive physical exertion and insufficient lighting. In turn, risks associated with particularly dangerous machines and devices in medical facilities is associated with the use of saws and high-speed drills (used during surgical procedures).

The quoted at the beginning data of the Statistics Poland, as well as literature data (e.g. [2-8]) and the results of own research (i.e. conducted by the Central Institute for Labour Protection – National Research Institute (CIOP-PIB)) [9-11] in the field of objective assessment of working environment factors in medical facilities confirm the occurrence of cases in which the limit values of factors harmful

to health in the work environment are exceeded. In the case of noise in operating rooms, the A-weighted sound pressure level from saws and drills reaches up to 110 dBA, e.g. during hip replacement, the levels measured by CIOP-PIB employees reached values within 90 dBA.

The paper discusses the results of surveys on the assessment of working conditions in medical facilities due to noise.

2. Research method

According to surveys conducted periodically by the European Foundation for the Improvement of Living and Working Conditions (Eurofound) in Dublin as part of the reviews of working conditions, there is a need to assess hazards in the working environment both by objective and subjective methods. Subjective risk assessments are determined by the individual characteristics of employees, the psychological conditions of their work, as well as the sense of occupational risk. They constitute an indirect method for the employees' assessment of occupational hazards and their effects on health and life. The significance of subjective studies is directly linked to the health definition adopted by the World Health Organization: "*Health is not just the absence of disease or disabilities, but the full physical, mental and social well-being*".

Pursuant to the approved methodological concept, a survey was carried out by means of the technique of the direct interview – personal with the use of the categorized paper-form PAPI structured interview. Each of the respondents answered questions included in the questionnaire. The questionnaire comprised close-ended questions, multiple-choice questions, short or single-word responses and open-ended questions enabling a respondent's free response. The survey was carried out in the area of 5 voivodeships: Mazowieckie, Greater Poland, Silesian, West Pomeranian and Lesser Poland.

3. Characteristics of the studied group

The survey was carried out among 301 respondents (N = 301):

- 151 physicians,
- 120 nurses,
- 30 employees of diagnostic laboratories.

Considering the key division into physicians, nurses and diagnostics laboratory staff from the perspective of the research project, the division of surveyed group, including gender is presented in

the following way: men are overrepresented among surveyed physicians – 56.3%, whereas groups of nurses and diagnostics laboratory staff are predominated by women, 99.2% and 60.0% respectively. There is a statistically significant correlation between practiced profession and gender (as relevance = 0.000, that is less than standard threshold of 0.050). Nearly all nurses are women. There is a strong relationship between gender and occupational group $\chi^2 = 94.49$; $p < 0.001$, Cramer's coefficient gauge is $V = 0.560$.

Taking into consideration the type of performed work, it follows that surveyed physicians comprise the oldest age group. The youngest group of respondents accounted for diagnostics laboratory staff. There is a strong correlation between age and occupational group $\chi^2 = 30.619$, $p = 0.001$, Cramer's coefficient gauge is $V = 0.225$ – the correlation is weak.

4. Test results

4.1. Characteristics of working conditions

Definitely top rated working conditions are evaluated by the surveyed physicians – up to 55.0% of indications to answer “very good”. Also, the diagnostics laboratory staff highly evaluate their working conditions. The working conditions are relatively worst rated by the surveyed nurses (Table 1). Statistical tests corroborate substantial disparities observed in distribution of responses, which is confirmed by Chi-squared test: $\chi^2 = 49.514$ (Table 2). There is a statistically significant correlation between the evaluation of working conditions and the exercised profession (as relevance = 0.000, that is less than standard threshold of 0.050).

Table 1. Overall appraisal of working conditions and in division into job positions

Rating scale	General results		Physicians		Nurses		Diagnostics laboratory staff	
Very good	115	38.2%	83	55.0%	21	17.5%	11	36.7%
Good	136	45.2%	45	29.8%	72	60.0%	19	63.3%
Average	49	16.3%	22	14.6%	27	22.5%	0	0.0%
Poor	1	0.3%	1	0.7%	0	0.0%	0	0.0%
Very poor	0	0.0%	0	0.0%	0	0.0%	0	0.0%
In total	301	100.0%	151	100.0%	120	100.0%	30	100.0%

Table 2. Overall appraisal of working conditions and in division into job positions – statistical tests

Chi-square tests			
Parameter	Value	df	Asymptotic relevance (bilateral)
Pearson's Chi-squared test	49.514 ^a	6	0.000
Likelihood ratio	56.878	6	0.000
Linear relationship test	7.282	1	0.007
N key observations	301		
Symmetric measures			
		Value	Approximate relevance
Nominal by Nominal	Phi	0.406	0.000
	Kramer's V	0.287	0.000
N key observations		301	

The ANOVA non-parametric test for Kruskal-Wallis ranks proved that there is a difference in the appraisal of the working conditions by the particular occupational groups $\chi^2 = 30.84$; $p < 0.001$. The comparison by pairs was made with an application of post-hoc Dunn's test for professional groups. Significant differences were noted between physicians and nurses ($p < 0.001$) and between diagnostics laboratory staff and nurses ($p = 0.018$).

The working conditions are estimated at the lowest rate by nurses, average grade $R_{AVR} = 182.35$ (the scale was designed in such way that if the higher score is, the worse working conditions are), considerably worse comparing to physicians and diagnostics laboratory staff. Diagnostics laboratory staff rate their working conditions as higher, $R_{AVR} = 137.48$. Physicians evaluate their working conditions as highest, $R_{AVR} = 128.77$, however the difference between their appraisal of the working conditions and diagnostics laboratory staff appraisal is irrelevant.

4.2. Nuisance from factors in work environment

The assessment of nuisance from particular environmental factors proceeded according to scale from 1 to 5, where 1 means no effect of nuisance of a given factor, and 5 signifies the highest level of nuisance. Results were presented by means of average grade, which was accorded to each of the mentioned sources causing a discomfort of work. Among the factors set, the highest rate was given to noise annoyance in the work environment. Average rating of this source of nuisance in the workplace amounted to 2.02 in scale from 1 to 5. The remaining factors of the work environment able to constitute the source of nuisance obtained a much lower average grading. The surveyed employees also pointed to

such nuisance factors as: lighting – the average grade is 1.52, mechanical factors causing injuries (e.g. mobile machines and their components, slippery uneven surfaces) – the average grade is 1.37, microclimate – the average grade is 1.27, dusts and chemical substances – the average grade is 1.23, and odour – the average grade is 1.20. Respondents are to a lesser extent exposed to risk of such nuisance as mechanical vibrations (affecting arms or full body) – the average grade is 1.18 and optical radiation (UV, IR) – the average grade is 1.13.

4.3. Nuisance of noise sources in the workplace

According to the respondents, the source of noise causing the highest level of nuisance is the movement of persons inside the building – 51.5% indications. A very high percentage of respondents also pointed to such noise sources as: conversations (including phone calls) – 47.5%, ringing telephones – 42.9% and outdoor traffic (road, railway, air) – 40.9% indications. Subsequent factors such as technical installations of the building (e.g. air-conditioning, elevators), tools, devices as well as apparatuses and medical equipment were indicated by 32.9% and 29.2% of the respondents respectively. Other sources of noise being some sort of nuisance also include: machines and appliances located outdoors (e.g. transformers, wind turbines) – 28.2%, alarm bells – 22.9% and lighting – 19.2% indications.

4.4. Noise annoyance nuisance in the workplace

The crucial issue, which formed the basis for further in-depth analyses necessary for the determination of the correlation between a subjective risk assessment of noise in the workplace, its circumstances and experienced ailments was indication of noise annoyance in the workplace. Each of the respondent made a subjective assessment of noise annoyance by using the scale from 0 to 10, where lower values stand for no annoyance, higher values denote very burdensome noise. The average grading of noise nuisance in the workplace in scale from 0 to 10 was 2.77, and hence the noise annoyance was assessed as slightly. According to data, nurses are those, who assess noise nuisance in the workplace at the highest degree. The average grading in case of nurses equalled 3.47, among diagnostics laboratory staff – 2.37, however among physicians – 2.30.

Based on data, it needs to be ascertained that there is the correlation between an occupational group and noise nuisance in the workplace $\chi^2 = 106.839$; $p < 0.001$. The correlation is weak – coefficient $\text{Eta} = 0.284$ (Table 3).

Table 3. Noise nuisance in the workplace – statistical tests

Chi-squared tests			
Parameter	Value	df	Asymptotic relevance (bilateral)
Pearson's Chi-squared test	106.839 ^a	16	0.000
Likelihood ratio	122.134	16	0.000
Linear relationship test	6.638	1	0.010
N key observations	301		
Directional measures			
			Value
Nominal by Sectional	Eta	Dependable variable Noise annoyance in the workplace	0.284
		Dependent variable Group	0.471
Symmetric measures			
		Value	Approximate relevance
Nominal by Nominal	Phi	0.596	0.000
	Kramer's V	0.421	0.000
N key observations		301	

The ANOVA non-parametric test for Kruskal-Wallis ranks showed that there is a difference in the assessment of noise nuisance in the workplace in relation to respective occupational groups $\chi^2 = 27.77$; $p < 0.001$. The comparison by pairs was made with an application of post-hoc Dunn's test for the professional groups. Material differences were noted between physicians and nurses ($p < 0.001$) and between diagnostics laboratory staff and nurses ($p = 0.012$).

Noise annoyance in the workplace is the most closely felt by nurses, average grade $R_{AVr} = 182.95$ (scale was designed in such way that if the higher score is, the higher nuisance is). Noise in the workplace is less inconvenient to diagnostics laboratory staff $R_{AVr} = 132.57$ and to physicians $R_{AVr} = 129.27$.

5. Statistical analysis

In order to show the correlation of noise annoyance in the workplace with other working conditions, Spearman's analysis of the correlation has been made for all respondents (see Table 4). The analysis of the individual quantitative and ordinal variables for experiencing arduousness of noise in the workplace has been presented below.

First of all, a statistical relevance was analysed. If it is lower than 0.050 it means that a given variable significantly correlates with nuisance grading. In such case, additionally the correlation coefficient was taken into consideration – the correlation coefficient takes values from “-1” to “+1”. The correlation is stronger, if the value of correlation coefficient will be further from 0.

Positive values denote that with the raising value of a single variable, the other’s value increases, and negative values vice versa – with the rise in value of a single variable, it decreases. Considering foregoing information, it arises that a strong dependence concerns working hours on a daily and weekly basis, and sensation of noise and the duration of work in the place of employment. The longer daily/weekly working time, the noise annoyance is higher. Then, the longer job seniority in a particular place of employment, the noise annoyance is lower. The statistically significant scores are highlighted in red (Table 4).

Table 4. Noise annoyance and the number of working hours and job seniority – statistical tests

Spearman’s Rho		Age	How many hours a week do you work? open-end question	How many hours a day do you work? open-end question	How long have you been working in your profession/place of employment (years)? open-ended question
Noise annoyance in the workplace	Correlation coefficient	0.019	0.687**	0.687**	-0.176**
	Relevance (bilateral)	0.749	0.000	0.000	0.002
	N	301	301	301	301

The correlation of noise annoyance in the workplace with other working factors, well-being and health conditions is presented in the Table 5. The statistically significant scores are highlighted in red.

Table 5. Analysis of correlation of the noise annoyance in the workplace with other working factors, well-being and health conditions

Working factor, well-being and health conditions (question)	Spearman's Rho		
	Noise annoyance in the workplace		
	Correlation coefficient	Relevance (bilateral)	N
How much time do you work in the above-assessed noise?	-0.081	0.163	301
How do you assess your working conditions?	0.709	0.000	301
Mechanical vibrations (affecting arms and full body)	0.204	0.000	301
Noise	0.686	0.000	301
Lighting	0.402	0.000	301
Microclimate	0.423	0.000	301
Optical radiation (UV, IR)	0.247	0.000	301
Mechanical factors causing injuries (e.g. mobile machines and their components, slippery uneven surfaces)	0.095	0.099	301
Dusts and chemical substances	0.377	0.000	301
Odour	0.245	0.000	301
Tools, devices, apparatuses and medical equipment	0.437	0.000	301
Lighting fixtures	0.469	0.000	301
Technical installations of the building (e.g. air-conditioning, elevators)	0.624	0.000	301
Alarm bells	0.342	0.000	301
Ringling telephones	0.366	0.000	301
Conversations (including talks on the phone)	0.563	0.000	301
Movement of persons inside the building	0.699	0.000	301
Machines and appliances located outside the building	0.607	0.000	301
Transformers, wind turbines	0.587	0.000	301
Lighting arduousness in the workplace	0.751	0.000	301
How long do you work in the conditions of the above-assessed lighting?	0.123	0.033	301
Microclimate annoyance in the workplace	0.338	0.000	301
How long do you work in the above-assessed micro-climate?	0.031	0.590	301
I need a complete silence to sleep well at night	-0.324	0.000	301
I need quiet surrounding to work on new tasks and assignments	0.027	0.640	301
When I am at home, I get accustomed to prevalent noise quickly	0.411	0.000	301
I grow really upset when I hear someone talking while I strive to fall asleep	-0.269	0.000	301
I am very sensitive to noisy sounds from the neighborhood	-0.351	0.000	301
When people are loud around me, I cannot concentrate on my work	-0.045	0.438	301

Working factor, well-being and health conditions (question)	Spearman's Rho		
	Noise annoyance in the workplace		
	Correlation coefficient	Relevance (bilateral)	N
I am sensitive to noise	-0.420	0.000	301
My efficiency is considerably lower in noisy surroundings	-0.110	0.058	301
I do not feel well-rested if the preceding night had been noisy	-0.219	0.000	301
I do not mind living by the noisy street	0.446	0.000	301
I am able to accept other discomforts for a quiet place of residence	-0.394	0.000	301
I need peace and quiet to fulfill challenging tasks	0.075	0.195	301
I can fall asleep despite an occurring noise	0.290	0.000	301
How do you assess the general state of your health?	0.450	0.000	301

6. Conclusions

Noise is present in the workplace of almost all nurses (98.3%) and diagnostics laboratory staff (90.0%) and for the majority of physicians (68.9%). For physicians, to a greater extent than in the case of other professional groups, the source of noise is the medical activities performed (e.g. the use of surgical instruments). For nurses, to a greater extent than for other groups, the source of noise is technical installations/devices (e.g. air conditioning, lighting fixtures), noise penetrating from other rooms or corridors, conversations of staff or patients and noise penetrating from outside the building to the room. However, for diagnostics laboratory staff, more than for other groups, the source of noise are the drive systems of tools, equipment, medical devices. It was found that nurses assess noise annoyance in the workplace at the highest nuisance. The average rating of its nuisance on a scale of 0 to 10 (lower values mean noise that is not burdensome or not burdensome, higher values are very annoying noise) is small and amounts to 2.77, while in the case of nurses it is 3.47, and in the case of diagnostics laboratory staff and physicians it is 2.37 and 2.30 respectively.

On the basis of the obtained results it was found that the statistically significant correlations with positive direction of noise annoyance in the workplace with individual operating conditions occur for the following variables:

- assessment of the working conditions $Rho = 0.709$; $p < 0.001$;
- environmental factors being the source of annoyance:

- mechanical vibrations (affecting arms and full body) $Rho = 0.204$; $p < 0.001$,
- lighting $Rho = 0.402$; $p < 0.001$,
- microclimate $Rho = 0.423$; $p < 0.001$,
- optical radiation (UV, IR) $Rho = 0.247$; $p < 0.001$,
- dusts and chemical substances $Rho = 0.333$; $p < 0.001$,
- odour $Rho = 0.245$; $p < 0.001$;
- frequency of noise sources annoyance:
 - tools, devices, apparatuses and medical equipment $Rho = 0.437$; $p < 0.001$,
 - lighting fixtures $Rho = 0.469$; $p < 0.001$,
 - technical installations of the building (e.g. air-conditioning, elevators) $Rho = 0.624$; $p < 0.001$,
 - alarm bells $Rho = 0.342$; $p < 0.001$,
 - ringing telephones $Rho = 0.366$; $p < 0.001$,
 - conversations (including talks on the phone) $Rho = 0.563$; $p < 0.001$,
 - movement of persons inside the building $Rho = 0.699$; $p < 0.001$,
 - transformers, wind turbines $Rho = 0.587$; $p < 0.001$;
- lighting annoyance in the workplace $Rho = 0.751$; $p < 0.001$;
- working time in conditions related to lighting $Rho = 0.123$; $p = 0,033$;
- microclimate annoyance in the workplace $Rho = 0.388$; $p < 0.001$;
- sensitivity to noise – “*When at home I get accustomed to noise around quickly*” $Rho = 0.411$; $p < 0.001$;
- sensitivity to noise – “*I do not find it annoying to live by the noisy street*” $Rho = 0.446$; $p < 0.001$;
- sensitivity to noise – “*I am able to fall asleep despite the noise*” $Rho = 0.290$; $p < 0.001$;
- overall evaluation of health condition $Rho = 0.450$; $p < 0.001$.

On the basis of the obtained results it was found that the statistically significant correlations with negative direction of noise annoyance in the workplace with individual operating conditions occur for the following variables:

- necessity to raise voice at work $Rho = -0.253$; $p = 0.022$;
- sensitivity to noise – “*I need a complete silence to sleep well at night*” $Rho = -0.324$; $p < 0.001$;
- sensitivity to noise – “*I grow very annoyed when I hear someone talking when I try hard to fall asleep*” $Rho = -0.269$; $p < 0.001$;

- sensitivity to noise – “*I am very sensitive to noises coming from the neighbour area*” Rho = -0.351; p < 0.001;
- sensitivity to noise – “*I am sensitive to noise*” Rho = -0.420; p < 0.001;
- sensitivity to noise – “*I do not feel well-rested if the previous night had been noisy*” Rho = -0.219; p < 0.001;
- sensitivity to noise – “*I am able to accept other inconveniences for a quiet place of residence*” Rho = -0.394; p < 0.001.

Acknowledgements

This publication has been based on the results of:

- the fourth stage of the program “Safety and working conditions improvement”, co-funded in the years 2017 – 2019 within the capacity of the governmental services by the Ministry of Family, Labour and Social Policy; the main coordinator: Central Institute for Labour Protection – National Research Institute
- a research task carried out within the scope of the fifth stage of the National Programme “Improvement of safety and working conditions” supported within the scope of state services by the Ministry of Family, Labour and Social Policy, task no. 3.SP.10 entitled “Ensuring integration with European networks active in the field of occupational safety”. The Central Institute for Labour Protection – National Research Institute is the Programme’s main coordinator.

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