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ANALYSIS OF CLINICAL SIGNS OF NOISE EXPOSURE ON HUMAN HEALTH IN PLANTS WITH HIGH EXPOSURE TO NOISE

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ABSTRACT: *If a person continuously listens to a faint, barely audible sound for a lengthy period of time, after a while he stops perceiving it because his hearing adapts to this stimulus. If the sound is louder, it is still perceived, however at a reduced level. Long-term exposure to excessive noise can cause hearing impairment along with the damage or destruction of sensory cells of the inner ear. This paper describes clinical symptoms of the noise impact on human health using Pareto's analysis, which gives an insight into the nature of the problem and enables to distinguish between vital causes and those that are less important.*
KEYWORDS: *noise, clinical signs, noise exposure, Pareto analysis*

INTRODUCTION

Acoustic wave motion is part of the physical fields surrounding a person and affects the human body, influences the health and well-being of the person, his behaviour, activities, efficiency and physiological comfort.[6, 7] Noise as a factor of the work environment is one of the most significant bio-negative factors within the living environment of a civilized individual. [1]

Exposure to noise at work can result in health problems among many employees relating to noise-induced hearing disorders.[5] In the last decades of the 20th Century the number of newly registered occupational diseases diagnosed as „noise-induced hearing impairment" repeatedly exceeded 200 cases per year. Due to the adoption of new legislative measures to provide protection of employees from noise, this number decreased dramatically to 47 cases annually.

Noise also has also an impact on:

- *Hearing organ: functional reduction of auditory ability to recognize sounds, temporal reduction of hearing (short-term noise exposure), organic damage of the inner ear sensory cells (long-term noise exposure), damage of the eardrum (most often of a permanent character), tinnitus (buzzing in the ears),*
- *Vegetative system: an increase of blood pressure, heart rate (dizziness), deeper and faster breathing (breathing problems),*
- *Nervous system: weakening of inhibition in the cerebral cortex, decrease in the depth of sleep, sleep disorders, migraine (headaches), higher susceptibility to cramps,*
- *Motor activity and psychic activity: impairment of sensory reactions, impairment of the perception of vibrations, worsening perception of colours (deterioration of eyesight), increase of muscle tone, functional disorder of emotional balance.*
- *Metabolism: changes in the amount of sodium and potassium in plasma, changes in the sugar and adrenalin level in the blood.*

Short-term exposure to noise of excessive intensity may cause acoustic trauma [4] which is considered as occupational injury.[2] Long-term intensive noise results in a temporary shift of the auditory threshold and only later at noise levels higher than 85 decibels, a permanent threshold shift occurs causing occupational hearing loss.[4] The main cause of occupational hearing loss is degenerative damage and even completes destruction of sensory cells of the hearing organ due to subsequent disorder of other inner ear elements.[10] Prolonged exposure to excessive noise that may cause occupational hearing loss can be found in forges, saw mills, engine test rooms, airports and also there where power saws, pneumatic tools or other noisy machinery are used. [2, 14]

The symptoms of acoustic trauma [4] are feelings of fullness, pressure of pain in the ear and incessant ringing in the ears, also known as tinnitus. The symptoms may go away minutes or days after the exposure to noise ends and then the hearing returns to normal (tinnitus may be permanent).

Noise-induced hearing disorder results from repeated exposure of hearing analyzer to excessive noise. This disorder is usually gradual and develops over a period of several years; it is not immediately perceivable by the person affected as it starts at high frequencies which for communication by speech are not too significant. Progressive loss of hearing is first noticed by the person only in the period when the frequencies are affected which for speech recognition are important. [9]

PARETO ANALYSIS

Pareto analysis is one of the most effective easily applied statistical decision making techniques used to separate the important (vital) causes of problems from less important (insignificant) ones. Pareto method is often called 80/20 rule according to which 80% of the problems are produced by only 20% of causes.

Each cause can be identified in several ways, e.g. in terms of absolute frequency of individual causes, by cost (financial losses) or establishing the significance of causes (e.g. according to their importance and effect on the human body), etc. If weight is assigned to these causes, it is the so-called weighted Pareto analysis.

A graphic tool of the analysis is a bar graph of absolute frequencies or relative frequencies, prevalence of individual causes. This graph is called Pareto chart (Pareto graph) where a Lorenz curve is drawn which gives the cumulative relative frequencies of individual causes /in %). The detailed analysis of causes should usually consider the causes with cumulative frequency from 0 to 80%. [12, 13]

ANALYSIS OF CLINICAL SIGNS OF EXPOSURE TO NOISE

The analysis of clinical signs was performed based on the data of medical preventive examinations. The input criterion for incorporating into the database was work in a risky environment and time of working in such an environment for minimum 5 years. A group of 47 patients (43 men and 4 women) were chosen for the database that worked or work in workplaces with high exposure to noise.

The average age of the patients was 63.6 years and the average time of exposure almost 28 years. Basic statistical characteristics of the sign such as patient's age (years) are given in Table 1.

Table 1. Characteristics of patient's age and exposure time

Patient's age (years)			Exposure time (years)		
Arithmetic average	Maximum	Minimum	Arithmetic average	Maximum	Minimum
63,6	83	45	27.9	43	10

19 patients (40.4%) were in the 50 to 60 age group and approximately the same numbers (17 patients, 36.2%) were in the 60 to 70 age group. One of the patients was younger than 50 years of age and 10 patients (21.3%) were older than 70.

The time of exposure was determined in each patient (Table 2) as well as their occupations using the International Standard Classification of Occupations ISCO-80.

Table 2. Exposure time

Exposure time	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
Number of patients	1	2	7	7	11	8	9	2
Number of patients (%)	2.1	4.3	14.9	14.9	23.4	17.0	19.2	4.3

In the group of 47 patients, 57.4% (27) worked or work in occupational category 72 (moulders and ironmasters, welders), 53.2% (25) in the category 93 (workers in mining and quarrying of mineral raw materials), 23.4% (11) in the category 83 (lorry and truck drivers, operators of cranes and lifting devices, etc. 21.3% in the category 75 (wood processors, carpenters, sewing machine operators, etc.).

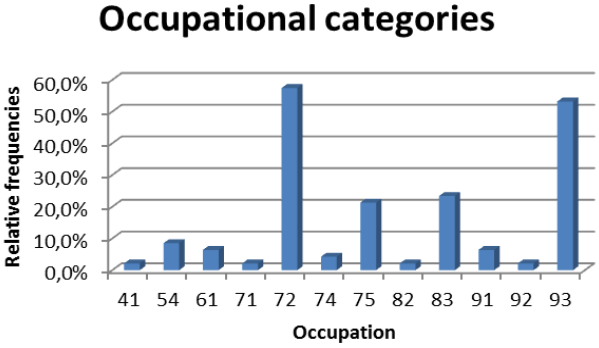

Figure 1. Occupational category according to ISCO-80

The diagnosed clinical signs of exposure to noise were divided into eleven groups: P0 - impairment of hearing, P1 - dizziness , P2 - buzzing and ringing in the ears, P3 - impairment of sight , P4 - headaches, P5 - breathing problems, P6 - join pain of upper and lower limbs, P7 - tingling of hands, P8 - cramps of lower limbs , P9 - excessive sweating , P10 - change of skin colour.

The analysis showed that all the patients have impaired hearing. As many as 76.6% (36 patients) complained of buzzing and ringing in the ears (P2) and 70.2% (33 patients) suffer from tingling of hands (P7). Percentual distribution of other signs is given in Table 3.

Table 3. Diagnosed clinical signs

Signs	P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Number of patients	47	11	36	8	11	31	29	33	3	6	21
Number of patients (%)	100	23.4	76.6	17.0	23.4	66.0	61.7	70.2	6.4	12.8	44.7

The signs are grouped according to the absolute frequencies of their prevalence as well cumulative absolute frequencies and cumulative relative frequencies which are given in Table 4.

Table 4. Frequency table for creating a Pareto chart

Sign code	Frequency	Cumulative absolute frequency	Cumulative relative frequency
P0	47	47	19.9%
P2	36	83	35.2%
P7	33	116	49.2%
P5	31	147	62.3%
P6	29	176	74.6%
P10	21	197	83.5%
P1	11	208	88.1%
P4	11	219	92.8%
P3	8	227	96.2%
P9	6	233	98.7%
P8	3	236	100.0%

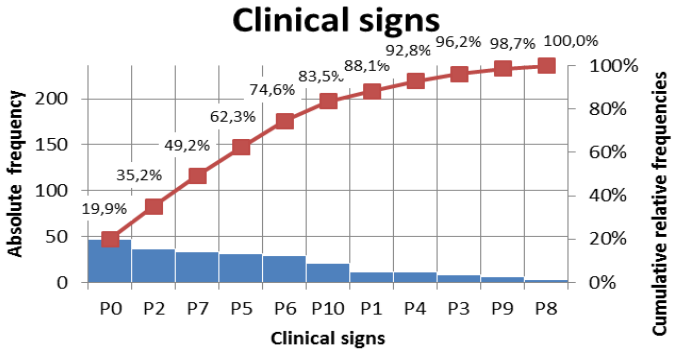

Figure 2. Pareto chart - signs without weight

Table 4 and the Pareto chart (Fig. 2) show that more than 83 percent of all recorded problems in 47 patients are caused by six signs: P0, P2, P7, P5, P6 a P10.

Each sign of exposure to noise in the work environment was assigned a weight according to the seriousness and effect on the human body. The signs are grouped according to the weighted frequencies of their prevalence as well cumulative absolute frequencies and cumulative relative frequencies which are given in Table 5.

Table 5. Frequency table for creating Pareto chart - signs with weights

Sign code	Frequency	Weight	Weighted frequency	Cumulative absolute frequency	Cumulative relative frequency
P0	47	5	235	235	27.3%
P2	36	5	180	415	48.2%
P5	31	4	124	539	62.6%
P7	33	3	99	638	74.1%
P6	29	3	87	725	84.2%
P10	21	2	42	767	89.1%
P1	11	3	33	800	92.9%
P3	8	3	24	824	95.7%
P4	11	2	22	846	98.3%
P8	3	3	9	855	99.3%
P9	6	1	6	861	100.0%

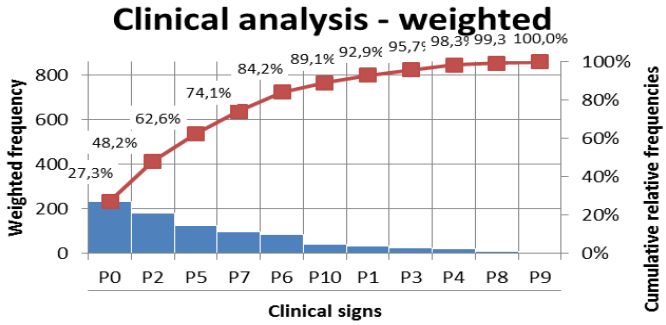

Figure 3. Pareto chart - signs with weights

Table 5 and Pareto chart (Fig. 3) show that more than 84 percent of all the recorded problems in 47 patients are caused by five signs: P0, P2, P5, P7 a P6.

From the records it is apparent that two patients have nine, other two patients have eight signs. Seven clinical signs were diagnosed in five patients. A more detailed listing of the numbers of signs is given in Table 6.

Table 6. Number of diagnosed signs

Number of signs	2	3	4	5	6	7	8	9
Number of patients	4	6	8	10	10	5	2	2
Number of patients (%)	8,5	12,8	17,0	21,3	21,3	10,6	4,3	4,3

CONCLUSIONS

Through monitoring of the diagnosed clinical signs of exposure to noise and its effects on human health as well as using a weighted Pareto chart it was found out that more than 84% of the recorded health problems were caused by five signs: impairment of hearing, buzzing and ringing in the ears,

breathing problems, tingling of hands and join pain of upper and lower limbs. A similar result was also obtained in the case of the analysis of signs without determining weight according to the level of seriousness and effect on the human body. It is important to be aware of the fact that the issue of assessment and evaluation is very complicated and therefore there exist a lot of different approaches to tackle the problem. The technique of assessment of clinical signs presented by the authors in this paper is one of the possible solution methods of this problem available. The results presented here are based on the authors' practical experience in this area.

The hearing organ is able to adapt to noise, but over time this ability decreases. Deterioration of the hearing organ can occur just after a few weeks or several years. Individual's exposure to noise and perception of the noise levels are different. There are people who are insensitive to noise and exhibit no signs of damage working in high level noise environment. Some people are sensitive to a certain type of noise or certain levels of noise. In assessment of noise in the person' s work environment it is necessary to determine what type of workplace it is, the types of machinery and equipment used at work, how much protection against noise is provided, what is the technical condition of the machines and equipment used, etc. Measurement of the noise helps to determine to which noise levels a worker in the given workplace exposed is. [3]

The method of noise assessment and the highest allowable levels of noise in the work environment are defined in the regulations on the protection of human health against noise or technical standards separately for common audible noise, infra noise, ultra noise, high-frequency noise and low-frequency noise. [5]

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REFERENCES

[1] ROVNÝ, I., A KOL. 1995. Preventívne lekárstvo: Učebnica pre stredné zdravotnícke školy. Vydavateľstvo Osveta, 1995. ISBN 80-217-0574-4.
[2] PELCLOVA, D. A KOL. 2006. Nemoci z povolání a intoxikace: Učební texty univerzity Karlova v Praze. Nakladatelství Karolinum. Praha 2006. ISBN 80-246-1183-X.
[3] LUMNITZER, E., BADIDA, M., ROMANOVÁ, M, 2007. Hodnotenie kvality prostredia. Elfa s.r.o., Košice 2007. ISBN 978-80-8073-836-5.
[4] BUCHANCOVÁ, J. A KOL. 2003. Pracovné lekárstvo a toxikológia. 1. Slovenské vydanie. Vydavateľstvo Osveta, spol. s.r.o., Martin 2003. ISBN 80-8063-113-1.
[5] HATINA. T. A KOL. 2007. Encyklopedický súbor bezpečnosti a ochrany zdravia pri práci. Inštitút pre výskum práce a rodiny. Bratislava 2007. ISBN 978-80-7138-124-2.
[6] ŽIARAN, S. 2008. Ochrana človeka pred kmitaním a hlukom. Slovenská Technická univerzita v Bratislave. Vydavateľstvo STU v Bratislave, Bratislava 2008. ISBN 978-80-227-2799-0.
[7] ŽIARAN, S. 2001. Kmitanie a akustika: Ochrana človeka pred kmitaním a hlukom. 1. Vydanie. Vydavateľstvo STU v Bratislave, Bratislava 2001. ISBN 80-227-1607-3.
[8] JANOUŠEK, M. 2005. Obmedzte hluk! Zásady BOZP pri práci v hluku. Pravidlá dobrej praxe. Národný inšpektorát práce. EuropeanAgencyfor Safety and Heathat Work. Publikácia 12. ICOP Košice 2005. ISBN 80-968834-7-X.
[9] HAVRÁNEK, J. A KOL. 1990. Hluk a zdrví. Avicentrum. Zdravotnické nakladatelství, Praha 1990. ISBN 80-201-0020-2.
[10] KUBÍK, Š. A KOL. 1976. Hluk na pracovisku a jeho odstraňovanie. II. doplnené vydanie. Praha. Vydavateľstvo a nakladateľstvo ROH, Bratislava 1976. ISBN 74-022-76.
[11] NV SR č.115/2006. Z.z. o minimálnych zdravotných a bezpečnostných požiadavkách na ochranu zamestnancov pred rizikami súvisiacimi s expozíciou hluku.
[12] CHAJDIAK, J. 1998. Štatistické riadenie kvality. Statis, Bratislava 1998. ISBN 80-85659-12-3.
[13] NENADÁL, J. 2008. Moderní management jakosti. Management Press, Praha 2008. ISBN978-80-7261-186-7.
[14] Rusko, M: Safety and environmental management, Žilina: Strix, environmental science - 7, 4. revised edition. 2010, ISBN 978-80-89281-58-9. 335p.
[15] BADIDA, M., ANNOVÁ, J., LUMNITZER, E., KISS, I. 2010. Evaluation of hearing loss of human in working condition using audiometrical measurements. Annals of Faculty Engineering Hunedoara: international journal of engineering. Vol. 8, no. 2. 2010. p. 141-144. - ISSN 1584-2665

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