The knowledge of medical staff on the impact of noise on neonatal intensive care units patients and its application in practice.

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Abstract

Noise is an undesirable environmental factor whose control and reduction should be standard in every Neonatal Intensive Care Unit. Its impact can have negative effects on both the mental and physical health of the body. Newborns, especially premature infants, are particularly sensitive to the negative effects of noise. The negative impact of noise can be reduced through appropriate behaviour of the medical staff.

Aim. The aim of the study is to analyse the knowledge of medical staff on the impact of noise on newborns staying in Neonatal Intensive Care Units and to evaluate its use in practice.

Methods. A total of 104 respondents working in neonatal wards participated in the study. The survey was conducted online using social media. The study employed the diagnostic survey method with a self-designed questionnaire. The first part of the questionnaire concerned the aspects of knowledge on the impact of noise on hospitalised newborns; the second part addressed the socio-demographic issues of the medical staff.

Results. Training on noise exposure for newborns is not common in the workplace. There are no recommendations regulating noise standards and control equipment. The surveyed individuals do not have in-depth knowledge about acceptable noise levels in newborn rooms. Only one in three employees was able to provide the correct answers in this regard. Older employees with longer experience and residents of large cities scored higher in knowledge than younger individuals. Those with a higher level of knowledge and satisfaction with their work and earnings show the greatest care in reducing noise intensity in the ward.

Conclusions. In neonatal pathology wards and (NICUs), noise standards and recommendations are more common than in physiology wards. Employees caring for newborns need training on the sources and impact of noise on babies. It is necessary to limit the noise generated by the staff, such as loud conversations, slamming furniture, placing objects on incubators, or moving equipment.

Keywords: Noise, Newborns, Neonatal Intensive Care Unit (NICU)

Introduction

Noise is sound of excessive intensity, which humans perceive as "pointless, then annoying, unpleasant, annoying, and finally harmful" (Wydanie zbiorowe, 2022). Its impact can have negative effects on both the mental and physical health

of the body. There is no doubt that noise is an undesirable environmental factor that should be reduced to the lowest possible level. The degree of impact of sounds on an individual depends on parameters such as intensity, duration, frequency, age, clinical condition, level of sensitivity, and fatigue (Natarajan et al., 2023). Newborns in Intensive Care Units are particularly sensitive to the negative impact of noise. This is especially true for prematurely born children, who are characterised by high multi-organ immaturity. Adaptation to extrauterine life is a real challenge for them. Attention is drawn to the fact that noise not only affects the current clinical condition of the newborn but can also have long-term effects on their health. After birth, newborns are able to distinguish the voices of their mother and loved ones from those they are encountering for the first time. Recognition of sounds from the external environment, with which the fetus was stimulated during pregnancy (e.g., music), can be observed. This means that the newborn can identify the pitch, intensity, and rhythm of noises. An auditory memory is formed at this time, making the baby less sensitive to sounds (Graven & Browne, 2008; Pino, 2016; Movalled et al., 2023). Babies born prematurely do not have the chance to create such auditory memory. Their maturing auditory system is stimulated by the ICU environment, which generates louder and high-frequency sounds that are not attenuated by amniotic fluid (Lehman & Królak-Olejnik, 2019; Lahav, 2015).

A newborn staying in a ward is exposed to noise generated by the daily functioning of such a place. Noise is generated by all equipment and by the work and communication of staff. It is important to reduce noise to the minimum necessary. This can be achieved through appropriate behaviour among medical personnel. The formation of appropriate habits must be based on a high level of knowledge. Raising awareness can be done through appropriate training, as well as procedures implemented in hospitals. Among the most commonly stigmatised actions of staff members are loud talking, laughing, putting objects down from above the incubator, and slamming incubator doors and ward furniture (Cedrowska-Adamus & Gulczyńska, 2018; Das et al., 2023). The reason for such behaviour may be not only lack of knowledge, but also routine, exhaustion, or professional burnout.

According to the recommendations of the AAP (American Academy of Pediatrics), the average sound level during the day in a newborn's room should be between 40 - 45 dB, while at night it should be up to 35 dB. Instantaneous, transient sounds should not exceed the 65 dB limit (White et al., 2013). However, studies (Parra et al., 2017; Cepuch et al., 2019) indicate that these standards are clearly exceeded. The highest intensity of sounds is recorded between 8:00 a.m. and 12:00 p.m., which coincides with the time when most medical procedures are performed. Instantaneous transient sounds reach as high as 65.4 - 97 dB inside the incubator, which can be compared to the operation of a vacuum cleaner or even a lawnmower (Parra et al., 2017). The sounds generated in the Neonatal Intensive Care Unit are not indifferent to the health and development of patients. The effects of noise can be divided into short-term and long-term. The former group manifests itself in changes in the neonate's clinical condition and reactions during hospitalisation, while the latter manifests itself as developmental disorders and hearing loss. The

impact of excessive sound is observed primarily in the sphere of neurological development and brain structures. The risk is greater the lower the gestational age of the newborn and is associated with the length of stay in the ward. The most common changes include a reduction in brain volume, abnormalities in the white matter microstructure, and abnormalities in cognitive development (Lehman & Królak-Olejnik, 2019). Noise also leads to a number of changes in the endocrine system: cortisol and blood glucose levels increase. Its impact accelerates the heart rate, raises blood pressure, slows intestinal peristalsis, and disrupts the diurnal rhythm of sleep and wakefulness (Wachman & Lahav, 2011).

Ensuring adequate acoustic conditions is challenging, but certain measures can significantly facilitate this task. Therefore, it is important to train staff and raise their awareness of the impact of noise on newborns. Providing adequate knowledge and displaying posters reminding people of the dangers of excessive noise can help prevent routine activities that generate excessive noise. Additionally, considering the use of a meter that continuously monitors sound levels can make it easier for staff to maintain appropriate silence levels.

Aim of the study

The purpose of this study was to analyse the knowledge of medical personnel regarding the impact of noise on neonates in Neonatal Intensive Care Units (NICUs). Additionally, the study aimed to evaluate the following:

- The influence of selected variables such as age, education, and place of residence on the level of knowledge about the impact of noise on newborns.
- The influence of place of work and seniority on the level of knowledge about the impact of noise on newborns.
- The correlation between the variables studied.

Materials and methods

The survey was administered to a group of 104 medical professionals working in neonatal wards. It was distributed to participants via social media platform Facebook. The survey utilised a diagnostic survey method, employing a questionnaire of our own authorship consisting of two parts. The first part comprised closed questions pertaining to staff training, ward equipment, as well as knowledge of the impact of noise on neonates hospitalised in the Neonatal Intensive Care Unit (NICU) and the application of this knowledge in practice. The second part, known as the "metric," included questions regarding sociodemographic data such as age, gender, place of residence, occupation, education, as well as the ward in which the respondent works and length of service. A reliability analysis of the test was conducted using Cronbach's Alpha statistic, which yielded a value of 0.806, demonstrating adequate reliability. The collected data underwent statistical analysis in Excel and Statistica v.13. Student's t-test (test for independent samples) was employed for the characteristics of the dis-

tributions of the studied variables. Calculations were performed for levels of statistical significance at $p < 0.05$ and $p < 0.1$.

Results

The respondents who participated in the survey were predominantly women (99%). The age range of the respondents varied from 21 to 58 years, with an average age of 36 (Table 1). The surveyed group was predominantly composed of individuals with higher education qualifications, with 35% holding a bachelor's degree and 48% holding a master's degree.

Table 1. Age of respondents

Table 1
Age of respondents

Age	% N	N
from 25 years	19,2%	20
26-35 years	38,5%	40
36-45 years	18,3%	19
46 and more	24,0%	25

Those who participated in the survey were primarily midwives/midwives (70) or nurses/nurses (26). Physicians comprised a smaller group of eight respondents. The majority of the respondents were employed in the neonatal intensive care unit (Table 2).

Table 2
Respondents' place of work

Department	% N	N
neonatal physiology	14,4%	15
neonatal pathology	23,1%	24
neonatal intensive care	62,5%	65

From the statements of respondents, it appears that training on the impact of noise on newborns is not common in the workplace. Additionally, this topic is not adequately discussed during teaching or education. Nearly all respondents expressed the need for such training (98%). Employees' knowledge of noise standards and recommendations for acceptable levels in the ward varied greatly depending on the workplace (Fig. 1).

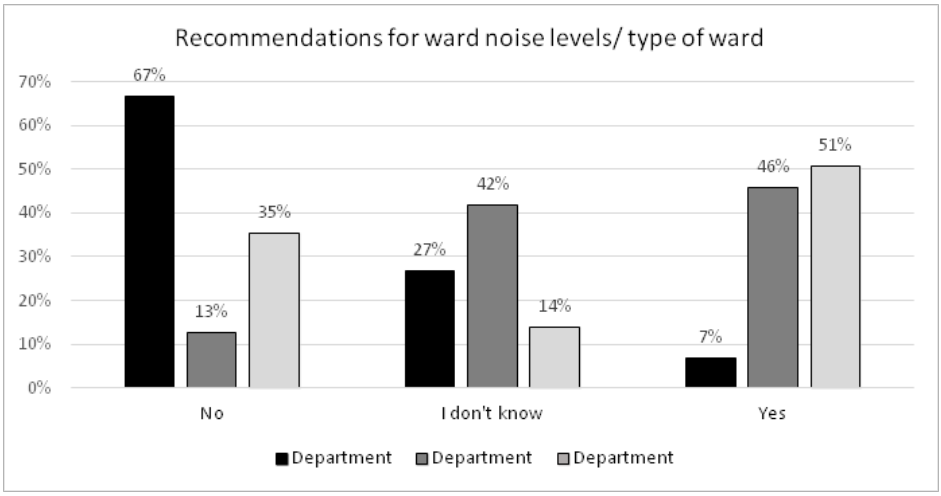

Figure 1
Recommendations for ward noise levels/type of ward

Among the respondents, the vast majority declared that there were no noise meters in the workplace that would visually indicate if sound intensity limits were exceeded (see Fig. 2). This lack of equipment was reported by a total of 86.5% of respondents. However, 66% of respondents acknowledged the usefulness of such a device.

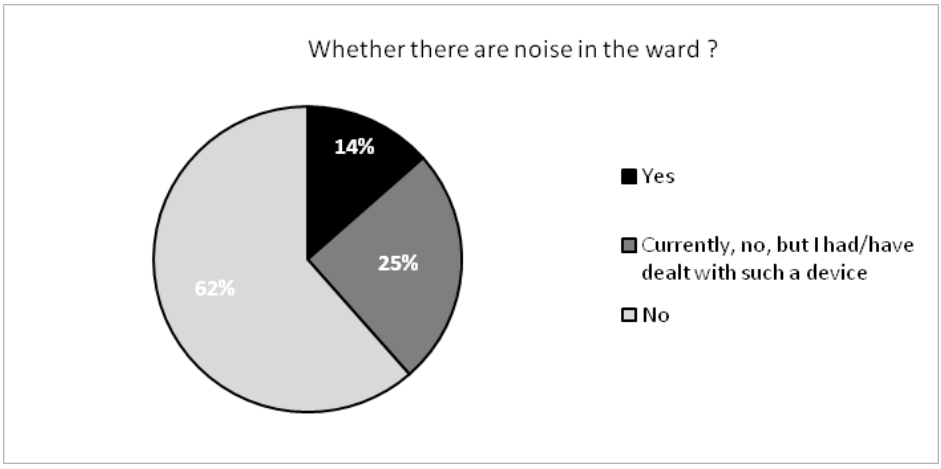

Figure 2
The presence of a noise meter in the ward

The vast majority of wards utilised incubator covers (always 63% or often 19%) and special nests made of soft material for newborns (always 67% or often 21%) as part of noise reduction strategies. These solutions were most frequently implemented in Neonatal Intensive Care Units compared to other wards

One of the goals of the survey was to assess the knowledge of medical personnel regarding the impact of noise on hospitalised newborns. Slightly more than a third of respondents were able to answer the question about the permissible maximum noise level in the newborn's room during the day without error. The percentage of those who indicated the correct answer to the question about the acceptable noise level in the neonatal room at night was even lower, at just 25%. However, the medical staff's knowledge of acceptable momentary and transient sounds in the newborn room fared slightly better. In this case, almost 36% of respondents provided the correct answer (Fig. 3).

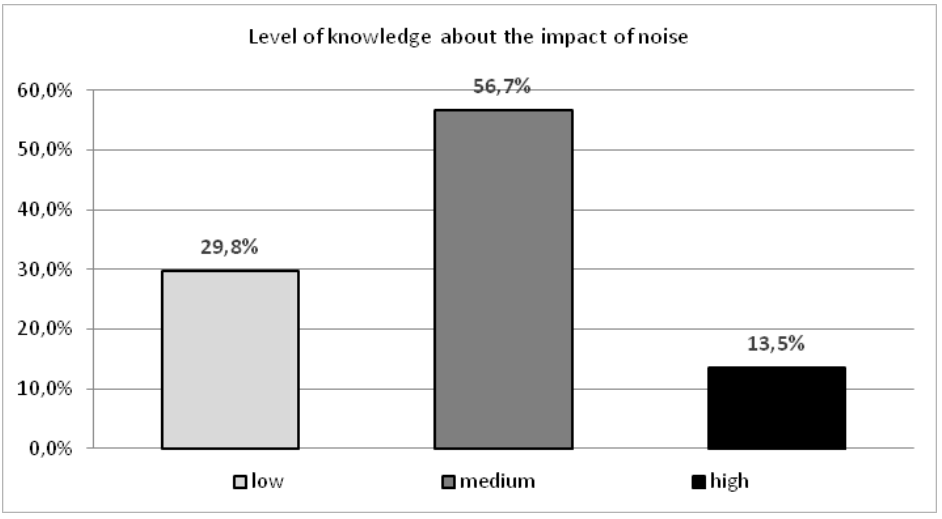

Figure 3
Respondents' level of knowledge about the impact of noise on newborns

Only 15% of survey participants demonstrated knowledge about the risk of hearing disorders in newborns hospitalised in Neonatal Intensive Care compared to healthy newborns. However, most respondents correctly identified the effects of noise on several areas, including increasing the secretion of cortisol, aldosterone, and catecholamines (98%), decreasing tidal volume and vital lung capacity (84%), and increasing sweating of the hands and feet in term newborns (82%). The factor that significantly differentiated staff knowledge was the type of ward in which the respondent worked (Fig. 4). Furthermore, older staff and those with longer work experience exhibited greater knowledge in this area. Notably, midwives and nurses with a master's degree provided the most correct answers regarding the impact of noise on newborns.

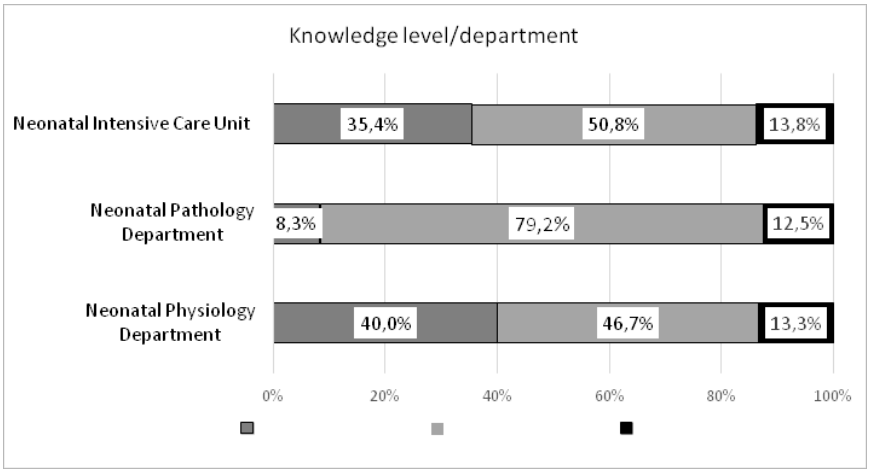

Figure 4
Knowledge of permissible noise levels/type of branch

The questionnaire also included questions on subjective assessment of behaviour related to maintaining appropriate noise levels in the hospital environment.

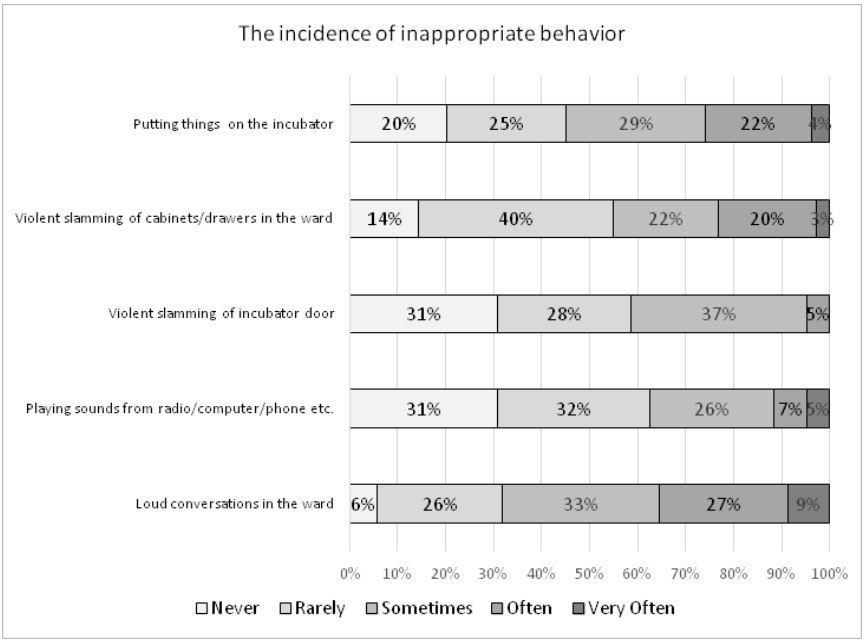

Figure 5
Self-assessment of the frequency of staff behaviour related to maintaining acceptable noise levels

According to the declarations of those surveyed, as many as 36% admitted that they sometimes talked loudly in the ward (often or very often), 26% acknowledged that they often or very often placed things on the incubator, and 23% reported slamming cabinets or drawers often or very often. However, 63% stated that they never or rarely played sounds from the radio, computer, or phone, and 59% indicated that they never or very rarely slammed the incubator door violently (Fig. 5). Interestingly, medical staff members who demonstrated a high level of knowledge about the effects of noise on newborns during the survey were far more likely than those with less knowledge to show care in reducing sound levels in the ward. This was evident in all areas diagnosed in the survey, indicating that staff members tended to put their knowledge into practice.

Noise in neonatal intensive care units is often generated by numerous pieces of equipment and alarms. It has been found that this not only negatively affects hospitalised patients but also impacts the medical staff themselves. Respondents admitted that they themselves struggle with fatigue and irritation caused by the large number of alarms and technical signals from equipment - as many as 68% indicated experiencing such inconveniences during their work in the unit.

Discussion

Caring for neonates hospitalised in Intensive Care Units poses a significant challenge for the entire treatment team. The goal is not only to treat conditions and defects or relieve pain but also to ensure optimal conditions of development similar to intrauterine life. This includes maintaining adequate temperature, lighting, and acoustic environment. However, achieving this task is extremely difficult, as it is impossible for a hospital room, filled with the necessary equipment and medical apparatus, to perfectly replicate or even resemble the environment known to newborns from fetal life.

The impact of noise on patients in Neonatal Intensive Care Units is an issue that has not received adequate attention in Poland. Among the publications (Lehman & Królak-Olejnik, 2019; Lahav, 2015; Cedrowska-Adamus & Gulczyńska, 2018; Cepuch et al., 2019; Slevin et al., 2000) on this subject, works in the English-language literature have a significant advantage. While some scientific research has been conducted in our country, it is limited to single articles. Additionally, only a few Polish neonatology wards are equipped with sound level monitoring devices. However, posters with information about noise in the ward environment and guidelines for minimising it are often visible.

According to several studies from different countries, acceptable sound intensity standards are consistently exceeded in NICUs. For instance, a study by Parra et al. (2017) found that neonates in intensive care are exposed to noise levels that far exceed American Academy of Pediatrics standards, particularly inside the incubator. The average sound intensity (Leq) during measurement periods was 60.4 dB, with an intensity of 62.1 dB occurring more than 10% of the time (L10), and the highest recorded value (Lmax) reaching 89.1 dB. This

exceeds the recommendations of 45, 50, and 65 dB, respectively. Similar findings were reported in the study by Krueger et al. (2005), where measurements from 9 areas of the NICU showed average Leq intensity of 60.44 dB, L10 of 59.26 dB, and Lmax of 78.39 dB.

In contrast, a study by Chang et al. (2006) revealed that more than 90% of noise is generated by people, with the loudest areas being where staff congregate, such as the nurses' counter, where the average sound level was 62 dB. In a self-reported survey, only slightly more than half of the respondents indicated that the NICU where they work has recommendations for noise standards. The remainder either stated that such guidelines do not exist or were not known by them. Therefore, it is essential to draw the attention of medical personnel to the negative impact of external factors on patient condition, raise their awareness, and monitor whether their knowledge adequately translates into actual conditions in the ward.

Reducing noise levels should begin with appropriate staff education. In our survey, only 16% of respondents indicated that the above issues were adequately discussed during their education, while 19% received on-the-job training. However, even such one-off training sessions can have a demonstrable benefit in reducing sound levels in the ward. A study by Incekar and Balci (2017) examined noise levels on different days and at different times, and then medical staff participated in training on how to reduce it. After the course, measurements were taken again, and the intensity of sounds was significantly lower in all measurement periods. The average difference in intensity levels ranged from 1.59 ± 7.05 dBA to 2.74 ± 6.04 dBA depending on the day and time of measurement. Similar studies were conducted in Canada by Wang et al. (2014) and in the US by Hull and Wright (2023). In these studies, noise levels were measured before and after the implementation of a noise reduction programme, and the measures applied had the intended effect of reducing sound intensity. In our own study, almost all respondents indicated that they felt the need to receive training on the impact of noise on newborns. This underscores the importance of providing education and training to medical staff in order to effectively reduce noise levels in neonatal care settings.

Our study revealed a statistically significant relationship between respondents' knowledge and selected sociodemographic variables, including age, place of residence, and place of work. Respondents belonging to the oldest age group with the longest work experience demonstrated a significantly higher level of knowledge in this regard compared to younger individuals. Therefore, it can be concluded that work experience significantly contributes to improving employee awareness. Interestingly, respondents from the youngest age group and with the least work experience were more likely to have a high knowledge score than others, although this difference was not statistically significant. This result may be attributed to recently completed education and the absence of entrenched work routines. Additionally, the survey found that residents of large cities were more likely to have a higher level of knowledge, likely due to easier access to higher-level training providers. A higher level of knowledge also correlated

with greater attention to reducing sources of noise, indicating that knowledge is indeed put into practice.

The presence of sound intensity meters that provide a visual signal of exceeding standards plays a significant role in reducing noise in intensive care units. In our own survey, only 13.5% of respondents reported the presence of such a device in their workplace, but a larger proportion (25%) had encountered such equipment in the past. According to Lehman and Królak-Olejnik (2019), about 30% of departments in Poland utilise such a noise control method. In a study by Wang et al. (2014), they compared sound intensity levels between a period where the meter did not provide visual signals when noise standards were exceeded, and a period where the meter illuminated red when the sound intensity was too high. The results showed a statistically significant increase in the periods of time when the noise level was below 50 dB in all areas where newborns were present.

Studies also demonstrate that the layout of rooms and care stations for newborns, as well as the conditions for transporting newborns, are of great importance in reducing noise levels (Aminudin et al., 2023). This issue has been highlighted by numerous authors (Kruszecka- Krówka & Cepuch, 2018; Cardoso et al., 2015; Pineda et al., 2017; Bergez et al., 2023). For instance, Chen et al. (2009) compared sound intensity levels in patients housed in incubators in single, enclosed rooms versus those in open, multi-station spaces. They found that the hourly average noise intensity in the multi-patient room was 50.8-57.2 dB, while in the single rooms it was 45.9-51.7 dB. The average difference between the areas was 4.5 dB. It is noteworthy that a 5 dB change in sound is clearly perceived by people, and a 10 dB increase in values is perceived as noise twice as loud. Additionally, the average values of L10 and Lmax in the open rooms significantly exceeded those of the single rooms. Similarly, Liu (2012) came to similar conclusions in his study, demonstrating that Lmin, L50, L10, and Leq measurements were lower in single rooms, and this difference was statistically significant. The exceptions were cases in which newborns were ventilated at high frequencies.

Analysing the results of our own research and comparing them with the findings of other authors from various countries, it is evident that insufficient attention is paid to creating an appropriate acoustic environment in Intensive Care Units (ICUs). To address this issue, several measures should be taken: 1. Appropriate education of medical personnel: Providing comprehensive training on the impact of noise on newborns and methods to reduce noise levels should be a priority. 2. Creation of appropriate guidelines: Developing clear guidelines and protocols for noise reduction in ICUs can help standardise practices and ensure consistent efforts to minimise noise.

Conclusions

- In neonatal pathology and neonatal intensive care units, standards and recommendations for noise reduction are more common than in neonatal physiology units.

- The highest level of knowledge about the impact of noise on newborns was demonstrated by those in the oldest age group and with the longest work experience.
- Those living in large cities have a higher level of knowledge in the area of the impact of noise on patients than the other respondents.
- The high level of knowledge in the field in question is used in practice and translates into the leveling of behaviour that generates harmful noise, such as loud conversations, playing sounds, slamming furniture, or putting objects on the incubator.

References

Aminudin, N., Franta, J., Bowden, A., Corcoran, J. D., El-Khuffash, A., McCallion, N. (2023). Noise exposure exceeded safe limits during neonatal care and road transport but was reduced by active noise cancelling. Acta Paediatrica, 112(10), 2060-2065. https://doi.org/10.1111/apa.16900.

Bergez, L., Jourdain, G., & De Luca, D. (2023). Noise produced by neonatal ventilators inside and outside of the incubators. Respiratory Care, 68(12), 1693-1700. https://doi.org/10.4187/respcare.10989.

Calikusu Incekar, M., Balci, S. (2017). The effect of training on noise reduction in neonatal intensive care units. Journal for Specialists in Pediatric Nursing, 22(3), e12181. https://doi.org/10.1111/jspn.12181.

Cardoso, S. M. S., Kozlowski, L. D. C., Lacerda, A. B. M. D., Marques, J. M., Ribas, A. (2015). Newborn physiological responses to noise in the neonatal unit. Brazilian journal of otorhinolaryngology, 81, 583-588. https://doi.org/10.1016/j.bjorl.2014.11.008.

Cedrowska-Adamus, W., Gulczyńska, E. (2018). Kontrola poziomu dźwięków na oddziale noworodkowym [Controlling sound levels in the neonatal unit]. Postępy Neonatologii, 24(2), 129 – 133.

Cepuch, G., Kruszecka-Krówka, A., Biedra, I., Gniadek, A. (2019). The assessment of the exposure of premature babies born with respiratory failure to noise and artificial light on the first day of hospitalization in the Neonatal Intensive Care Unit-preliminary report. Przegląd Lekarski [Medical Review], 76(4).

Chang, Y. J., Pan, Y. J., Lin, Y. J., Chang, Y. Z., Lin, C. H. (2006). A noise-sensor light alarm reduces noise in the newborn intensive care unit. American Journal of Perinatology, 265-272. https://doi.org/10.1055/s-2006-941455.

Chen, H. L., Chen, C. H., Wu, C. C., Huang, H. J., Wang, T. M., Hsu, C. C. (2009). The influence of neonatal intensive care unit design on sound level. Pediatrics & Neonatology, 50(6), 270-274. https://doi.org/10.1016/S1875-9572(09)60076-0.

Das, S., Chakraborty, P., Bora, R., Chakraborty, P. (2023). Sound levels and its effect on physiology of low birth weight newborns in a special care newborn unit—a prospective observational study. Egyptian Pediatric Association Gazette, 71(1), 30. https://doi.org/10.1186/s43054-023-00176-9.

Graven S. N., Browne, J. V. (2008). Auditory development in the fetus and infant. Newborn and infant nursing reviews, 8(4), 187-193. https://doi.org/10.1053/j.nainr.2008.10.010,

Hull, W., Wright, K. (2023). A quality improvement pilot project for noise reduction in the NICU. Advances in Neonatal Care, 23(5), 401-408. https://doi.org/10.1097/ANC.0000000000001074.

Joshi, R., Van Straaten, H., Van De Mortel, H., Long, X., Andriessen, P.,Van Pul, C. (2018). Does the architectural layout of a NICU affect alarm pressure? A comparative clinical

audit of a single-family room and an open bay area NICU using a retrospective study design. BMJ open, 8(6), e022813. https://doi:10.1136/bmjopen-2018-022813.

Krueger, C., Wall, S., Parker, L., Nealis, R. (2005). Elevated sound levels within a busy NICU. Neonatal network, 24(6), 33-37 https://doi.org/10.1891/0730-0832.24.6.33.

Kruszecka-Krówka, A., Cepuch, G. (2018). Wybrane czynniki traumatyczne i ich oddziaływanie na chore noworodki w warunkach szpitalnych z uwzględnieniem Oddziału Intensywnej Terapii Noworodka: część I: hałas i sztuczne oświetlenie [Selected traumatic factors and their impact on sick newborns in hospital conditions, including the Neonatal Intensive Care unit: part I: noise and artificial lighting]. Problemy Pielęgniarstwa [Problems of Nursery], 26(4). https://doi.org/10.5114/ppiel.2018.84132.

Lahav, A. (2015). Questionable sound exposure outside of the womb: frequency analysis of environmental noise in the neonatal intensive care unit. Acta paediatrica, 104(1), e14-e19. https://doi.org/10.1111/apa.12816.

Lehman, I., Królak-Olejnik, B. (2019). Dźwięk na oddziale intensywnej terapii i jego wieloaspektowy wpływ na rozwój noworodka. Postępy neonatologii, 25(2), 115-23.

Liu, W. F. (2012). Comparing sound measurements in the single-family room with open-unit design neonatal intensive care unit: the impact of equipment noise. Journal of Perinatology, 32(5), 368-373. https://doi.org/10.1038/jp.2011.103.

Movalled, K., Sani, A., Nikniaz, L., Ghojazadeh, M. (2023). The impact of sound stimulations during pregnancy on fetal learning: a systematic review. BMC pediatrics, 23(1), 183. https://doi.org/10.1186/s12887-023-03990-7.

Natarajan, N., Batts, S., Stankovic, K. M. (2023). Noise-induced hearing loss. Journal of Clinical Medicine, 12(6), 2347. https://doi.org/10.3390/jcm12062347.

Parra, J., de Suremain, A., Berne Audeoud, F., Ego, A., Debillon, T. (2017). Sound levels in a neonatal intensive care unit significantly exceeded recommendations, especially inside incubators. Acta Paediatrica, 106(12), 1909-1914. https://doi.org/10.1111/apa.13906.

Pineda, R., Durant, P., Mathur, A., Inder, T., Wallendorf, M., Schlaggar, B. L. (2017). Auditory exposure in the neonatal intensive care unit: room type and other predictors. The Journal of Pediatrics, 183, 56-66. https://doi.org/10.1016/j.jpeds.2016.12.072.

Pino, O. (2016). Fetal memory: The effects of prenatal auditory experience on human development. BAOJ Med Nursing, 2(4), 2.

Slevin, M., Farrington, N., Duffy, G., Daly, L., & Murphy, J. F. A. (2000). Altering the NICU and measuring infants' responses. Acta Paediatrica, 89(5), 577-581. https://doi.org/10.1111/j.1651-2227.2000.tb00342.x.

Wachman, E. M., Lahav, A. (2011). The effects of noise on preterm infants in the NICU. Archives of Disease in Childhood-Fetal and Neonatal Edition, 96(4), F305-F309. https://doi.org/10.1136/adc.2009.182014.

Wang, D., Aubertin, C., Barrowman, N., Moreau, K., Dunn, S., Harrold, J. (2014). Examining the effects of a targeted noise reduction program in a neonatal intensive care unit. Archives of Disease in Childhood-Fetal and Neonatal Edition, 99(3), F203-F208. https://doi.org/10.1136/archdischild-2013-304928.

Wang, D., Aubertin, C., Barrowman, N., Moreau, K., Dunn, S., Harrold, J. (2014). Reduction of noise in the neonatal intensive care unit using sound-activated noise meters. Archives of Disease in Childhood-Fetal and Neonatal Edition, 99(6), F515-F516. doi.org/10.1136/archdischild-2014-306490.

White, R. D., Smith, J. A., & Shepley, M. M. (2013). Recommended standards for newborn ICU design. Journal of Perinatology, 33(1), S2-S16. https://doi.org/10.1038/jp.2013.10

Wydanie zbiorowe (2022). Encyklopedia Popularna PWN wydanie 40 [Encyclopaedia Popular PWN edition 40]. Warszawa: Wydawnictwo Naukowe PWN.