ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

Study of Noise Levels in Neonatal Intensive Care Units (NICU) in Public Hospitals in Gaza City, Gaza Strip

Ass. Prof. Abed SCHOKRY
Islamic University – Gaza, department of Industrial Engineering

Abstract: ***Numerous recent studies have been published discussing the problem of high noise levels in the neonatal intensive care unit (NICU). The purpose of the current study is to evaluate noise levels in a NICU in a small city in a developing country. A noise level meter was used to assess noise levels in different NICUs at two public hospitals and to compare those levels with recommended international standard. Noise levels measured inside the NICUs in both hospitals were significantly higher than the standard recommended level for noise in NICU (58 - 78 dB A). Noise levels were also significantly higher outside the NICU (71 - 73 dB A). These findings are consistent with those of previous studies and demonstrate that noise levels in the NICU are alarmingly high. Industrialized countries and developing counties are facing the same problem of noise. Some intervention strategies are recommended.***

***Index Terms*— Noise, Neonatal Intensive Care Unit, incubator, newborn.**

I. INTRODUCTION

Noise is everywhere including in hospitals and therefore it has become a major concern for care providers, scientists and researchers [1], [2], [3], [4]. The level of sound (Noise) in the NICU has received attention for more than 25 years. Several recent studies have documented NICU noise levels ([5], [6], [7], [8].

Given the physical characteristics of these facilities, the quantity of equipment and transit of personnel, the measuring of the level of noise in NICUs is a complex task and a significant challenge. Given the potential risks posed by noise to patients (newborns) cared for in NICUs the sound levels of these facilities need to be known. This knowledge is essential in order to implement changes that enable controlling and reducing noise.

Noise sources in NICUs can be divided into two main categories: external incubator noise and internal incubator noise. Sources of external incubator noise include the nursing staff and clinical interventions. Often, extremely high noise is caused by the medical alarm systems commonly used in a NICU including ventilators, monitoring devices, feeding pumps, etc. Sources of internal incubator noise include the thermoregulation and ventilation systems attached to the units [9]. The use of technology to care for newborns has improved survival but has also transformed neonatal intensive care units (NICU) into very noisy places. Recent studies show that the average sound levels in a NICU range between 70 to 80 dB, but the American Academy of Pediatrics recommends a maximum safe noise level of 45 dB. Sound levels increase with acuity and technological care and exhibit daily patterns related to unit routine [8], [10]. . Research has shown that sound levels outside of the normal range can be harmful to the healthy development of premature newborns in the NICU [11], [12], [13].

Fetuses born after 24 weeks have almost complete cochlea and sensory organs, and when fetuses are born too early they leave the silent atmosphere of the uterus and enter the noisy environment of the NICU [14]. High sound levels have been shown to interfere with a newborn's sleep and have a negative consequence on the infant's critical signs, oxygen saturation, and auditory attention [11], [13], [15]. Simple frequent acts, such as closing the incubator door, can reach levels of 100 dB or more, which is equivalent to exposing an infant to the noisy sound levels at a rock concert [16]. As a result of repeated exposure to loud noise in the NICU early newborns are more at risk of sensor neural hearing loss (SNHL) and future developmental delay [17]. It is essential to continually assess how to maintain safe sound levels within the NICU [14], [13]. Health organizations and experts have tried to establish guidelines limiting the levels of noise in NICUs. The World Health Organization (WHO) recommends that noise in hospital facilities should not exceed 40 dB (A). The American interdisciplinary committee indicates acoustic treatment so that habitual noise does not exceed the recommended parameters: hourly Leq of 45 dB (A), hourly L10 50 dB (A), and Lmax 65 dB (A). The Brazilian standard NBR 10152, approved by the Brazilian Technical Standards Association (ABNT) indicates that levels up to 45 dB (A) are acceptable for nursery wards but does not specify limits for NICUs. Even though knowledge concerning damage caused by early exposure to high levels of noise needs to be improved, stays longer than 48 hours in NICUs are already considered as a risk factor for infants' hearing impairment. Additionally, changes observed in the development of newborns have encouraged the implementation of new approaches in care delivery that include rebuilding the physical environment of NICUs, especially in relation to the monitoring and control of Noise levels. This is an issue to which both Brazilian and international nursing professionals have considerably contributed [18].

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

II. LITERATURE REVIEW

In 2000 the World Health Organization (WHO), [19] published a document on community noise and found that in hospitals sleep disturbance was a main critical effect for most spaces and recommended that the maximum sound level for hospital wards during nighttime should not exceed 40 dB (A), in order to maintain an acceptable environment for sleep.

There are many publications regarding this topic of noise in NICUs [18].

Technological advances and improved understanding of the neonatal condition have reduced infant mortality, and some infants are spending weeks or even months as inpatients in NICUs. However, improvements in neonatal care have been accompanied by concerns about the impact of the NICU environment on these infants. The technology-backed environment of a NICU is a noisy one, and this noise has been found to be a major source of environmental stress for the neonate. Numerous published studies have measured noise levels that would be considered dangerous to adults working in a noisy workplace [18].

The effects of noise on infants in the NICU have been well researched, particularly the cardiovascular and respiratory effects. Studies have documented the effect of noise on the infant's auditory system, such as noise-induced sensor neural hearing loss (SNHL) (usually mild to moderate in severity). Some research has also suggested that attention-related difficulties and information processing disorders at pre-school and school ages as well as speech delay, language-related problems and learning difficulties might be due to noise exposure in the NICU [20].

Several clinical studies have shown that high noise levels in the NICU environment and/or the interior of the incubators could cause health problems on premature infants, namely infants born before the 37th-38th week of pregnancy. In general, noise exposure has adverse effects on the physical and psychological health as well as the cognition of children. The health problems associated with high, discrete or continuous, noise levels in the NICU may be classified in two broad categories: neurological disorders and hearing loss. Discrete, high noise may cause problems in distinguishing various audio frequencies later on, fluctuations in arterial pressure, increased heart and breathing rates, lower blood saturation that can, in turn, affect the development of vital organs, and increased intracranial pressure that could contribute to hypoxic brain damage [21].

Noise in these places can affect newborns, increasing their heart rate and respiratory frequency, dropping their oxygen saturation, diminishing the duration of their sleep state and hindering their ability to stay in a deep sleep state, and also causing alterations in their motor activity [22], [23], [24], [25]. There is also increased danger of weakening of the blood vessel walls in the neonatal brain and increased likelihood of problematic development of the central neurological system. Continuous, annoying noise during sleep may increase heart and breathing rates, cause breathlessness, possibly decrease blood oxygen levels, and obviously cause sleep fragmentation and sleep deprivation with behavioral, cognitive, neurological, biochemical and other consequences [21]. Normal motional development is finally threatened as environmental and mechanical noise inside and outside of the incubators interfere with the parents' voices particularly for prolonged incubator stays. For all the above reasons, experts and associated institutions, such as the American Academy of Pediatrics (AAP) and the British Association of Perinatal Medicine (BAPM), have established noise limits for the interior of the incubators. These limits are 45 dB (A) during the daytime and 35 dB (A) at night. These limits, however, are often exceeded even in the most modern NICUs.

Premature infants in the NICU are often exposed to continuous loud noise despite research documenting the presence and damaging effects of noise on the preterm infant's development. Excessive auditory stimulation creates negative physiologic responses such as apnea and fluctuations in heart rate, blood pressure, and oxygen saturation. Preterm infants exposed to prolonged excessive noise are also at increased risk of hearing loss, abnormal brain and sensory development, and speech and language problems. Reducing noise levels in the NICU can improve the physiologic stability of sick neonates and therefore enlarge the potential for infant brain development. [26].

Neonatal units, like most hospital environments, tend to be very poor acoustically due to hard, reflective surfaces. Beds are often close to each other, visitors can talk loudly and staff have to work quickly and move equipment around. In addition, with incubators being opened and closed, occasional tapping on the lid and items dropped accidentally the noise levels soon become unpleasant for the baby. One of the foremost problems is the alarm, which is clearly essential, but as the background noise levels get higher the alarm needs to be set louder. A quieter background allows for quieter alarms. The immediate effects of noise in the neonatal units are reasonably clear. The baby's sleep is easily disturbed and sudden loud noises (bangs on the incubator for example) can have a startling effect on the heart rate and breathing patterns. High and intermittent noise is also unpleasant and distracting for both staff and parents. Defined "Quiet Times", when noise and light levels are kept down, certainly help and are now used in many units (Weiss, B. The Evolution of Healthcare Design: From the Dark Ages to the Age of Enlightenment).

The long term effects of noise in the NICU are not so obvious. Hearing impairment as a result of exposure to high noise levels can be expected but research over the last few

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

years has also shown a link with language development. This seems to be related to the fact that a baby that goes full term is only exposed to lower frequency noise (< 250 Hz) during the brain and sensory development stages [27].

IV. STUDY DESIGN AND METHOD

A. Instrumentation

The study was conducted in different NICUs at two public hospitals in Gaza City where noise levels were measured. Sound intensity (dB) was measured using a sound level meter, AEMC CA832, (35 dB to 130 dB), conformance to EU Standard. It assesses sound ambiences or annoyances in accordance with international safety and quality standards. The Sound Level meter was calibrated using a calibration device C.A. 833. In the study, measures used the dB (A) scale, which approximates reception characteristics of the human ear [28]. Each time a new set of measurements were taken the sound level meter was calibrated.

The noise level was measured at zero distance and at 6 feet from the incubator simultaneously. The noise level was also measured outside the NICU. Each time five measurements

III. OBJECTIVE OF STUDY

To examine and monitor the noise levels in Neonatal Intensive Care Units (NICU) in two public hospitals in Gaza City. The measurements were taken close to the incubator (not inside) and 6 feet away from it.
were taken. All measurements were taken during the day shift.

B. NICU Environment

The NICU in the first public hospital has nine incubators and is about 2402 feet large, while the other two NICU's are having 15, and nine incubators and are 3362 & 1952 feet large respectively. The NICU at the first hospital was fully occupied, while the NICU's at the second hospital were not.

V. RESULTS AND DISCUSSION

A. Results

The following figures (1, 2, 3) are showing the noise levels in the NICU wards of the three public (governmental) hospitals in Gaza Strip.

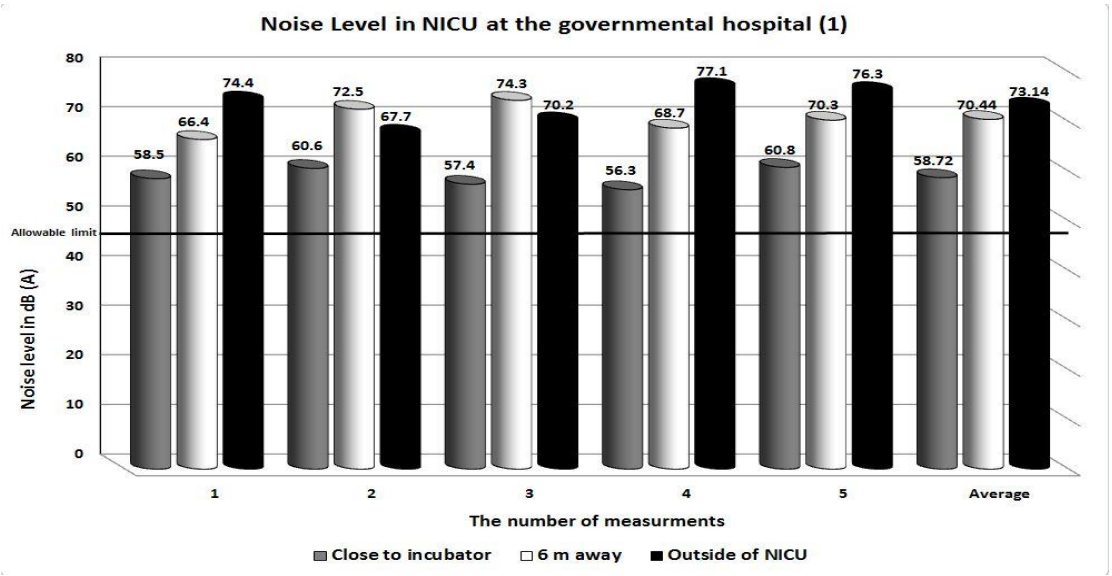

Fig. 1: Noise Levels in NICU at Public Hospital 1

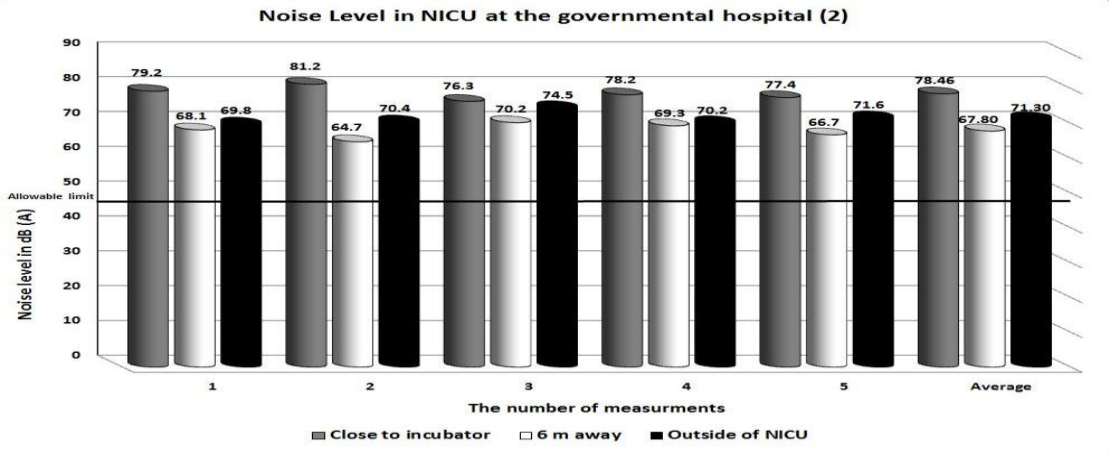

Fig. 2: Noise Levels in NICU (1) at Public Hospital 2

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

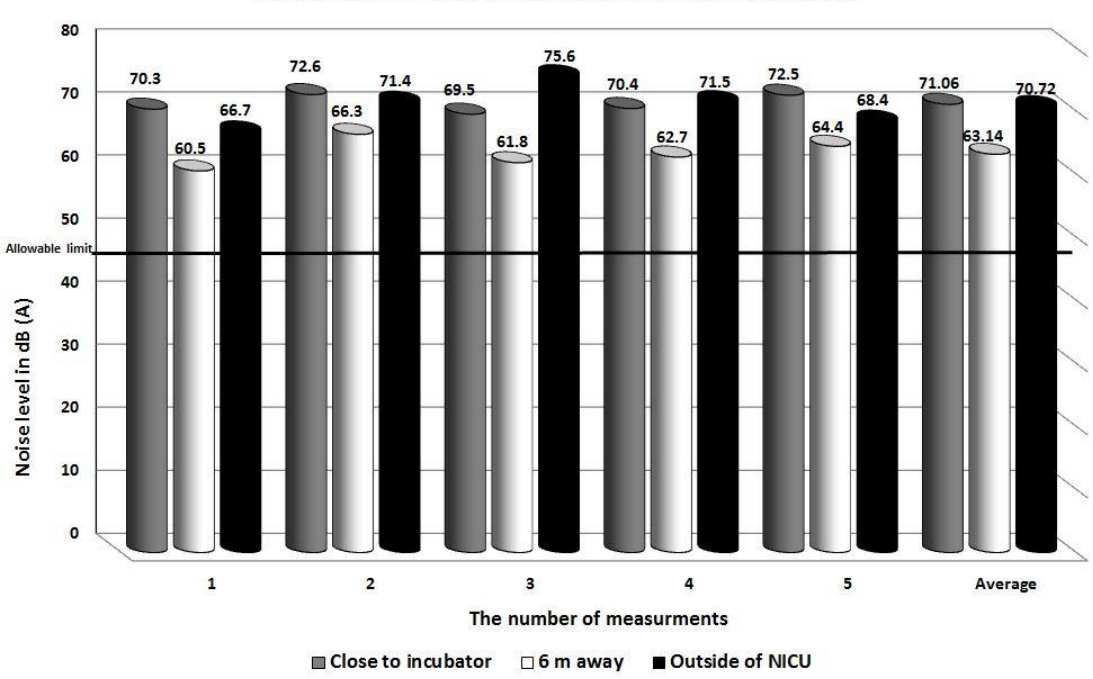

Fig. 3: Noise Level in NICU (2) at Public Hospital 3

Table (1) contains a comparison between the three NICU's as well as at the various distances.

Table 1: Noise Levels in all NICU wards

	dB (A)		
Distance	Hospital 1 - Ward 1	Hospital 2 - Ward 1	Hospital 3 - Ward 1
Close to incubator	58.72	78.46	71.06
6 m away	70.44	67.80	63.14
Outside of NICU	73.14	71.30	70.44

A basal noise level variation between 56 and 81dB (A) was recorded. The noise level – close to the incubator- in hospital (1) was lower than the other two hospitals, while the noise level outside this ward was the highest. At the same time, the noise level at 6 m away from the incubator was also the highest among the three NICUs. The lowest noise level was recorded 6 m away from the incubator in the NICU of the third hospital.

B. Limitations

The Measurements were taken on two days only and not over a long period of time and no measurements were taken during the night. Five measures of specific sounds were carried out each time. No differentiating was done regarding the sources of noise during the measurements. Furthermore staff as well visitors possibly adapted their behavior during the study period.

C. Discussion

The lowest noise level recorded during the study was 56 dB (A) and this was taken close to the incubators. The lowest noise level 6 m away from the incubator was 60.6 dB (A). Outside the wards the lowest noise level was 67.7 dB (A).

From the table and figures above it can be seen that the noise levels in all NICU wards exceed the level recommended by the Environmental Protection Agency (EPA) published in 1974, where acceptable sound levels are no more than 45 dB (A) during the day and also exceed the noise level recommended by the American Academy of Pediatrics (AAP) which is 45 dB (A) [28], [16]. Furthermore, the World Health Organization (WHO) recommends that daytime noise levels in patient treatment rooms should not exceed 30 - 40 dB (A) [19]. While in all wards noise levels were lower at a distance of 6 m from incubators, the levels were higher than the recommended 45 dB (A). Noise levels outside the NICU wards were also relatively high. Outside the wards the additional sources of noise are movement and communication of visitors and staff as well as background noise.

Many studies show that both industrialized countries and developing countries are facing the same problem regarding noise in NICUs. The study of Laroche, C, Fournier et al. carried out in Canada, shows average noise levels of 61 dB (A), 65 dB (A), and 53 dB (A) for the day, evening and night shifts respectively [29]. All these measurements are higher than the recommended noise levels for NICUs. A study by Williams, A. L. et al. [30], conducted in USA, recorded noise levels between 55 dB (A) and 63 dB (A) which exceed the recommended noise level. Berg, A. L. et al. [31] examined and monitored sources of noise levels in a tertiary NICU of a large urban regional prenatal center and found that noise

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

always (with few exceptions) exceeded the recommended < 50 dB (A) level (American Academy of Pediatrics (AAP). Darcy, A. E. et al. [32] evaluated the average noise levels in three different NICUs and compared them to the suggested guidelines set by the US Environmental Protection Agency (EPA) and the American Academy of Pediatrics (AAP). The study found that the mean noise level for the three sites on the day shift was 57.2 dB and the mean noise level for the night shift was 57 dB (A). Bellieni, C., et al. [33] established that background noise ranged from 46-50 dB (A), closing portholes ranged from 70-74 dB (A) and baby cry ranged from 81 to 87 dB (A) inside the incubator. Sound levels within the incubator ranged from 58 to 71 dB (A). A study conducted at Johns Hopkins Hospital in Baltimore [34] found that at all locations and all times of day, the Leq indicated that a serious problem existed. The average equivalent sound levels were within the range of 50 to 60 dB (A) and that No location was in compliance with current WHO Guidelines. Another study, which was conducted at King Fahd University Hospital in Saudi Arabia at an ICU and the results of the study revealed that the mean level exposure to noise in the ICU is 60.4± 7.1 dB measured on three working days and 59.2±5.3 at weekends. Although, the noise level was high in comparison with the WHO standards, there was no significant difference between the level of noise in the different shifts and at the weekends [35].

It is important to take a look at the Report of the Eighth Consensus Conference on Newborn ICU Design, January 26, 2012 Clearwater Beach, Florida.*"(Multiple bed rooms shall have a minimum of 8 feet (2.4 meters) between infant beds. There shall be provision for visual privacy for each bed, and the design shall support speech privacy at a distance of 12 feet (3.6 meters)"*. [36]. It can be easily seen that all NICUs in the study are not conform with the recommendation above, they are over occupied with incubators that's lead an overlap of noise from different sources and this could also be another reason, why it is so noisy in those NICU.

A review of objective data showed that this was the same for most hospitals all around the world. This analysis concluded that the problem of hospital noise is obviously under-studied and not well understood.

VI. SOLUTIONS AND INTERVENTIONS

For example, sound levels should be controlled and kept below 40 dB (womb-like level). This means controlling all sources of noise and all other irrelevant background noise.

In general the following are ways of reducing or eliminating noise:

- At the source,
- Installing a barrier between the source and the recipient,
- At the point of human reception (difficult to realize in case of the newborn).

The solutions can be divided into three categories:

- Technical
- Administrative
- Personnel

A. Technical solutions

The best solution is to implement noise control in the design process of the NICU but as this is usually not an option, solutions involve adding sound absorption materials for floors and ceilings, and sound transmission barriers. The acoustical properties of the incubator should shield the premature infant against excess of noise. Installing quieter heating, ventilation, and air-conditioning (HVAC) system and other mechanical systems. Installing acoustic seals for doors to meet sound transmission class (STC) criteria. Stainless steel sinks and troughs can be very noisy; where used, and waste bins should be foot-operated with soft-close tops. The use of plastic rather than metal, with a damping system, for cupboard doors and drawers, and trash cans. Reducing the volume of neonatal alarms. This needs to be balanced with the need to minimize Healthcare-Associated Infection (HCAI). Sound-monitoring equipment may help to maintain low noise levels.

B. Administrative solutions

Reducing the density of incubators in the NICU. Locating the unit secretary, nurse's station, and consultation places outside the main nursery [15]. Defined "Quiet Times" when noise and light levels are kept low.

C. Personnel solutions

Staff education to recognize noise pollution and reduction. Modifying behavior such as limiting conversations at the bedside, moving teaching rounds away from the beside, properly closing doors of the incubator and turning oxygen to face out [12], [13], [37]. Educating cleaning staff about noise sources and noise reduction related to cleaning activities. The use of "Quiet, Please" posters to remind staff and visitors to reduce noise. Turning overhead lights down induces people to lower their voices.

VII. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

Noise is everywhere worldwide and developing countries are facing the same problem as industrial countries. The basal noise level recorded in this study exceeds the noise level recommended by the World Health Organization (WHO), American Psychological Association (APA), and many other national and international organizations. Noise levels in the NICU environment were found to be much higher than the recommended standard of 45 dB (A). Noise levels in the NICU environment ranged from 61 to 78 dB (A), which cannot be solely attributed to the HVAC system.

Further research is required to ascertain the precise source of noise in NICU wards. Only then may solutions be found and appropriate action taken.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

B. Recommendations

- Determining the appropriate sound level that promotes neonate tranquility
- Identifying noise sources in the NICU and recognizing noise as a problem
- Recognizing noise effects on the newborn and children
- Raising awareness, for example thinking about noise exposure when planning the settings where newborn and children stay,
- Setting-up noise control campaigns in hospitals and schools,
- Developing noise mapping, action plans, community involvement, informing the media and decision-makers and health professionals,
- Increasing public and professional education to recognize noise pollution and reduction,
- Developing noise barriers, building sound insulation, or using sound-absorbent materials,
- Identifying and turning off noise at the source and masking unwanted sound.

ACKNOWLEDGEMENT

The Author would like to thank Prof. Dr. med. Hab. Friesdorf for his support and the Catholic Academic Exchange Service (KAAD) for the scholarship and Mr. Struan Robertson for his reviewing and editing my paper.

REFERENCES

[1] Elander, G., Hellstrôm G. et al. Reduction of noise levels in intensive care units for infants: Evaluation of an intervention program. Heart & Lung: The Journal of Acute and Critical Care Volume 24 , Issue 5, 376 – 379, 1995.

[2] Topf, M. Stress of personal Control over Hospital Noise. Behavioral Medicine. Vol. 17, Iss. 2, 1992.

[3] Hodge B, Thompson J.F. Noise pollution in the operating theatre. Lancet 335:891–894, 1990.

[4] Aitken RJ. Quantitative noise, analysis in modem hospital. Arch Environ Health. 37(6):361–4, 1982.

[5] Kent WD, Tan AK, Clarke MC, Bardell T. Excessive noise levels in the neonatal ICU: potential effects on auditory system development. J Otolaryngol. Dec; 31(6) 355-360, 2002.

[6] Krueger, C., Wall, S., Parker, L., & Nealis, R. Elevated sound levels within a busy NICU. Neonatal Network, 24(6), 33-37, 2005.

[7] Krueger, C., Schue, S., & Parker, L.. Neonatal intensive care unit sound levels before and after structural reconstruction. MCN: The American Journal of Maternal/Child Nursing, 32(6), 358-362, 2007.

[8] Levy, Daniel, Granot, R., and Bentin S. Neural sensitivity to human voices: ERP evidence of task and attentional influences Psychophysiology, 40,291–305, 2003.

[9] Xie, H., Kang, J., Mills, G. H. Clinical review: The impact of noise on patients' sleep and the effectiveness of noise reduction strategies in intensive care units. Critical Care, 13 (2): 208, 2009.

[10] Byers, J.F., Waugh, W. R. and Lowman, L. Sound Level Exposure of High-Risk Infants in Different Environmental Conditions. Neonatal Network, 25, (1) 2006.

[11] Bremmer, P., Byers, J. F., Kiehl, E. Noise and the premature infant: physiological effects and practice implications. Journal of Obstetric, Gynecologic and Neonatal Nursing, 32 (4): 447-454, 2003.

[12] Johnson, A. N. Adapting the Neonatal Intensive Care Environment to Decrease Noise. Journal of Perinatal & Neonatal Nursing. Volume 17 - Issue 4 - p 280–288, 2003.

[13] Philbin MK, Gray L. Changing levels of quiet in an intensive care nursery. J Perinatol. Sep; 22(6) 455-460, 2002.

[14] Gerhardt KJ, Abrams RM. Fetal exposures to sound and vibroacoustic stimulation. J Perinatol. Dec; 20(8 Pt 2) S21-30, 2000.

[15] Gray, L., & Philbin, M. K. Effects of the neonatal intensive care unit on auditory attention and distraction. Clinics in perinatology, 31(2), 243-260, 2004.

[16] American Academy of Pediatrics. Committee on Environmental Health. Noise: A hazard for the fetus and Newborn. Pediatrics. 100 (4): 724-27, 1997.

[17] Surenthiran, S S., Wilbraham K., May J., Chant T., Emmerson A. B., Newton V. E. Noise levels within the ear and post-nasal space in neonates in intensive care Arch Dis Child Fetal Neonatal, 88:4, 2003.

[18] Nogueira, M. D. F. H., Di Piero, K. C., Ramos, E. G., Souza, M. N. D., & Dutra, M. V. P. Noise measurement in NICUs and incubators with newborns: a systematic literature review. Revista latino-americana de enfermagem, 19 (1), 212-221, 2011.

[19] World Health Organization (WHO). "Guidelines for Community Noise". (Eds. Berglund, B; Lindvall, T.; Schwela D.H. and Goh, K.T., WHO, Geneva), 2000.

[20] Nathan LM, Tuomi SK, Muller AMU. Noise levels in a neonatal intensive care unit in the Cape metro pole. SAJCH. 2 (2):50–54, 2008.

[21] Stratikopoulos, I. S., Saatsakis, G., & Kallergi, M. Noise monitoring and alarm system for infant incubators. E-Journal of Science & Technology, 7(3), 2012.

[22] Als H., Lawhon G., Duffy FH, McAnulty GB.,Gibes-Grossman R., Blickman JG. (1994).

[23] Merenstein, G. B. Individualized developmental care: An emerging new standard for neonatal intensive care units? JAMA, 272(11), 890-891, 1994.

[24] Oehler, J. M. Developmental care of low birth weight infants. The Nursing Clinics of North America, 28(2), 289-301, 1993

[25] Tucker Blackburn, S. and VandenBerg, K.A. Assessment and management of neonatal neurobehavioral development. In Comprehensive neonatal nursing: a physiologic perspective, Kenser, C., Brueggemeyer, A., Gurgeron, L. (eds). W.B, Saunders, 1094-1130, 1993.

[26] Bremmer, P., Byers, J. F., Kiehl, E. Noise and the premature infant: physiological effects and practice implications. Journal

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 4, October 2016

of Obstetric, Gynecologic and Neonatal Nursing, 32(4): 447-454, 2003.

[27] Stromswold, K., & Sheffield, E. Neonatal intensive care unit noise & language development. Rutgers University Center for cognitive science, technical report, 2004.

[28] Gray, L., & Philbin, M. K. Measuring sound in hospital nurseries. Journal of perinatology: official journal of the California Perinatal Association, 20(8 Pt 2), S100-4, 2000.

[29] Laroche, Chantai, Fournier, Paula. Study of Noise Levels in a Neonatal Intensive Care Unit, Canadian Acoustics, 27(1): 11-19, 1999.

[30] Williams, A. L., van Drongelen, W., & Lasky, R. E. Noise in contemporary neonatal intensive care. Journal of the Acoustical Society of America, 121(5), 2681-2690, 2007.

[31] Berg, A. L., Chavez, C. T., Serpanos, Y. C. Monitoring Noise Levels in a Tertiary Neonatal Intensive Care Unit, Contemporary Issues in Communication Science and Disorders, Volume 37: 69-72, spring, 2010.

[32] Darcy, A. E., Hancock, L. E., Ware, E. J. A descriptive study of noise in the neonatal intensive care unit. Ambient levels and perceptions of contributing factors. Advances in Neonatal Care, 8(3): 165-175, 2008.

[33] Bellieni, C. V., Buonocore, G., Pinto, I., Stacchini, N., Cordelli, D. M., Bagnoli, F. Use of sound-absorbing panel to reduce noisy incubator reverberating effects. Biology of the Neonate, 84(4): 293-296, 2003.

[34] Busch-Vishniac, I. J. et. al. Noise Levels in Johns Hopkins Hospital, The Journal of the Acoustical Society of America, 118(6): 3629-3645, Dec., 2005.

[35] Qutub, H. O., & El-Said, K. F. Assessment of ambient noise levels in the intensive care unit of a university hospital. Journal of family & community medicine, 16(2), 53 – 57, 2009.

[36] Report of the Eighth Consensus Conference on Newborn ICU Design Clearwater Beach, Florida, January 26, 2012.

[37] Robertson, A., Cooper-Peel, C., & Vos, P. Sound transmission into incubators in the neonatal intensive care unit. Journal of perinatology: official journal of the California Perinatal Association, 19(7), 494-497, 1998.

AUTHOR BIOGRAPHY

Dr. A. Schokry, born in 1971 in Gaza strip, Palestine. After finishing the school, I had moved to Germany, where I had studied (Bachelor of Mechanical Engineering, Master of Biomedical Engineering and Ph.D. in the field of Ergonomics & Safety). In 2007 I came back and since 2008 I am working at the IE Department at the Faculty of Engineering. My research fields are Ergonomics, Safety and Quality. I am a member in local, national and international Organizations. At time I am the vice dean for quality and development at IU-Gaza.