PERSPECTIVE

Noise as a Health Hazard for Children: Time to Make a Noise about it

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Noise, a modern day curse of advancing infrastructure and technology, has emerged as an important public health problem. Exposure to noise during pregnancy may result in high-frequency hearing loss in newborns, growth retardation, cochlear damage, prematurity and birth defects. Newborns exposed to sound above 45 decibels may experience increase in blood pressure, heart rate, respiratory rate; decreased oxygen saturation; and increased caloric consumption. Noise exposure in older children may result in learning disabilities, attention difficulties, insulin resistance, hypertension, stress ulcers and cardiovascular diseases. Sudden exposure to loud noise can lead to rupture of eardrum. The damaging effects of noise pollution are more noticeable in large metropolitan cities, the hubs of urban settlements and industrial growth. Another concern is noise pollution inside the hospitals (particularly intensive care areas) that can lead to serious health consequences both for caregivers and for children. The issue needs to be addressed by both researchers and policy makers on an urgent basis.

Keywords: *Environment, Health problems, Noise pollution*.

Noise is defined as an unwanted sound. Acoustic signals producing a pleasant sensation are referred to as 'sound' whereas the unpleasant sounds are referred to as 'noise'. Noise has emerged as a modern day pollutant and an environmental stressor. Source can be both indoors (audio and video devices, musical toys, games, electrical gadgets, kitchen appliances, classroom noises etc.) or outdoors (vehicular traffic ranging from aircrafts to road traffic, factory sirens, loud speakers, environmental noises in play grounds etc.). Increasing pollution and industrialization has contributed to the menace. Most of our knowledge related to hazardous effects of noise originates from studies on occupational effect of noise in adults; where high ambient noise exposure may result in hearing impairment, the toxicity being dose-dependent [1,2]. Harmful effects of noise in children may start from the intrauterine period [3]. In variance with adults, neonates and children are passive consumers of harmful noise, and are more susceptible to its damaging effects. Sound levels and their adverse effects in some common situations in our surroundings are depicted in ***Fig.* 1**.

Harmful Effects of Noise

Intrauterine Life

The auditory system starts developing by 3-6 weeks of gestation [4,5], and the structural aspects required for audition are well developed by 20 weeks of gestation. A functional vestibular system develops by 29 weeks of gestation. That fetus is able to hear, is indicated by observations of blink-startle responses to vibro-acoustic stimulation during antenatal ultrasonography around 24 weeks of gestation. Fetus can respond to auditory stimulus originating both inside and outside the womb. Sources of sound in the materno-fetal unit include heartbeat of mother, placental flow, mother's voice, and vibroacoustic stimulations from antenatal ultrasonography. Sources of sound outside the womb depend on the environment in which the mother is living or working. It can be from traffic signals, or from workplace machinery for working mothers. Household sources of sound to fetus include sounds from vacuum cleaner, mobile phone, washing machine, televisions, radios, and loud conversations.

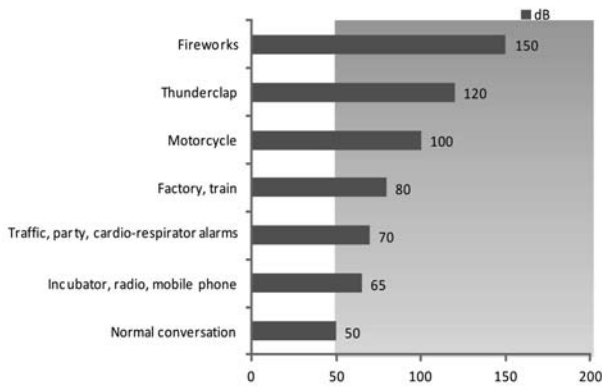

Fig. 1 *Sound levels with their adverse effects in some common situations.*

Hepper, *et al.* [4] observed that fetal sensitivity to auditory stimulus initiates at lower frequencies; response to higher frequencies develops later. Intrauterine exposure to excessive sound can have long-lasting effects. Studies have documented high frequency hearing loss in children who were exposed to noise in the range of 85 to 95 decibels (dB) during intrauterine period [6,7]. *In utero* exposure to loud noise can also cause cochlear damage. Besides auditory damage, intrauterine exposure to noise may contribute to prematurity and birth defects. Mamelle, *et al.* [8] documented increased risk of preterm delivery in women exposed to 80 dB for an 8-hour shift. Knipschild, *et al.* [9] reported that women, who resided in an area where the day-night sound level of aircraft noise exceeded 60 to 65 dB, delivered low birth weight babies. Women residing in areas adjacent to airport also have lower maternal placental lactogen after 36 weeks of gestation [10].

Neonatal Period

Neonatal intensive care unit (NICU) environment is characterized by continuous sounds from monitors, ventilators, alarms, infusion pumps, incubators, and conversations between doctors, staff and family. The American Academy of Pediatrics (AAP) Committee on Environmental Health has recommended that sounds levels should be at or below 45 dB in neonatal intensive care units (NICU) [3]. Hassanein, *et al.* [11] evaluated the sound levels from equipment commonly used in NICU and pediatric intensive care units (PICU). It was observed that cardio-respiratory alarms increase the sound level to 73 dB, endotracheal suctioning to 68 dB, and the telephone ringing to 83 dB. Marik, *et al.* [12] demonstrated the sound inside an incubator with all equipment off and the hood down is 53 dB, which increases to 59 dB with cardio-respiratory alarms. Intensity of sound further increases to 68 dB with high-frequency ventilators. Normal activities in NICU thus produce sound levels exceeding the AAP recommendations.

High intensity sounds may cause damage to the cochlear cilia leading to hearing loss. Repeated arousal of the baby as a result of the sounds produced by equipment may lead to fatigue and irritability. Studies have also shown the possible synergistic effects of aminoglycosides and noise on hearing loss in NICU graduates. Winkel, *et al.* [13] studied the incidence of hearing loss in 91 preterm NICU graduates at the age of 4-6 years; all five cases of moderate to severe sensorineural hearing loss were seen in infants treated with kanamycin and kept in incubators. Inappropriate sound exposure (consistency, reverberation, frequency, and excessive levels) causes negative neuro-sensory and physiologic long-term developmental outcomes related to the maturation process. Johnson [14] concluded that increased environmental sound is a cause of stress for the neonate, leading to agitation and increased morbidity. Loud sounds interrupt sleep which is essential for CNS development. Infants exposed to loud noises in the NICU also demonstrate hypoxemia and changes in behavioral and physiological responses [15,16].

Preterm infants are more vulnerable to adverse physiological effects of noise like increased blood pressure, heart rate, respiratory rate, and decreased oxygen saturation. Increased need of oxygen and increase in caloric consumption are also more pronounced in preterms [7].

Studies have shown the beneficial effects of noise reduction in NICU. D'Agati , *et al.* [17] showed that earmuffs worn by premature infants substantially increase the quiet sleep time. Als, *et al.* [18], by reducing the frequency of opening and closing of the incubator, concluded that the group treated with environmental interventions needed considerably fewer days of respiratory support and oxygen administration. Simple steps like covering the infant incubator, modification of behavior of treating physicians and nurses have shown to significantly reduce the ambient noise [18,19].

Noise can also have long-term adverse affects on neurodevelopmental outcome. Turk, *et al.* [20] conducted a randomized control trial to evaluate the role of ear plug protection in very low birth weight babies in NICU. Of the surviving infants at 18-22 months, those with ear plug protection scored 15.5 points higher on Bayley Mental Development Index [20].

Beyond Neonatal Period

The source of noise in children can be both indoors and outdoors. Rural homes are less burdened with sound exposure compared to urban homes. Machines used in agriculture are less distressing compared to traffic noise. Due to lack of proper planning and lack of space in urban areas, particularly the metropolitan cities, residential colonies and schools are placed close to busy roads, airports, railway stations and even factories. Sources of noise inside the houses include air conditioners, coolers, washing machine, televisions, music systems, vacuum cleaners, video and computer games. Noise from social, cultural and recreational activities is another nuisance, particularly in densely populated cities. Many toys produce noise and children love to play with them. A study in Finland on 40 toys concluded that toys which gave a single impulse reached a peak level that was so high that even exposure to one single impulse could cause hearing

defect. Preschool children who spend quite a good amount of time in day care institutions are also exposed to noise originating from toys, overcrowding, and air conditioners.

Schoolchildren spend most of their time in classroom and playground. Noise in schools is multipronged originating from the poor acoustics of the room, slamming of doors, noisy corridors, ventilation systems and computers. In addition there is external noise from road traffic particularly from schools built on highways or near congested roads. Background noise is found to be higher in classrooms with natural ventilation as compared to those with mechanical ventilation as shown by a study in Denmark [21]. There is significant drop in children's reading performance when background noise interfered with speech [22]. Teenagers frequently visit discotheques and concerts where a very high sound pressure level is generated; this increases the chances of hearing loss. Youths also turn up the volume of their car stereo while driving, which is damaging not only for ears it further increases the chances of traffic accidents.

Noise-induced hearing loss is particularly more pronounced in children with learning disabilities, attention difficulties and children on ototoxic medications. Noise-induced hearing impairment is usually accompanied with loudness recruitment, paracussis and tinnitus. These changes may be temporary or permanent. In 2001, it was estimated that 12.5% American children between ages of 6 to 19 years had hearing impairment in one or both ears [23]. Similar data for Indian children are lacking. The ultimate results of hearing loss may range from dejection, impairment of speech, absence of schooling and restricted job opportunities.

Noise-induced sleep deprivation suppresses the rapid eye movement (REM) sleep pattern [24]. The body response to noise is in terms of fight or flight, thus resulting in adverse nervous, hormonal and vascular changes. Exposure to noise during sleep increases the adrenaline, noradrenaline and cortisol excretion. An increase in cortisol indicates activation of hypothalamic-pituitary axis (HPA). Long term activation of HPA is associated with insulin resistance, hypertension, stress ulcers and cardiovascular diseases [24]. Another side effect of noise is enhanced pain sensation, which may increase the requirement of dose of analgesics.

Health hazards of noise exposure in different age groups are summarized in ***Table* I**.

THE STEPS AHEAD

Pediatricians are responsible for creating parental awareness regarding the harmful effects of noise in children. Simple changes in the working environment can help in reducing the level of noise in intensive care areas (e.g., responding to alarms immediately, cleaning ventilator tubing, use of incubators with minimal opening of ventilator hoods, use of plastic instead of metallic trash cans). Practicing behavior changes, keeping mobile in silent mode, and use of sound meters by patient's bed side are other measures for decreasing ambient sounds in hospitals. Surveillance for sound levels is essential to facilitate early interventions. Sound levels produced by the equipment should be one of the criteria to determine their procurement for NICU and PICU. Universal screening of newborns for hearing loss is a concept gaining foothold in India. Studies have shown that auditory screening of NICU graduates help in early diagnosis and treatment before 6 months; which is an essential pre-requisite to prevent speech defects [25].

Our daily life, whether indoors or outdoors, is full of noise. Children brought up in this environment learn to identify noise as the part and parcel of existence. Thus, they see no harm in creating noise also. This trend can only be reversed by behavior change modification, starting at parental level and percolating beyond to family, community and population at large. Interventions are needed at home, school, and other areas children frequent. Home appliances and toys should be developed with a sound level below 50 dB. A potential source of noise-induced hearing loss among youngsters is use of ear

TABLE I HEALTH HAZARDS OF NOISE IN DIFFERENT AGE GROUPS

Timing of insult	*Sound (dB)*	*Effects*
Intrauterine	>80 for >8 h at stretch	High frequency hearing loss; Prematurity, low birth weight, birth defects
Newborn	>45	Damage to the cilia of the cochlea leading to hearing loss; Increased blood pressure, heart rate, respiratory rate, and decreased oxygen saturation; Increased need in oxygen and energy consumption.
		Changed behavioral and physiological responses of infants. Enhanced pain perception.
Child	>70 for prolonged period or sudden exposure to >100	Learning disabilities, attention difficulties. Ruptured ear drum.

phones. Ear buds that do not fit tightly into ear canals can be promoted [26]. For pregnant women residing in areas with high environmental noise like airports or industrial zones, sound proofing homes with acoustic foam panels or installing carpets and wall coverings remain a viable option. Noisy machines inside home (washing machines, dishwasher) should be kept away from living areas as much as possible. Working females should try to spend some time away from noise in library, silent zones, or vacation to a quiet spot. Laws need to be strict regarding location of schools and houses. There should be segregation of residential and commercial zones while developing cities. Existing regulations against the use of loudspeakers in social gatherings need strict enforcement. "Cheers for ears", a pilot noise-induced hearing loss prevention program initiated by Government of Australia [27] is a novel initiative to reduce noise pollution.

Research is lacking in almost all areas related to children and noise. Indian Academy of Pediatrics has not issued any Guidelines on tolerable sounds and modes for prevention by excessive noise. Sources and ill-effects of noise are mostly well documented. Future research needs to focus on feasibility and role of interventions designed to reduce and/or prevent noise. Advocates of child health should call to emphasize and work towards the 'Right to a Noise-free Environment for Children.'

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