

Noise Pollution as a Cardiovascular Health Hazard

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Abstract— Introduction: Noise pollution is a health hazard and induces both auditory and non-auditory effects. Extensive levels of noise are associated with a high risk of physiological changes such as hypertension, increased levels of heart beat rate, peripheral vasoconstriction and thus peripheral vascular resistance. Noise can trigger both endocrine and autonomic nervous system responses that in turn affect the cardiovascular system and may be a high risk for the appearance of cardiovascular disease.

Aim: This retrospective study provides a comprehensive review of the new evidence linking noise pollution to cardiovascular risk. It considers some fundamental issues concerning noise and its consequences on the cardiovascular system.

Method: An extensive review of the International literature was performed through the electronic databases Pubmed, Scopus and Google Scholar and the Association of Greek Academic Libraries Link (Heal-Link), using as key words the following terms: noise pollution, noise exposure, cardiovascular risk, hypertension.

Results: Sleep deprivation or fragmentation is usually considered the most severe non-auditory effect of noise pollution, which in turn affects the cardiovascular system. Noise exposure is also associated with hypertension and consequently with other cardiovascular disease, the results from the literature, however, are inconclusive.

Conclusions: Noise pollution has many adverse effects on health and especially on the cardiovascular system. Understanding the harmful effects of noise pollution on cardiovascular health will help us to take all the appropriate measures to prevent or to reduce the possible health risks.

Index Terms— noise pollution, noise exposure, cardiovascular risk, hypertension

I. INTRODUCTION

Noise pollution is a major age-old problem for humans, as noise, which is defined as “unwanted sound” causes temporary disruption in the natural balance leading to a number of health consequences. Florence Nightingale in 1859 in her book entitled ‘Notes on Nursing’ wrote that “Unnecessary noise is the most cruel abuse of care which can be inflicted on either the sick or the well”[1]. The adverse effects of noise in modern-day societies are huge as it interferes with people’s daily activities at school, at work, at

home and during leisure time [2]. Noise is a prominent feature of the modern environment including noise from industry and big machines working at a very high speed and high intensity, noise from transport traffic, and neighborhood [3]. All these sources of noise affect our everyday life without our being aware of it. It is impossible to voluntarily shut our ears in order to exclude unwanted auditory input even during our sleep [4]. In 1972 Saphiro and Baland were the first who recorded the intensity of noise and noise pollution and described it as the “third pollution” after the air pollution and water pollution [5]. Noise pollution is a by-product of urbanization, industrialization, economic growth and motorized transport [2].

Given the fact that noise is a health hazard and induces both auditory and non-auditory effects, it should be avoided [6]. Noise is a stress mediator and as such impairs concentration and communication, causes sleep disturbance, changes in psychosocial behavior, and poorer performance in all aspects of everyday life [2], [7]. Extensive levels of noise are also associated with a high risk of physiological changes such as hypertension, increased levels of heart beat rate, peripheral vasoconstriction and thus peripheral vascular resistance. In addition, noise causes headaches, irritability, nervousness, feeling of fatigue, which in combination with the all previous mentioned factors adversely result in more severe and chronic health issues [6], [8]. Noise can trigger both endocrine and autonomic nervous system responses that in turn affect the cardiovascular system and may be a high risk for the appearance of cardiovascular disease, especially when there is a long-term daily exposure or an acute exposure to noise of high intensity [9], [10].

II. CARDIOVASCULAR EFFECTS OF NOISE DURING SLEEP

Sleep is characterized as a naturally recurring state of mind which is of vital importance for human’s development, health and well-being [11]. It is a complex and very active process, incorporating many essential physiological procedures such as protein biosynthesis, specific hormonal release, memory consolidation, glucose regulation that, in a broad sense, leads to normal functioning of the cardiovascular system and helps a person to recuperate and be adequately prepared for the next wake period [12], [13]. When individuals fail to obtain adequate duration or quality of sleep, they may experience reduced performance, measurable changes to different organic systems, especially to cardiovascular system and, increased risk for accidents and death. For all these reasons, sleep deprivation or fragmentation is usually considered the most severe non-auditory effect of noise pollution [14], [15]. Sleep environment and culture seem to play an important role on the quality and quantity of sleep. Differences in attitudes about the acceptability of daytime sleep periods and cultural beliefs regarding the relative value of nocturnal sleep are apparent among different ethnics [16]. In the industrial world the opportunity to sleep as needed gradually disappeared as a

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consequence of technological advances and working practices. It has also far removed from the biological norm that our organism is prepared to expect due to continued growth of a 24 hour culture in most developed countries which results from a number of factors including more activity and noise external stimulus' intrusion into the night-time sleep period. More people nowadays sleep during the daytime when the noise levels are higher [11].

There are many side-effects of daytime noise exposure, but the risk tends to be increased during night. The relationship between night noise and health effects in the population, according to WHO and NGG is divided into four ranges of continuous outside sound level at night. When the noise level is <30 dB, there aren't any biological effects of considerable importance. The primary effects on sleep start to appear at the level of 30-40 dB, in which the harmful effects concern mainly vulnerable groups of patients. These effects become more severe at the level of 40-55dB, and vulnerable groups are seriously affected in this stage. The most adverse health effects occur frequently with high percentage of the population more annoyed by noise of more than 55dB [11]. The noise threshold for cardiovascular problems derived from chronic nighttime exposure is determined as the noise level of light traffic, which is about of at least 50 A-weighted decibels [17]. The effect of noise on sleep, however, not only depends on the acoustical parameters of noise but also on the individual mediating factors such as personality characteristics and diurnal type, age and self-estimated sensitivity to noise [18].

Exposure to environmental noise during night has been shown to be closely related to an increased risk of sleep fragment, resulting in redistribution of time spent in the different sleep stages [13]. Slow- wave sleep which is the most restorative sleep stage has been associated with decreased heart rate, blood pressure, sympathetic nervous activity and cerebral glucose utilization, compared with wakefulness. Furthermore, growth hormone is released and stress hormone cortisol is prevented [13], [19]. Normally, the previously mentioned sustained decrease in blood pressure during night (known as dipping) contributes to gentle resetting the cardiovascular system and maintaining cardiovascular health [20]. Thus, disruptions to sleep increase arousals or fragmentation that are associated with a sustained increase in daytime blood pressure (nondipping blood pressure profile) linking acute and long-term effects of noise exposure on hypertension with the cardiovascular disease occurrence, in line with the general stress theory [21]. The physiological theory of stress highlights the roles played by epinephrine and norepinephrine secretion in the activation of the sympathetic-adrenal medullary system, and to hormone output from the pituitary-adrenocortical axis [22]. The auditory orienting response, startle reflex and defensive response translate sound stimuli into action and sometimes into stress induced bodily changes through "fight or flight" neural mechanisms [23]

III. NOISE EXPOSURE AND CARDIOVASCULAR RISK

Hypertension is a well-known risk factor for cardiovascular disease and more precisely for the prevalence and incidence of ischaemic heart disease (IHD). Transportation noise studies that have been conducted to examine the potential

effects of environmental noise on cardiovascular health show a possible link between noise exposure and myocardial infarction, for which noise-induced hypertension may be one of the path ways [24].

Although there is a considerable part of literature nowadays linking environmental noise exposure with hypertension and consequently with other cardiovascular disease, the results, however, are inconclusive. In many cases they considered to be supportive rather than definite due to failure to reach the level of statistical significance [25]. Furthermore, there is a certain degree of heterogeneity among studies regarding the age, gender, mean of assessment/ measurement of exposure, duration of exposure, and sound level used, leading to mixed results [12].

The results of a meta -analysis regarding the association between road traffic noise and cardiovascular risk, in which 37 studies were included, show that the strongest evidence of a relation between environmental noise and cardiovascular endpoints was found for ischemic heart diseases, including acute myocardial infarction, other acute and subacute forms of ischemic heart disease, old myocardial infarction, angina pectoris, and coronary atherosclerosis. Most of these studies examined the effect of road traffic noise on cardiovascular system and were carried out on males, as the incidence rates of ischemic heart disease are usually higher in middle-aged male subjects [26]. This finding is consistent with more recent study in which it was found a significant higher systolic blood pressure per 10 dB increase of the road traffic noise level in middle-aged subjects with stronger and significant associations in men and older participants [27]. Unlike, another study about the association of hypertension with noise exposure, in which hypertension adjusted for some variables (age, smoking, occupational status and house type), it was found that the stronger association was among women. Furthermore, in this study was proved that a strong association between hypertension and traffic exposure was among those living at the same address for more than ten years and among those living in single-family houses than those living in apartments. This result can be explained if we take into account the differences that probably exist in building construction between the two residences. The apartments are more often equipped by triple-glazed windows. Other possible factors that may have an impact on the final results are the dilapidated state of the building as well as the place in the building where the window of the bedroom is located (eg near the street) [28].

In contrast with the previous mentioned results are the findings of Erkson's et al (2007) study in which was found that the impact from air traffic increases the risk of arterial hypertension in not annoyed by the noise participants [29]. This happened probably due to the concomitant exposure of these participants to other sources of noise and this fact led to these controversial findings.

Except from adults, noise pollution has negative consequences on children's cardiovascular system. Chronic aircraft noise exposure has been associated with raised blood pressure and has been interfered with impairments in reading comprehension and long-term memory [30]. Traffic noise at home has been also referred as a stressor that could affect children's blood pressure and especially pre-school children as well as in school children of age seven to eleven years old.

Noise around kindergartens, schools, and children's homes might be significantly related to, particularly, higher systolic blood pressure [31], [32].

IV. PREVENTION AND CONTROL OF NOISE POLLUTION

The first step in prevention and control of noise pollution is the careful planning of appropriate measures, such as measures to limit the noise at the source, to control the sound transmission path, to protect the receiver's site, to plan land use, and to raise public awareness. It is of major priority that the countries take precautionary measures for the noise prevention, but it is also important to implement measures to mitigate existing noise problems [33].

Environmental strategies for noise reduction should include a lot of measures, such as: keeping sufficient distance between airports and residential areas, occurrence of surveillance systems for noise-related adverse health effects, and introduction of the appropriate standards for the construction of new buildings. Furthermore, additional insulations of house can help the elimination of noise exposure from railroad and road traffic. Noise control in the work environment should involve all the measure that will reduce noise being generated, and/or will reduce the noise transmission through the air or through the structure of the workplace, including modifications of the machinery, the workplace operations, and the layout of the workroom [34]. Furthermore, land use planning should be implemented including calculation methods for predicting the noise effect caused by different sources of noise, noise level limits for various zones and building types as well as noise maps in which the existing noise situation is described [33]. Except from all the measures taken by the different countries, it is important each individual to be aware and to take personally any measures that will help him/her to reduce the existing noise in his/her own environment. For this reason information and awareness raising campaigns should be organized by each state in order the citizens to be adequately informed and prepared to manage the noise stimuli.

Information and awareness raising campaigns can be carried out at many environments, such as, kinder gardens, schools, work places, hospitals. Campaigns and information should be sensitive to the needs and knowledge of the target groups and should give the message that noise pollution is as dangerous as other sources of pollution and that's why should be prevented and controlled [33]. Some years before, Artists and Musicians against Tinnitus (AMMOT), a voluntary association in Sweden, prepared a video and carried out visits to schools and festivals to communicate with young people with the aim of raising awareness about preventing harmful noise and the importance of protecting the ears and hearing [35]. Initiatives of this kind can lead to a better understanding of the hazard and to realize that in order to protect our health it is essential taking and keeping the appropriate measures.

V. CONCLUSION

There is a sufficient evidence for a positive association between noise pollution and cardiovascular disease but because of a lack of consistent results due to a certain degree of heterogeneity among studies, it is difficult to arrive to a definite conclusion. Unadequate duration or quality of sleep causes multiple biological changes to the cardiovascular

system and noise-induced hypertension is considered to be a possible path way that links noise exposure to cardiovascular diseases. Understanding the harmful effects of noise pollution on cardiovascular health will help us to take all the appropriate measures to prevent or to reduce the possible health risks.

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