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THE EFFECT OF NOISE POLLUTION ON HUMAN CARDIOVASCULAR SYSTEM.

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Abstract

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 heartbeat 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 maybe a high risk for the appearance of cardiovascular disease. This work 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. 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 diseases, the results from the literature, however, are inconclusive. 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.

KEYWORDS:
Cardiovascular Risk, Hypertension, Noise Exposure, Noise Pollution, Sleep Deprivation

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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 several health consequences. Florence Nightingale in 1859 in her book entitled ,,Notes on Nursing" wrote that "Unnecessary noise is the cruelest abuse of care which can be inflicted on either the sick or the well (Nightingale, 1860). 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 (WHO, 2011). 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 (Stansfeld & Matheson, 2003). Babisch (2005) is on the view that all these sources of noise affect our everyday life without our being aware of it. It is impossible to voluntarily shut our ears to exclude unwanted auditory input even during our sleep. 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 air pollution and water pollution (Shapiro RA, Berland, 1972). Noise pollution is a by-product of urbanization, industrialization, economic growth and motorized transport (WHO, 2011).

Given the fact that noise is a health hazard and induces both auditory and non-auditory effects, it should be avoided (Babisch, 2015). According to WHO (2011) and Shambo, Umadhay & Pedoto (2015) 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. Extensive levels of noise are also associated with a high risk of physiological changes such as hypertension, increased levels of heartbeat rate, peripheral vasoconstriction, and thus peripheral vascular resistance. Besides, 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 [Babisch, 2015; Conserve Energy Future (CEF), 2015]. Noise can trigger either endocrine and autonomic nervous system responses that in turn affect the cardiovascular system

and maybe 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 (Van Kempen et al., 2002; Willich, 2006).

PURPOSE OF THE STUDY

The purpose of this retrospective study is to provide a comprehensive review of the new evidence linking noise pollution to cardiovascular risk. Also, it considers some fundamental issues concerning noise and its consequences on the cardiovascular system.

THE CONCEPT OF NOISE POLLUTION

Noise pollution, also known as environmental noise or sound pollution, is the propagation of noise with a harmful impact on the activity of human or animal life. The source of outdoor noise worldwide is mainly caused by machines, transport (especially planes) and propagation systems (Hogan & Latshaw, 1973). Poor urban planning may give rise to noise pollution, side-by-side industrial and residential buildings can result in noise pollution in the residential areas. Some of the main sources of noise in residential areas include loud music, transportation noise, lawn care maintenance, nearby construction, explosions, or young people yelling (sports games). Noise pollution associated with household electricity generators is an emerging environmental degradation in many developing nations. The average noise level of 97.60 dB obtained exceeded the WHO value of 50 dB allowed for residential areas (Menkiti & Agunwamba, 2015). Research suggests that noise pollution is the highest in low-income and racial minority neighborhoods. Documented problems associated with urban environment noise go back as far as ancient Rome.

High noise levels can contribute to cardiovascular effects in humans and an increased incidence of coronary artery disease. In animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss. While the elderly may have cardiac problems due to noise, according to the World Health Organization, children are especially vulnerable to noise, and the effects that noise has on children

may be permanent. Noise poses a serious threat to a child's physical and psychological health, and may negatively interfere with a child's learning and behavior.

CARDIOVASCULAR EFFECTS OF NOISE DURING SLEEP

According to Hume (2010), sleep is characterized as a naturally recurring state of mind which is of vital importance for human development, health, and well-being. 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 (Münzel, Gori, Babisch & Basner , 2014; Halperin, 2014). When individuals fail to obtain adequate duration or quality of sleep, they may experience reduced performance, measurable changes to different organ systems, especially to the 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 (Cirelli, 2015; Muzet, 2007). Sleep environment and culture seem to play an important role in 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 (Babisch, 2015). In the industrial world the opportunity to sleep as needed gradually disappeared as a consequence of technological advances and working practices. It was 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 several 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 (Hume, 2010).

There are many side-effects of daytime noise exposure, but the risk tends to be increased during the 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.

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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 a high percentage of the population more annoyed by the noise of more than 55dB (Hume, 2010). The noise threshold for cardiovascular problems derived from chronic nighttime exposure is determined as the noise level of light traffic, which is about at least 50 A-weighted decibels (Mead, 2007). 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 (Salami & Adebayo, 2014).

Exposure to environmental noise during the night is closely related to an increased risk of sleep fragment, resulting in redistribution of time spent in the different sleep stages (Halperin, 2014). Slow-waves 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 (Halperin, 2004 and Van Cauter, Spiegel, Tasali & Leproult, 2008). Normally, the previously mentioned sustained decrease in blood pressure during the night (known as dipping) contributes to gentle resetting the cardiovascular system and maintaining cardiovascular health (Sayk, Becker, Teckentrup, Fehm, Struck & Wellhoener, 2007). Thus, disruptions to sleep increase arousals or fragmentation that are associated with a sustained increase in daytime blood pressure (non-dipping 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 (Haralabidis et al., 2008). 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 (Evans & Cohen, 1987). 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 (Westman & Walters, 1981).

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). Swift (2010), 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 pathways.

Although there is a considerable part of literature nowadays linking environmental noise exposure with hypertension and consequently with other cardiovascular diseases, the results, however, are inconclusive. Ndrepepa and Twardella (2011) opine that in many cases they considered being supportive rather than definite due to failure to reach the level of statistical significance. 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 (Münzel, Gori, Babisch & Basner, 2014).

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 relationship between environmental noise and cardiovascular endpoints was found for ischemic heart diseases, including acute myocardial infarction, other acute and sub-acute 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 the cardiovascular system and were carried out on males, as the incidence rates of ischemic heart disease are usually higher in middle-aged male subjects (Babisch, 2008). This finding is consistent with a more recent study in which it was found a significantly 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 (Sørensen, 2011).

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, 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 with 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 (e.g. near the street) (Bluhm, Berglind, Nordling & Rosenlund, 2007).

In contrast with the previously mentioned results are the findings of Erıkson's et al (2007) study in which was found that the impact from air traffic increases the risk of arterial hypertension is not annoyed by the noise participants. 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 for 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 (Stansfeld. & Matheson, 2003). Traffic noise at home has been also referred to as a stressor that could affect children's blood pressure and especially pre-school children as well as in school children age seven to eleven years old.

Noise around kindergartens, schools, and children's homes might be significantly related to, particularly, higher systolic blood pressure (Babisch, Neuhauser, Thamm & Seiwert, 2009).

PREVENTION AND CONTROL OF NOISE POLLUTION

According to WHO (1999), 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

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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 noise prevention, but it is also important to implement measures to mitigate existing noise problems.

Environmental strategies for noise reduction should include a lot of measures, such as: keeping sufficient distance between airports and residential areas, the occurrence of surveillance systems for noise-related adverse health effects, and the introduction of the appropriate standards for the construction of new buildings. Furthermore, additional insulations of the 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 the structure of the workplace, including modifications of the machinery, the workplace operations, and the layout of the workroom (Hansen, 2009). 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 (WHO, 1999). Except for all the measures taken by the different countries, it is important for each individual to be aware and to take personally any measures that will help him/her to reduce the existing noise in his/her environment. For this reason, information and awareness-raising campaigns should be organized by each state for the citizens to be adequately informed and prepared to manage the noise stimuli.

Information and awareness-raising campaigns can be carried out in many environments, such as kinder gardens, schools, workplaces, 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 is why should be prevented and controlled (WHO, 1999). 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 (Bistrup ML, Keiding, 2002). Initiatives of this kind can lead to a better understanding of the hazard and to realize that to protect our health it is essential taking and keeping the appropriate measures.

CONCLUSION

There is 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 at a definite conclusion. Inadequate duration or quality of sleep causes multiple biological changes to the cardiovascular system and noise-induced hypertension is considered to be a possible pathway 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.

RECOMMENDATIONS

Based on the findings, the following recommendations were considered appropriate:

a. Governments should ruminate the protection of populaces from community noise as an integral part of their policy for environmental protection.
b. Governments should consider employing action plans with short-term, medium-term and long-term goals for reducing noise levels.
c. Governments should embrace the health guidelines for community noise as targets to be achieved in the long-term.
d. Governments should include noise as an important subject when assessing public health matters and funding more research related to the health effects of noise exposure.
e. Legislation should be enacted to reduce sound pressure levels, and existing legislation should be enforced.
f. Municipalities should develop low-noise implementation plans.

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