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ENVIRONMENTAL NOISE: HEALTH AND POLICY - AN UP TO DATE MINIREVIEW

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Abstract

Noise is considered as an "unpleasant sound". Since ancient times noise was perceived like a disruptive element. In the last three centuries, particularly in industrialized countries, the noise became a major public health issue, especially for the hearing system. The harmful effects of noise are felt not only by the hearing system, but also by other systems (cardiovascular, central nervous system by affecting sleep and cognition) and it was recently pinpointed that the immune system and the fetus are affected. Studies conducted in several large cities from Romania, starting with the year 2000 show that a significant percent of population living in urban areas is exposed to over 55 dB noise during the day and above 50dB at night, the situation being identical with the one existing in other EU countries. There are more than two decades since the EU has been working on developing a harmonized noise policy. Until 2020, the EU policy's main objective is to ensure that "noise pollution in the Union will significantly decrease, moving closer to WHO-recommended levels".

Keywords: environment, health, noise, policy, urban area

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1. Introduction

1.1. Deafness and environmental noise

Noise is defined as "an unpleasant sound" (https://www.collinsdictionary.com/us/dictionary/english/noise), perceived as an element of stress or annoyance (Gille et al., 2017). In the last years the studies regarding the effect of noise on health have increased (Babisch, 2014; Dzhambov et al., 2018; Foraster et al., 2018; Recio et al., 2018; Sears et al., 2018; Simion et al., 2017; Zare Sakhvidi et al., 2018). Hearing loss secondary to inner ear disorders and / or to auditory nerve illness has long been called perception-hearing loss. Nowadays, with the emergence of new diagnostic tools and treatment technologies for deafness, especially with the discovery of the cochlear implant - which allows rehabilitation in the cochlear deafness (Radulescu and Martu, 2007) - many authors suggest that the term "sensorial" should be used more specifically, such as for cochlear deafness. For situations where the auditory nerve is affected "neural hearing loss", should be used.

There are multiple sensorineural hearing loss causes. Among the most common are: aging (presbyacusis), noise or genetic mutations (Radulescu et al., 2018). Although rare, infections, some drugs and circulatory disorders (Cobzeanu et al., 2012, Cobzeanu et al., 2013) etc. have been mentioned.

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Hearing loss and tinnitus may be the direct consequence of exposure to excessive noise, either long term or repeatedly (Platon et al., 2017; Zhao et al., 2018). It can also be the effect of short-term exposure to extremely intense noise (Hu and Zheng, 2008). The sensory neural elements of the hearing apparatus are damaged by acoustic energy through direct mechanical action, also by ischemia and cytotoxicity (Olivetto et al., 2015). Exposure to long-lasting sounds implies greater oxygen consumption by ciliated cells. This increased oxygen consumption generates high levels of free radicals in the cochlea (Cavaleriu et al., 2015). Radicals can induce cell death. Hearing loss may be permanent or temporary and it is usually bilateral.

The harmful effects of high levels of noise (Table 1) are felt not only by the hearing system, but also by other systems (cardiovascular, central nervous system by affecting sleep and cognition) (Kerns et al., 2018; Münzel et al., 2018; Passchier-Vermeer and Passchier, 2000). Recent studies attribute exposure to noise to more disturbances in the human body, particularly to the immune system and the fetus (Passchier-Vermeer and Passchier, 2000). Regarding the environmental noise effect on children - it is proved that exposure to noise during the pregnancy was associated with metabolic anomalies, that may cause the infant to have low weight at birth. Women exposed to 80 dB for 8-hour shifts have an increased risk of preterm delivery (relative risk, 1.6; 95% confidence interval, 0.9 to 2.9) (Mamelle et al, 1984).

Table 1. Levels of noise that may have harmfully effects on health

Effect	*Level of evidence*	*Db*
Hearing impairment	Sufficient	75
Hypertension	Sufficient	85
Ischemic heart disease	Sufficient	70
Annoyance	Sufficient	55
Performance in school	Sufficient	70
Sleep disturbances	Sufficient	
Sleep patern	Sufficient	60
Subjective sleep quality	sufficient	40

Children are particularly affected by environmental noise exposure. WHO estimates that 45000 healthy years are lost yearly in Western Europe due to cognitive impairment in children. The European Union has founded some studies that assessed the effects of transportation noise on children's health generally and with focus on cognition and deafness. A comprehensive multinational (Netherlands, Spain and the United Kingdom) research, RANCH project (Road Traffic and Aircraft Noise and Children's Cognition and Health) intended to evaluate cognition, shows that chronic noise exposure of children is detrimental to: task performance, recognition memory, reading comprehension. Also, the study confirmed that the children experience annoyance and loss of attention as negative effects of road noise exposure.

The second project founded by EU examined the effect of traffic noise on children′s hearing PINCHE (Policy Interpretation Network on Children's Health and Environment). The conclusion of this study was that road noise affects hearing both instantaneously and on long term by having a cumulative effect (Bistrup et al., 2006).

Forty-eight percent of the inhabitants from areas with noisy road traffic present sleep disturbances and only 12.9% from the ones living in quite areas. The association between insomnia and night traffic noise was found statistically significant (Evandt et al., 2017). Use of sleeping medicine might represent an important parameter in quantification of the magnitude of sleep disturbances. Results of the studies are controversal. Some studies found a highly significant correlation while in other studies the association is not clear (Evandt et al., 2017). When it comes to exposure to aircraft noise-a strong association with the use of sleep medication was found (Franssen et al., 2004).

2. Case-studies

2.1. Environmental noise in Europe and Romania

From the existing data, 65% of Europeans living in urban areas are exposed to 55 dB noise and above, during the day and 20% are exposed to noises above 50dB at night (EEA, 2018).

In Romania studies in several large cities indicate that:

- In Brasov over 100,000 inhabitants are exposed to over 55dB noises during the day and noises over 50dB at night (Chiru et al., 2009).
- Secondary road traffic noise in Cernavoda has increased at an important rate due to population growth, degradation of road infrastructure and an increase in the number of heavy and diesel cars. Measurements made in this setting have a noise level between 68 and 88 dB (Manea et al., 2017).
- In Cluj Napoca, the noise mapping action started in 2000, coordinated by the local public administration and that was finalized in 2007, revealed that a total of 6.67% of the population of Cluj is exposed to excessive noise (Popescu et al., 2013).
- In Iasi, a study by Oişte AM (Sărăriei and CA Rosetti streets) from 2015 reveals that street noise values are ranging from 43 to 65 dB in August - the month in which most residents are away on vacation and between 47 and 74.5 dB in October (Oiste, 2015).

In 2012, Romania has reported the strategic noise map for 19 agglomerations, each with more than 100 000 inhabitants (Arad, Bacau, Baia Mare, Botosani, Braila, Brasov, Bucharest, Buzau, Cluj-Napoca, Constanta, Craiova, Galati, Iasi, Oradea, Pitesti, Ploiesti, Sibiu, Targu Mures, Timisoara), covering more than 5 million people. The level of noise for the considered areas show that more than 2 million people are exposed at L_{den} (day-evening-night noise level) that exceed 55 dB (the WHO recommended threshold for day noise) and nearly one

million people are exposed to levels that exceed 65dB, with more than 250 000 people being exposed to noise levels above 70-75dB. Regarding night levels of noise, over 1 500 000 of people are exposed to noise levels that exceed the WHO recommended thresholds of 50dB and more than 400 000 people are exposed during the night to road noise levels between 60dB and 69dB. The most exposed five agglomerations to road noise during the day, by decreasing order are: Bucharest - with more than 800 000 people exposed to day levels of noise greater than 55dB, followed by Craiova, Iasi, Ploiesti and Pitesti each of them with almost 200 000 affected inhabitants. On the other hand, the urban agglomeration with the lowest number of affected people by noise traffic are: Baia Mare, Cluj Napoca, Arad, Braila and Brasov with less than 30 000 affected inhabitants in each city. The same ranking also applies for nocturnal noise levels.

Due to incomplete information from the other cities included in the study, the trend of pollution between 2007 to 2012 could be observed just for 4 urban agglomerations: Iasi, Bucuresti Craiova and Cluj. There is a decrease in the number of people exposed in Bucharest for L_{den} and an increase of number of people exposed in Cluj to L_{night} (night noise level) while in Iasi and Craiova all the levels remained the same.

We can conclude that more than half of the studied group from Romanian is exposed to road noise levels above the established limit of 55dB L_{den}. Austria, Estonia, Ireland, Lithuania, the Netherlands, Poland, Spain and Switzerland reported similar statistics to Romania with more than 50 % of inhabitants being exposed to road noise above 55dB L_{den} in urban areas with over 100 000 inhabitants. Belgium, Bulgaria and Luxembourg reported more than 75% of inhabitants exposed to road traffic noise. (Fig. 1) (EEA, 2014). The trend of the noise levels in European countries shows that there is an overall increase in the segment of people exposed to 65-69 dB and to 70-74 dB Lden and, simultaneously, a reduction in the number of people exposed to values above 75 dB in some countries (EEA, 2014).

2.2. Noise sources

The development of economic activities, the acquisition of agricultural lands by various companies have led us to witness the migration of the population to urban areas in recent years. Fast urbanization in Europe and also in Romania has led to a concentration of population in large cities, so a European ranking highlights that 97% of the Belgian population lives in cities, the UK is ranked second with 90%, followed by Denmark with 86%, Spain and France with 77%, Germany with 75%, etc. As far as our country is concerned, Romania reached the urbanization threshold of 50% in 1985, and the maximum urbanization was 54% - in 2014 (World Urbanization Prospect, 2015).

In industrialized countries in particular, noise is a major public health issue (WHO, 2011a). The risk of excessive noise exposure is present in many of the daily life activities: at work and in activities independent of the profession. If we refer to workplace noise, statistics show that in an industrialized country (such as USA, Germany) - 12 to 15% of the workforce is exposed on a daily basis to noise levels above 85dB (http://www.who.int/occupational_health/publications/noise5.pdf). In addition to exposure to workplace noise, individuals are increasingly exposed to noise from non-occupational sources.

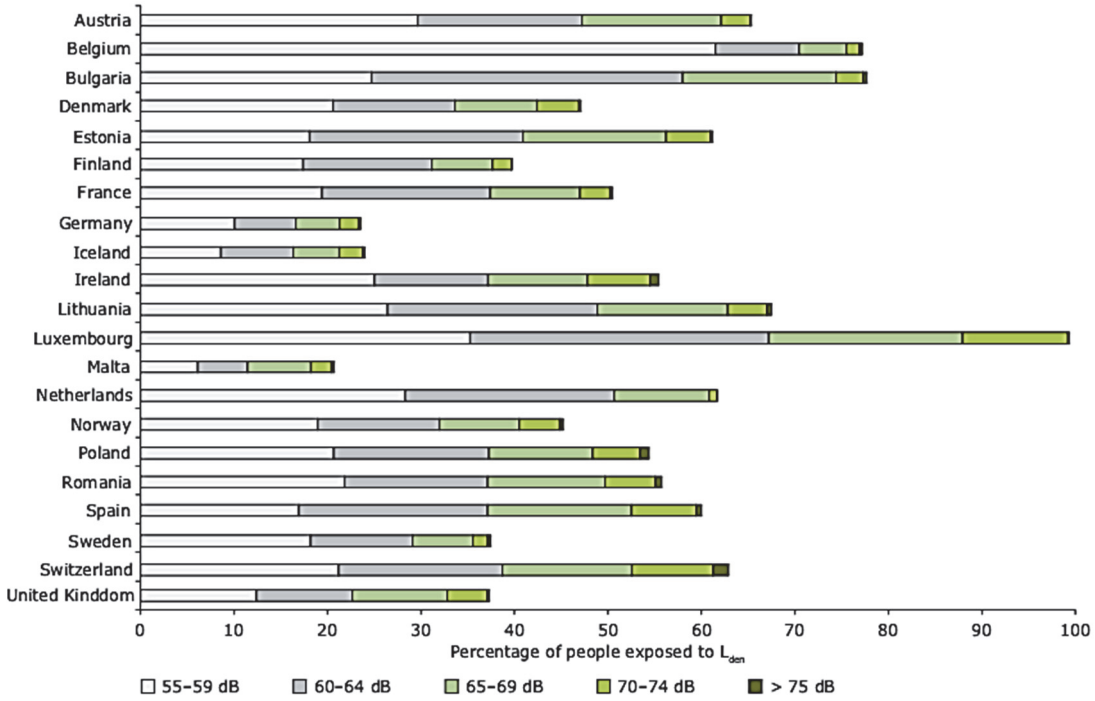

Fig.1. Percentage of population exposed to road noise, L_{den}, in 294 urban areas in European Member States (2012)

Recreational noises are a source of noise with a significant increase in recent years (discos, nightclubs, concerts, sports events). It is also worth mentioning the use of personal recreational devices at a high volume level.

Traffic noise exposure (road, air, and rail) holds a special place in acoustic trauma causes. In West European countries it was estimated that traffic noise is responsible for DALY 1 - 1.6 million (disability-adjusted living years) (WHO, 2011b; WUPH). It is estimated that by 2020, 80% of the people will live in urban areas. (EU Eurostat, 2017). This implies an increase in noise pollution from intensified road traffic. In fact, in the third quarter of 2017, there was a 68% growth in passenger car registrations compared to the same quarter of 2016 (http://www.economica.net/crestere-de-58prc-a-inmatricularilor-de-masini-in-2017-627-743-de-unitati_149634.html).

3. Results and discussions

3.1. Environmental noise and policy

The harmful effects of noise have been recognized since ancient times. Even before the Christian Age there were regulations on limiting noise sources in communities. Thus, the first known mention dates back to the year 600 BC, when the city council of Sybaris, a town in the Calabria region (Magna Greece) decided that potters and tinsmiths must live outside the city because of the noise they made and also that no inhabitant could have roosters in homes (Wong, 2018). In 500 BC Hippocrates identified tinnitus (ringing in the ear) to be caused by prolonged exposure to noise (Sandlin and Olsson, 1999). In 44 BC Julius Caesar issued a decree banning the chariots to be driven after sunrise along the streets of Rome or in the suburbs where there was continuous housing.(http://avalon.law.yale.edu/ancient/law_of_caesar.asp).

In the 16th century London, the law forbid the noise on the streets "No man after the hour of nine in the night sudden outcry in the still night ... or beating his wife, or servant, or singing ... to the disturbance of his neighbors under the four shillings four pence" (Bohun, 1702). In 1713, the Italian physician Bernardino Ramazzin, considered the founder of industrial medicine, published the first paper in which he described the link between deafness and occupational noise in coppersmiths and suggested that they should protect themselves (Douke, 2014; Franco, 1999). In 1864, following a petition addressed to the British Parliament by London intellectuals including Charles Dickens - who complained about the disruptive noise produced by street musicians - the Act for Better Regulation of Street Music in the Metropolis was issued. Today, mostly due to the urbanization and industrialization, noise is becoming more and more of a problem in the European cities (Goines and Hagler, 2007). In 2010 EC asked for a survey to evaluate the perception of noise by the EU citizens. The survey included 27 EU countries (26602 respondents). Eighty percent of participants believed that noise affects their health, either to some or to a great extent (EC Eurobarometer 73.3, 2010). A Eurobarometer report based on 28 000 respondents of 28 EU countries showed that 15% of respondents are concerned about the noise pollution, considering it to be one of top five environmental issues (EC Special Eurobarometer 416, 2014).

Every four years, in Europe, quality-of-life surveys are conducted. These surveys evaluate the quality of life of European citizens using objective and subjective parameters. The last survey, conducted in 2016–2017, has involved nearly 37 000 citizens and comprises questions related to environmental noise exposure. Third of the respondents, of whom 49% being from cities, reported problems with noise (between 14% and 51%, depending on the country) (EUROFOUND, 2017).

There are more than two decades since the EU has been working to develop a harmonized noise policy. Finally, in 2002, the European Commission (EC) adopted and implemented a directive which has the following main objective: "to define a common approach intended to avoid, prevent or reduce on a prioritized basis the harmful effects, including annoyance, due to exposure to environmental noise". This directive was named: Environmental Noise Directive (END) (EC Directive, 2002).

As a result of Directive 2002/49/EC of the European Parliament, the EC has introduced common noise indicators (day-evening-night noise level - L_{den} and night noise level - L_{night}) and common noise assessment methods (EC Directive, 2015). Using these parameters and methods each and every Member State was required to create strategic noise maps as a first step in fighting the environmental noise.

According to the END, a strategic noise map is "a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area". The minimum requirements for strategic noise mapping are also listed in the END documents.

In 2012 the noise strategic maps were reported at the European level. In April 2014 the Council and the European Parliament adopted the Regulation (EU) no. 540/2014 regarding the sound level of motor vehicles and of replacement silencing systems. The main objective of this directive is to reduce the noise at source. It is expected that the traffic noise in Europe will decrease by the middle of 2027. However there are qualified opinions such as the German Federal Environment Agency and also of different other authors who evaluate the impact of Regulation 540/2014 and predict that, in their country, the effect will be almost absent, due to insufficient measures proposed by the action plan and the lack of an effective method for noise measurements (http://www.uba.de/uba-info-medien-e/4270.html; De Vos, 2009; King et al., 2011; Magri et al, 2009).

Until 2020 the EU policy has as main objective to ensure that "noise pollution in the Union will significantly decrease, moving closer to WHO - recommended levels" (Table 2) (WHO, 2018).

Table 2. WHO noise level recommendation depending to source

Type of source		***Noise limit***
Road traffic	during day	53 dB
	during night	45 dB
Railway noise	day	54 dB
	night	44 dB
Aircraft noise	day	45 dB
	night	40 dB
Wind turbine noise	day	45 dB
	night	No recommendation
Leisure noise		70 dB

4. Conclusions

Due to its obvious disruptive effect, recognized ever since the ancient times, the lawmakers tried over time to limit the level of noise in inhabited areas. In recent years, urbanization, industrialization, car traffic growth etc. have led to a significant increase in the environmental noise level throughout Europe, affecting more and more people.

Studies on the effects of environmental noise on health have also multiplied in the last few years. They are showing that the environmental levels of noise have increased nowadays to intensities that profoundly affect the comfort and health of the population. As a result, noise pollution became subject of extensive debate in the European Council. The EC desired to unify the law all over the European Union, including our country, for a better management of noise sources with the stated intention to avoid, prevent and reduce the noise levels.

The aim of the Environmental Noise Directive END is to assess the environmental noise levels, to elaborate an action plan and implement it to reduce noise and to oversee its results. There are many voices that concluded even in the initial phases – those of noise measurement and of strategic noise mapping - were not executed properly and it was considered that the action plan proposed by END was insufficient.

Due to its harmful effects on health, noise pollution also caught the attention of WHO, so in 2018 WHO published "Environmental Noise Guidelines for the European Region". The guidelines provide strong recommendations on limiting ambient noise (as transportation and leisure noise) in order to ensure health protection of the European citizens'

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