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ENVIRONMENTAL NOISE AS A DETERMINANT OF PUBLIC HEALTH

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In recent decades, technological development has reduced the cost of releasing large amounts of acoustic energy, either through powerful audio devices, machinery and/or vehicles with noisy exhaust. Thinking about acoustical energy as an inefficiency indicator is not a usual approach; neither is it thinking environmental noise as a public health issue. Since the WHO LARES Report 2004 has shown that annoyance itself is a health problem caused by high urban noise levels, some decision makers have begun to be more sensitive to environmental noise issues. In 2011, the figures about burden of disease from environmental noise published by the WHO were greatly impressive: at least 903,000 healthy life years are lost every year due to sleep disturbance caused by traffic noise in Western Europe and 587,000 years due to annoyance also related to it. In Uruguay there are only very few researches about the linkage between noise and health. Some results about annoyance related to urban noise are presented in this paper. They have been obtained in Montevideo city; sound pressure levels and opinion of walking people on a commercial area have been simultaneously acquired on 2013-2014. These data are analyzed and they are also compared with others from another opinion survey done during 1998-1999 in the same city. The concept about noise as an indicator of quality of life should be replaced by a public health approach. This could also help to retrieve, at least in part, the loss of solidarity in modern societies.

1. Introduction

Annoyance due to exposure to high sound pressure levels was not considered as an adverse effect on human health for a long time. It was intended only as a "mediator" for the occurrence of other consequences, but not "an adverse on human health" itself.

In 2004 the WHO LARES Report, Large Analysis and Review of European Housing and Health Status has shown that chronic exposure to high noise levels activates a high level link between annoyance and increased morbidity. Its first expression is as increased risks to the respiratory system, then on the cardiovascular, respiratory and musculoskeletal; in adults, it also predisposes to depression in adults [1].

When annoyance is assumed itself as an effect, the consequences of high ambient noise levels become more worrisome. It suffices to see the results published by the WHO in the report of disease

and years of healthy life lost (adjusted life years disability DALY, for its acronym in Spanish, disability-adjusted life years, DALY), which indicates to environmental noise as one of the main perpetrators of public health [2]:

"... It is estimated that the years of healthy life lost each year in the member states of the European Union and other countries in Western Europe due to environmental noise are 61,000 years of life from ischemic heart disease, 45,000 years for cognitive impairment in children, 903,000 years for sleep disorders, 22,000 years by tinnitus (ringing or tinnitus) and 587,000 years of hassle. This entails that at least a million years of healthy life are lost each year due to traffic noise in the western part of Europe."

The greater or lesser tolerance that every society has to noise depends on a number of factors that make their culture, so that the sound pressure levels that can be acceptable and quotidian in one case may be unacceptable in another. This is supported by the notion of *noise* as a *social construction* [3].

2. Annoying sounds, annoyed by sounds

The prediction of annoyance caused by noise is not a simple issue. There are multiple causes involved on the different appreciations about how annoying are different sounds with the same sound pressure level -even if they are the same kind of sounds-. As the same noise can trigger different degrees of annoyance to different receivers, predicting people reactions with basis only on the physical characteristics of noise is rather impossible. As Baron has argued over 40 years ago [4]:

"We can measure sound; but we can only make estimates about noise."

The concept of noise pollution as a social construct is closely related to education, values, culture [3]. The levels and types of noise that are acceptable for a society tell about the prevailing cultural values in it and also about the main features of different human groups within it.The interpretation or meaning that a society attributes to certain sound messages can make some kind of music to be socially considered as noise and reciprocally, also enable the incorporation of some noises into music.

Some features of the sounds make them to be annoying for most of people. They use to be physical characteristics that can be measured objectively, such as intensity, spectral composition, duration, impulsivity or periodicity. But these parameters cannot explain by themselves the annoyance experienced by the receivers: works for several leading researchers about annoyance caused by noise show that the physical characteristics of the noise can hardly explain more than 30 % of the variability of opinions ([4]-[6]).

Noise is not only linked to socio-demographic factors but also to a complex combination of other conditions that sometimes are not easy to quantify. Other properties are more related to the source than to the emitted sound. It is the case of the sense of inevitability of the source, its temporary or permanent condition of operation, the predictability of the occurrence of the sound, the time of the day at which the sound is emitted.

There are also some features related to the receiver that can turn an acoustic signal into an annoying one because “so-and-so is annoyed by it”. This often occurs when there is an adverse social perception about the sound source or the effectiveness of regulations and controls on it; nowadays the attitude about wind energy in Uruguay also appears on the perception and valuation of noise from wind turbines. Then, the attitude toward the sound source, the relationship between the receiver and producer of the noise and the perceived possibilities to control the source -either directly or through third parties- are involved on annoyance by noise [7].

Last but not least, the main characteristics of the receiver play an important role: the age and gender, personality traits (introvert people feel more annoyance by noise than extroverted people), fear produced by the noise, the receiver activities potentially affected by the occurrence of the sound, the belonging sense of the receiver to the affected place and so on. There is agreement that

the most important variable is the individual sensitivity to noise: it can explain over 20 % of the variance [5].

3. Noise sensitivity

The annoyance caused by noise is understood as *"a feeling of displeasure associated with noise that is believed to adversely affect a person or group"* or as *"the general rejection toward a noise, but not only includes the rejection to the noise itself but also to many other variables related to the source and the context in which that noise is experienced"* [8].

It is not the same as *noise sensitivity*. The noise sensitivity refers to the predisposition to be bothered or affected by noise; it manifests at physiological and behavioral planes. It is a general response to any noise [6].

The sensitivity to noise has a physiological root: it is genetically determined [9]. It does not depend on neither is a consequence of hearing loss perceived by the individual. This fact confirms that no subjective response is involved, even in the case of people who have been harmed by noise (or they feel so) [10]. It cannot be taken as an indicator of overall environmental perception of people [11].

Moreover, when comparing the sensitivity to noise with the Chemical Sensitivity Factor, it was observed that they are uncorrelated. Even more, they are associated to different variables: noise sensitivity was significantly correlated with hostility, self-control, neurosis, consumption analgesic, anger, depression and stress. The Chemical Sensitivity Factor is significantly correlated with allergies and analgesic consumption. Differences between men and women were also found [12].

It is important to keep these data in mind, because noise sensitivity has been found to be a frequent trait of aggressive people, depressive ones or those suffering from headaches ([13]-[18]).

4. Environmental noise as a determinant of public health

According to the definition given by the World Health Organization [19]:

"Health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity."

From a human rights perspective, the noise can be defined as *"any imposed sound"* [20].

A more common and general definition of noise is: *"an unwanted sound signal that is not useful to the receiver"*. Just because it is an unwanted sound, perhaps imposed, it is likely to affect in some degree the welfare of the receiver, thus becoming a potential aggressor to health [20].

The approach of environmental determinants of health is actively developed by the Pan American Health Organization. Many studies are carried out from this perspective, to explain the role of different environmental and social factors on the health of people living under their influence [21]. However, very little awareness of the adverse consequences that can be expected in noisy societies still seems to exist or, if any, it is not clearly integrated into current environmental management practices, especially in urban areas [22].

The evidence of adverse effects of noise on health is not new. Every time are backed up by larger studies, particularly in regard to non-hearing effects. An interesting review of scientific publications regarding the effects of noise on health, from 1970 to 2004, shows that some of them have been confirmed about 40 years ago, while others are still under research [23]. Although until the late '90s a significant relationship in terms of morbidity and exposure to environmental noise had not been stated yet, some health effects have been reported as such since the early '70s ([24], [25]). Others, such as changes in hormonal secretions, including adrenaline, noradrenaline and cortisol, have been confirmed in the 90s [24]. Other ones are much more recent. For example, the relationship between exposure to high ambient noise levels and increased respiratory illness in children and in adults has been stated on 2004 [1]. Among the most recent findings, Sørensen et al. have demonstrated the

occurrence of a statistically significant incremental risk, greater than 1.1%, in the incidence of diabetes in adults between 50 and 64 years each time the level of traffic noise to increase by 10 dB [26].

Bearer adds evidences on some effects of noise exposure in children, as intrauterine growth lag, prematurity and hearing loss in high frequencies in the newborn when the mother is exposed to high noise levels during pregnancy [27]. He also points out the difficulties in language acquisition and auditory discrimination experienced by children living near major roads. It is also known that environmental noise affects the psychophysical development of children, with consequences such as lack of attention and concentration, learning difficulties, anxiety, mental fatigue, which result in poor school performance [20].

5. Annoyance by noise in Montevideo city

In this section, results from two inquiries about urban noise and annoyance are presented. They have been done in Montevideo, on 2013-2014 (with basis on [28], [29]) and on 1999 [30]. Unfortunately, these opinion surveys have been done in different frames, so as different methodologies and questionnaires have been designed for each instance.

It should be remarked in advance that neither on the first inquiry nor on the recent one noise has been considered a major environmental problem in Montevideo. However, when the questions focus rightly on noise, the respondents immediately consider that it is an important issue for quality of life.

In both instances, the first spontaneous response about the main sources of noise in the city put traffic noise at the top place.

5.1 Some results from 2013-2014 inquiry

As a general frame:

- 14 % of men and 21 % of women are very annoyed by traffic noise
- 64 % of men and 70 % of women are annoyed or very annoyed by traffic noise
- 67 % of who have technical or University education is annoyed or very annoyed
- 20 % of people 55 or more years old are annoyed or very annoyed by traffic noise
- 20 % of people 25 or less years old are annoyed or very annoyed by traffic noise

Only 18 % have declared themselves as “very annoyed” by noise. People who are very annoyed by traffic noise have the following features:

- 32 % are men and 68 % are women
- 54 % have technical or University education
- 22 % are 55 or more years old
- 29 % are less than 35 years old
- 12 % are less than 25 years old

About the very annoyed women, it can be said that 57 % of them have technical or University studies; 54 % are 55 or more years old; 25 % are 35 or less years old but only 14 % are less than 25.

When regarding the features of people who are annoyed or very annoyed by traffic noise, it has been learnt that:

- 39 % are men and 61 % women
- 55 % have technical or University education
- 20 % are 55 or more years old
- 54 % are less than 35 years old
- 25 % are less than 25 years old

Please, notice that the main difference between the profiles of "very annoyed" and "annoyed or very annoyed" people appears on the responses of the younger people

5.2 Comparison with 1999 results

When compared the abovementioned results with those of the 1999 inquiry [30], five main remarks are to be noticed:

- Concern about environmental noise continues to be low, even if awareness about traffic problems has grown
- Gender distribution of annoyed people is about the same.
- Concern has grown between people who have technical or University education; it is about 3 times the percentage of 1999.
- Younger people are now more concerned about noise than they were in 1999.
- The most annoyed people in 1999 were the elder (65 or more years old); in the new inquiry, they were those from 46 to 55 years old.

5.3 Noise sensitivity

Taking into account the incidence of noise sensitivity on annoyance by noise, the research team tried to learn something about this issue on the 2013-2014 inquiry.

As a part of the questionnaire, respondents were asked if they considered themselves sensitive to noise or not. Answers have shown some interesting results about gender and age.

When compared by gender, women are more sensitive to noise than men (Fig. 1).

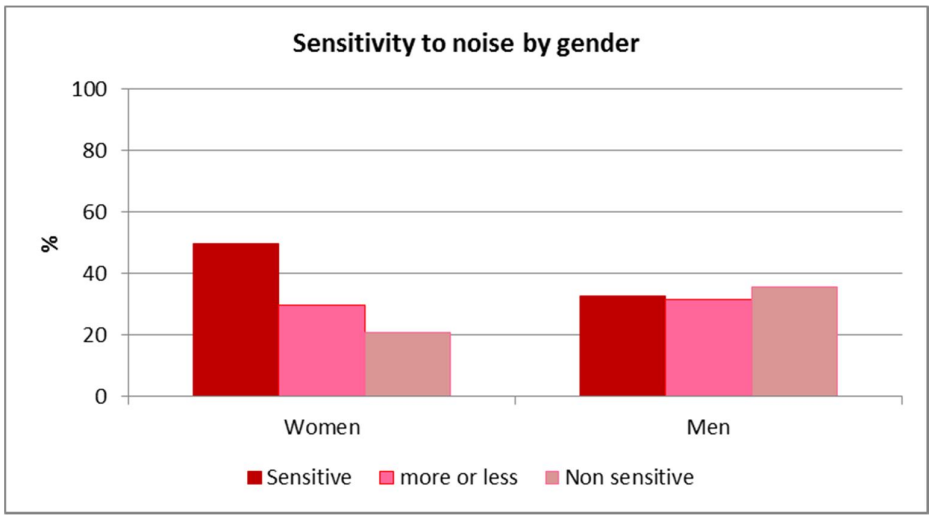

Figure 1. Sensitivity to noise by gender (Uruguay, 2013-2014)

For each gender, sensitivity to noise was analysed.

Men of different ages are distributed in a rather similar way in the three classes (Fig.2).

Women seem to have different responses connected to age: Women of different age seem to have different noise sensitivity: the percentage of sensitive women increases with age and the percentage of non-sensitive ones decreases as well (Fig. 3).

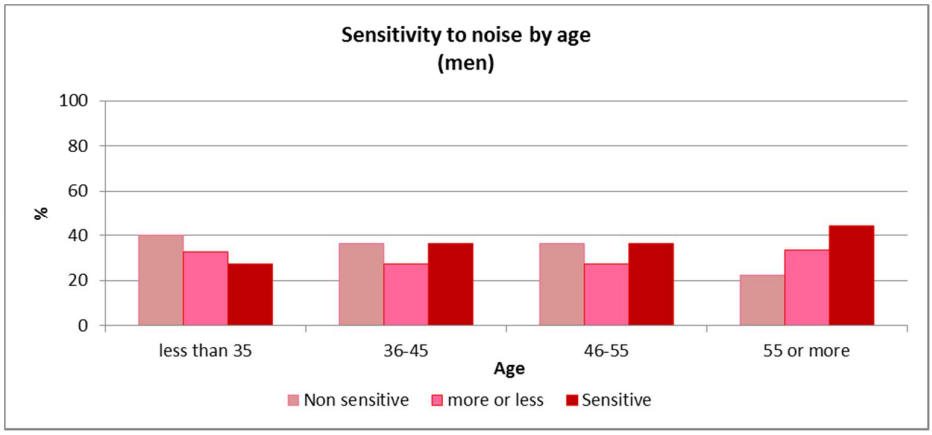

Figure 2. Sensitivity to noise by gender and age (Uruguay, 2013-2014)

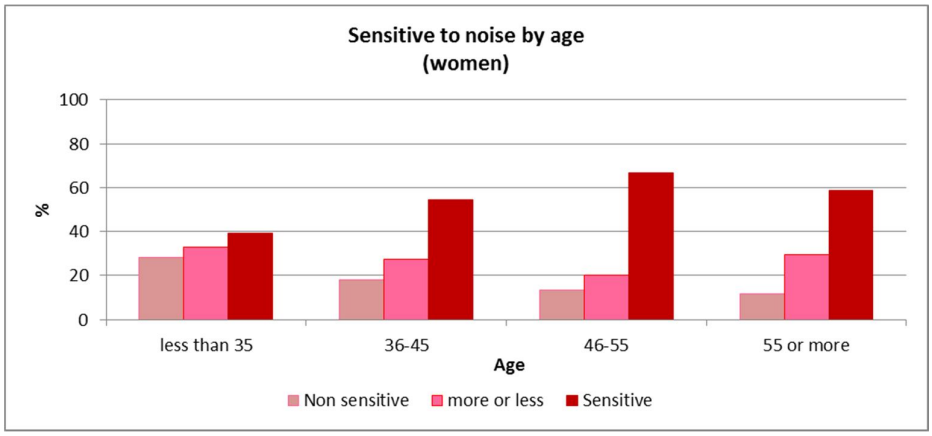

Figure 3. Sensitivity to noise by gender and age (Uruguay, 2013-2014)

6. Final remarks

Environmental noise and especially urban noise are to be considered as determinants of health and quality of life of the exposed populations.

Since 2011, urban noise and especially traffic noise are to be considered by the Word Health Organization as public health concerns.

Annoyance by noise depends on several factors: one of the most important is noise sensitivity.

Noise sensitivity, aggressiveness, depression and suffering from headaches share some biochemical and genetic basis, as they are linked to hormones and neurotransmitters.

Even if Montevideo people are not concerned about environmental noise, awareness about this problem seems to be increasing.

Sensitivity to noise has shown different patterns by gender and by age on Montevideo people: it is higher in women and it increases with the age.

REFERENCES

1 Niemann, H.; Maschke, Ch. (2004). WHO LARES. *Final report: Noise effects and morbidity*. Interdisciplinary research network "Noise and Health".

2 World Health Organization, Regional Office for Europe (2011). *Burden of disease from environmental noise. Quantification of healthy life years lost in Europe.* ISBN: 978 92 890 0229 5

3 Sexto, Luis Felipe. Communications to the network of researchers on urban noise, February 2000.

4 García Sanz, B.; Garrido, F. J. (2003). *La contaminación acústica en nuestras ciudades*. [Online] Available from: www.estudios.lacaixa.es © Fundación "La Caixa".

5 López Barrio, Isabel; Carles, José Luis; Herranz, Karmele. El estudio de los aspectos perceptivos en la acústica ambiental. *Revista de Acústica*. Vol. **31**. Nos 3 y 4, pp.1-5, 2000.

6 Martimportugués, C.; Gallego, J.; Ruiz, F. D. (2003). Efectos del ruido comunitario. *Revista de Acústica.* Vol. **34**. Nos 1 y 2 pp.31-39. Madrid, España.

7 Hanning, Ch. (2010) *Wind turbine noise, sleep and health. Sleep disturbance and wind turbine noise*, The Society for Wind Vigilance.

8 Alimohammadi, I.; Nassiri, P.; Azkhosh, M.; Hoseini, M. Factors affecting road traffic noise annoyance among white-collar employees working in Tehran. Iran. *J. Environ. Health. Sci. Eng*., 2010, Vol. **7**, No. 1, pp. 25-34.

9 Heinonen-Guzejev, Marja; Vuorinen, Heikki S.; Mussalo-Rauhamaa, Helena; Heikkilä, Kauko; Koskenvuo, Markku; Kaprio, Jaakko (2005) Genetic Component of Noise Sensitivity. *J of Twin Research and Human Genetics*, v.**8** n.3, pp 245-249. doi:10.1375/twin.8.3.245.

10 Heinonen-Guzejev M, Jauhiainen T, Vuorinen H, Viljanen A, Rantanen T, Koskenvuo M, Heikkilä K, Mussalo-Rauhamaa H, Kaprio J. Noise sensitivity and hearing disability. *Noise Health* [serial online] 2011; **13**:51-8. [Online.] available from: http://www.noiseandhealth.org/text.asp?2011/13/50/51/74000

11 Schreckenberg D, Griefahn B, Meis M. The associations between noise sensitivity, reported physical and mental health, perceived environmental quality, and noise annoyance. *Noise Health* [serial online] 2010; **12**:7-16 [Online] available from: http://www.noiseandhealth.org/text.asp?2010/12/46/7/59995

12 Heinonen-Guzejev M, Koskenvuo M, Mussalo-Rauhamaa H, Vuorinen HS, Heikkilä K, Kaprio J. Noise sensitivity and multiple chemical sensitivity scales: Properties in a population based epidemiological study. *Noise Health* [serial online] 2012; **14**:215-23. Available from: http://www.noiseandhealth.org/text.asp?2012/14/60/215/102956

13 Ramírez, J. M. Bioquímica de la agresión. *Psicopatología Clínica, Legal y Forense*. 2006: **5**, pp 43 - 66.

14 Miyara, F. Ruido, juventud y derechos humanos. En: *I Congreso Argentino - Latinoamericano de Derechos Humanos: "Una Mirada desde la Universidad"*. 2001.

15 Romano, S. Adicción al ruido como respuesta a la ausencia del vínculo afectivo. En: *Terceras Jornadas Internacionales Multidisciplinarias sobre Violencia Acústica*, Rosario, Argentina. 2000.

16 Stansfeld, Stephen A.; Matheson, Mark P. *Noise pollution: non-auditory effects on health. British Medical Bulletin*, The British Council, UK. 2003: 68 pp.243–257.

17 Carrillo Castro, Roberto Carlos. *Análisis teórico de las características de personalidad en personas violentas*. Barranquilla, Colombia: Universidad del Norte, 2007.

18 Benítez de Fornerón, Antonia; Cubilla de Cabañas, Mirta Rosa; Zanotti Cavazzoni, Juan Carlos. La agresividad en el ambiente: su detección y nuevo modelo terapéutico. *Revista de Ciencia y Tecnología* (Universidad Nacional de Asunción, Paraguay) 1996: **1**(2) pp.119-130.

19 Berglund, B.; Lindvall, T. (1995). *Community Noise*. Report for the World Health Organization.

20 González, Alice Elizabeth. *Contaminación Sonora y Derechos Humanos.* Serie Investigaciones: Derechos Humanos en las Políticas Públicas. N° 2. Investigación realizada para la Defensoría del Vecino de Montevideo. 463 pp., 2012. [Online] Available from: http://www.defensordelvecino.gub.uy/IMAGENES/Foro%20Defensor%C3%ADas%20Locales/DDHHA.pdf

21 Galvão, Luiz Augusto C.; Finkelman, Jacobo; Henao, Samuel (Eds.) *Determinantes ambientales y sociales de la salud.* Organización Panamericana de la Salud, Washington, D.C.: OPS, 2010. ISBN 978-92-75-33129-3

22 González, A. E. (2012) "*Noise Sources in the City: Characterization and Management Trends*". In: D. Siano, Ed. Noise Control, Reduction and Cancellation Solutions in Engineering. InTech, Croatia, ISBN 978-953-307-918-9, 2012, doi: 10.5772/25879. Available from: http://www.intechopen.com/books/noise-control-reduction-and-cancellation-solutions-in-engineering/noise-sources-in-the-city-characterization-and-management-trends-

23 Ising, H; Kruppa B. Health effects caused by noise: Evidence in the literature from the past 25 years. *Noise Health* [serial online] 2004; **6**:5-13. Available from: http://www.noiseandhealth.org/text.asp?2004/6/22/5/31678

24 Lercher, Peter. Environmental Noise and Health: an integrated research perspective. *Environment International*, vol. **22** N° 1 pp. 117-129. Elsevier Science Ltd., 1996.

25 United States Environmental Protection Agency USEPA (1981). *Noise Effects Handbook. A Desk Reference to Health and Welfare Effects of Noise.* Office of the Scientific Assistant, Office of Noise Abatement and Control, National Association of Noise Control Officials. USA.

26 Sørensen, Mette; Andersen, Zorana J.; Nordsborg, Rikke B.; Becker, Thomas; Tjønneland, Anne; Overvad, Kim; Raaschou-Nielsen, Ole. Long-Term Exposure to Road Traffic Noise and Incident Diabetes: A Cohort Study. *Environ Health Perspect* **121**:217–222 (2013). http://dx.doi.org/10.1289/ehp.1205503

27 Bearer, C.F. Noise (2004) In: *Children's health and the environment. A global perspective. A Resource Manual for the Health Sector, Section III: Specific Environmental Threats.* J. Pronczuk de Garbino, Editor-in-Chief. World Health Organization, Geneva, Switzerland, 2004.

28 Gianoli, Pablo; Cunha, Nicolás (2014) Molestia por ruido de tránsito en Montevideo. Primera Semana del Sonido, Montevideo 5 al 9 de mayo de 2014. *Las Semanas del Sonido Montevideo – Rosario 2014*, ISBN 978-9974-0-1142-7.

29 Barcala, M.V.; Gianoli, P.; Montero, J.; Ríos, A.; Teixeira, M. (2013) *Molestia por ruido de tránsito*. Taller de extensión en Ingeniería Ambiental, Universidad de la República, 97 pp., 2013

30 Convenio IMM – Facultad de Ingeniería. "*Mapa Acústico de Montevideo*". Final Report, 374 pp., October 1999.