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Systematic review of evidence of the cardiovascular and metabolic effects of environmental noise

Elise VAN KEMPEN[1]; Maribel CASAS[2]; Göran PERSHAGEN[3]; Maria FORASTER[4]

[1] Netherlands National Institute for Public Health and the Environment, Netherlands

[2] CREAL Centre For Research in Environmental Epidemiology, Spain

[3] Institute of Environmental Medicine, Karolinska Institute, Sweden

[4] Swiss Tropical and Public Health Institute; University of Basel, Switzerland

ABSTRACT

In 1999 and 2009, WHO has published reviews dealing with the scientific evidence on noise and health, and made recommendations for protecting human health from environmental noise exposure. Over the years, the number of studies investigating the impact of noise on the cardiovascular system has increased substantially. Among these, several large cohort studies have been performed. In the existing guidelines and published studies, the main sources of concern were road traffic and air traffic. The impact of sources such as rail traffic and wind turbines, was not addressed in previous guidelines. But with the ongoing extension of railway transport facilities, and the substantial growth of wind energy facilities, the number of studies investigating the impact of railway noise or wind turbine noise has increased. Another trend is that several studies have been published that investigated the possible effects of noise on our metabolic system, resulting in outcomes such as diabetes and obesity. For these reasons, WHO decided to revise their existing health guidelines. To this end, all pertinent literature was systematically reviewed, using a protocol developed for this purpose.

Keywords: Cardiovascular effects, metabolic effects, systematic review, WHO
I-INCE Classification of Subjects Number(s): 62.5

1. INTRODUCTION

During the past decades, several national and international organisations have published reviews dealing with the scientific evidence on noise and health, and made recommendations for protecting human health from environmental noise exposure (from now on referred as "noise") originating from various sources and community settings. Some of these documents also contain evaluations of the impact of noise on the cardiovascular system (1-5). In 1999, the World Health Organization (WHO) already stated that "Epidemiological studies show that cardiovascular effects occur after long-term exposure to noise with outdoor $L_{Aeq24hr}$ values of 65-70 dB. However, the associations are weak. The association is somewhat stronger for ischemic heart disease than for hypertension" (2). In 2009, WHO also made statements with regard to the effects of noise exposure during the night on the cardiovascular system. It should be noted that studies on the relationship between noise and cardiovascular disease often used the L_{day} as exposure measure. In their Night Noise Guidelines, WHO concluded that "there is limited evidence that night-time noise is related to hypertension and myocardial infarction; although the studies were few or not conclusive, a biological pathway could be constructed from the evidence". The guidelines recommended a general threshold of 55 dB (L_{night}) outdoors at night for protection from cardiovascular disease, and suggested an optimal target of 40 dB (5).

New evidence on the impact of environmental noise on the cardiovascular system has been accumulated in recent years. An important observation is that many results were published based on data analyses of existing or ongoing cohort studies (6). Also an increasing number of studies were

[1] Elise.van.Kempen@rivm.nl
[2] mcasas@creal.cat
[3] Goran.Pershagen@ki.se

published that investigated the combined effects of traffic-related noise and air pollution. Another development that should be addressed is the fact that during the last few years, several studies have been published regarding the possible effects of noise on the metabolic system, in particular on outcomes such as diabetes and obesity (6).

In the existing guidelines and published studies, the main sources of concern were transportation noise sources originated from road traffic and air traffic. The impact of noise sources such as rail traffic and wind turbines were hardly and/or not investigated and were, as a consequence, not addressed in previous guidelines. With the ongoing extension of railway transport facilities and the substantial growth of wind energy facilities, the number of studies investigating the impact of railway noise or wind turbine noise has increased. For these reasons, WHO decided to revise their existing health guidelines. To this end, all pertinent literature was systematically reviewed using a protocol developed for this purpose.

2. METHODS

The first step in the evidence review was to identify and select systematic reviews of sufficient quality that described the impact of noise exposure from several sources on the cardiovascular system, in different settings and populations. To this end, WHO carried out a bibliographic search with no time constrain. In addition, literature files of the National Institute of Public Health (RIVM) and the proceedings of conferences on noise and health were scanned. For all the identified publications title and abstract was checked to assess whether the review investigated the impact of exposure to environmental noise on the cardiovascular system. In total, 33 papers and reports (7-39) were identified and selected.

The quality of these selected reviews was assessed by two reviewers (EvK and MF) by means of the AMSTAR tool (40). Of these 33 systematic reviews, we selected 12 reviews that were identified as "sufficient quality" (AMSTAR score of 8/11 or higher) or "moderate quality" (AMSTAR score of 4-7) and relevant for our evidence review (8, 15-17, 19, 21, 24, 25, 30, 34, 35, 39). During the process of data-extraction of this evidence review, new reviews were published. Four of these new published reviews (41-44) were considered as relevant and therefore also selected. One was an update of a review that was already included (41); therefore, 15 systematic reviews were finally considered.

Table 1 - Characteristics of the 15 systematic reviews that were identified and selected that investigated the impact of aircraft, road, rail traffic, and/or wind turbine noise exposure on the cardiovascular system

Review	Studies included							Meta-analysis
	Number evaluated	Number of participants	Time range	Countries*	Population**	Noise source†	Health endpoint‡	
(21)	43	46 – 35150	1970-99	Worldwide	1	O, R, A	0, 1, 2	Yes
(20, 34)	62	94 – 145000	NR	Worldwide	1, 2	R, A, T	0, 1, 2	Yes
(19)	~28	NR	NR	Worldwide	1, 2	A	1	Yes
(17)	8	375-4320	Up to November 2009	Ger, Au, Sb, UK, Eur	1	R	1, 2	No
(15)	13	115-1542	1980-2010	USA, Ger, Aus, NL	2	R, A	0	No
(24)	18	22-3622	1965-2012	CR, Lit, Sb, Mc, Slo, Rus	1	R, A	0, 1, 2	No
(42)	12	417 – 809379	1980-2010	Eur	1	R, A	2	Yes
(35, 41)	10	243 - ~22.5	1994-2014	Eur, Can, USA	1	R, A, T	2	Yes

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(39)	27	357-38849	Up to 2010	Eur, Jap	1	R	1	Yes
(16)	11	43-1542	Up to Apr 2011	Eur, USA	1, 2	R, A, T	0, 2	No
(8)	9	719-445868	Up to Nov 2012	Eur, Can	1, 2	R	1, 2	No
(25)	12	243 - 412420	NR	Eur, Jap, Can	1	R	2	Yes
(42)	9	875-57053	Up to June 2014	Can, Den, Ger, Swe, SKor, USA	1	R, A, O	3	Yes
(30)	3	340-740	1980-2012	Swe, NL	1	W	1, 3, 4	No
(44)	5	1500-5828	1977-2010	NL, Swe, Aus	1	A	1	Yes

Abbreviations: NR = Not Reported; *) Au = Austria, Aus = Australia, Can = Canada, CR = Czech Republic, Den = Denmark, Eur = Europe, Ger = Germany, Jap = Japan, Lit = Lithuania, Mc = Macedonia, NL = Netherlands, Rus = Russia, Sb = Serbia, SKor = South Korea, Slo = Slovakia, Swe = Sweden, UK = United Kingdom, USA = United States of America; **) 1 = Adults, 2 = Children, †) O = occupational noise, R = road traffic noise, A = aircraft noise, T = rail traffic noise, W = wind turbine noise; ‡) 0 = blood pressure, 1 = hypertension, 2 = Ischaemic Heart Disease (including myocardial infarction, angina pectoris), 3 = diabetes, 4 = cardiovascular disease.

3. RESULTS AND CONCLUSIONS

Characteristics of the selected reviews are presented in Table 1. The number of studies investigating the impacts of noise on the cardiovascular system that were evaluated in these reviews ranged from 3 to 62. The time range of the participating studies in the reviews was from 1965 to June 2014. Most of the participating studies were carried out among adults and investigated the impacts of road and aircraft noise exposure. Three reviews also aimed to include studies that investigated the impact of rail traffic noise exposure; two reviews included studies that investigated the impact of occupational noise exposure whereas the rest were at residential level; and one review included studies that investigated the impact of wind turbine noise exposure. Nine reviews included one or more meta-analyses resulting in more than 13 exposure-response relationships. However, some of these exposure-response relationships are already outdated, because since their publication several new studies have been carried out and published. This was e.g. the case for the exposure-response relation describing the association between aircraft noise exposure and the prevalence of hypertension.

For other exposure-response relations, including the most recent studies investigating the impacts of noise on the cardiovascular system, a quality judgment of the individual studies was lacking. This was for example the case for the relationship between road traffic noise and IHD.

In 2012, Van Kempen and Babisch (39) published a meta-analysis on the association between road traffic noise and hypertension. Studies published until 2010 were included. However, in the period 2010-2014 several new studies have been published. Like the other meta-analyses, the meta-analysis of Van Kempen and Babisch (39) also did not include a systematic judgment of the quality of the evaluated studies.

During the past years, several new outcomes have been investigated in relation to transportation noise, namely stroke, diabetes and obesity. However, valid exposure-response relationships are not yet available.

Also, no exposure-response relationships describing the impacts of rail traffic noise and/or wind turbine noise on the cardiovascular system are available. During the past years, however, the results of several studies have been reported.

Finally, no exposure-response relationships are available that describe the impact of noise on children's blood pressure. From a public health perspective, blood pressure elevations at population level are undesirable (21). However, the degrees of blood pressure elevations found in relation to noise exposure in children were small and the clinical significance of such minor changes in childhood blood pressure is difficult to determine. It is assumed that the extent of blood pressure elevations found were probably not significant for children during their youth. However it could portend elevations later in life that might be health damaging (34). In this line, the literature suggests that increased blood pressure in children strongly predicts hypertension in young adults and that essential hypertension and the precursors of cardiovascular disease might originate in childhood (45-49).

As a follow-up of the evaluation of reviews, we decided to carry out a new systematic review in order to update some of the existing relationships and to assess the quality of the single studies. The preliminary results of this systematic review, including several meta-analyses, analyses of heterogeneity, will be shown at the INTERNOISE conference.

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