Recent progress in the field of non-auditory health effects of noise – trends and research needs

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ABSTRACT

With the aim to identify recent research achievements, current trends in research, remaining gaps of knowledge and priority areas of future research in the field of non-auditory health effects of noise, recent research progress was reviewed. A search was performed in PubMed (search terms “noise AND health”), for peer reviewed journal articles, published between 1 January 2014 and 1 January 2017 in English. Resulting references were screened for relevance by title and abstract where needed in case of doubt. Inclusion criteria: Original research papers on health effects of environmental or occupational noise exposure. Studies on auditory health effects (hearing loss) and animal studies were excluded. The search resulted in over 3000 references. A total number of about 150 papers was included in the review, 18 papers addressed mental health effects, a majority focused on (a wide range of) physiological health effects. A wealth of new research on non-auditory health effects of noise has been published over the last 3 years. Current trends, knowledge gaps and priority future research areas will be discussed.

INTRODUCTION

ICBEN Team 3 focuses on the non-auditory effects of noise. This review provides an overview of recent research progress in this area, with a focus on recent trends in research, gaps in knowledge and challenges for future research. This review shows a giant leap in non-auditory health effects research has taken place over the last 3 years.

METHODS

We performed a systematic search in PubMed. As search terms “noise AND health” were entered, to identify peer reviewed journal articles, published between the 1st of January 2014 and the 1st of January 2017, in the English language. The resulting references were screened for relevance by title, and secondly by abstract, where needed in case of doubt. All articles on

non-auditory health effects of environmental noise or occupational noise exposure were included in the review. The references identified through this initial search, where subsequently complemented with missing papers identified through other pathways, including: authors own archive, reference lists of identified papers, online suggestions of related papers, journal notifications of new publications in the field, and expert suggestions. Studies on auditory health effects (hearing loss), and animal studies were excluded.

RESULTS AND DISCUSSION

The PubMed search resulted in 3087 references, amongst which 134 papers on non-auditory health effects of environmental noise or occupational noise were identified. These were complemented with 10 papers identified otherwise. This resulted in 144 papers in total [1-144]. In addition, 6 papers presenting Health Impact Assessment calculations based on existing relationships were identified [145-150]. Thus, in total 150 publications on non-auditory health effects of noise were identified, published within the search period (1 Jan 2014- 1 Jan 2017). This high number illustrates the wealth of new research in the field of noise and non-auditory health effects that has been coming available in recent years. Prominent trends and key issues in non-auditory noise effects research are discussed below.

Recent trends in non-auditory health effects research

Epidemiological studies

In recent years, the number of large epidemiological studies coming available has been rapidly increasing. As compared to the last decades, within the last 3 years an impressive number of epidemiological studies on health effects of noise has been published. More than half of the total amount of studies (>75) identified in this review consists of epidemiological investigations.

Reviews and meta-analyses

The large number of epidemiological studies published on long term health effects of noise, underlines the growing knowledge base. New studies have increased insight in relationships confirmed. This trend is complemented with reviews of evidence and pooled analyses consolidating this knowledge. The number of recent reviews on noise and health is noteworthy, with about 30 reviews published recently within the search period [13, 16, 19, 23, 24, 28, 30, 31, 35, 53, 56, 58, 59, 60, 62, 82, 86, 89, 94, 105, 106, 115, 117, 121, 124, 129, 130, 132, 138, 139]. These reviews included a number of meta-analyses, providing pooled risk estimates [19, 24, 56, 58, 60, 86, 124, 139]. The findings from these meta-analyses will be briefly described hereafter.

An updated meta-analysis on the association between road traffic noise and coronary heart disease, including 14 studies, presenting a significant pooled effect estimate with an RR of 1.08 (95% CI 1.04-1.13) per 10 dB increase in L_{dn} [19]. In addition, a meta-analysis was published on transportation noise and ischemic heart disease, presenting a risk estimate in the same order of magnitude, with a pooled RR of 1.06 (95% CI: 1.03-1.09) [139]. Also, a meta-analysis was presented on cross sectional studies (published between 1980 and 2010) on transportation noise (different sources including road traffic and aircraft noise) and cardiovascular disease, presenting a positive but non-significant risk estimate [24]. In addition, a meta-analysis was published on ‘residential’ and occupational noise exposure and type 2

diabetes, presenting a positive and significant risk estimate for 'residential noise', but not for occupational noise [56]. The same authors published a meta-analysis on road traffic noise, aircraft noise and stroke, with a small positive pooled risk estimate for both road traffic noise and aircraft noise, which was significant for aircraft noise only [58]. Furthermore, they performed a meta-analysis on road traffic noise and children's blood pressure, presenting weak, positive but non- significant pooled effect size estimates for SBP and DBP [60]. A meta-analysis was published on aircraft noise and hypertension, presenting an overall OR for hypertension in 'residents with aircraft noise exposure' of 1.63 (1.14-2.33) [86]. In addition, one meta-analysis focused on occupational noise exposure and cardiovascular effects [124]. This meta-analysis concluded that there was a strong association between occupational noise exposure and hypertension, and a weak association for other cardiovascular effects, but the evidence is still limited and the authors note that more longitudinal studies into the effects of occupational noise and cardiovascular effects are needed.

Air pollution and noise: combined exposure

A topic that has received increasing interest in recent years is combined exposure to noise and air pollution. A number of health endpoints, e.g. cardiovascular effects, have been associated to both noise and air pollution, while there is support from the scientific literature for a causal role of both exposures. During the last decade, it has become widely recognized that these exposures may confound (or interact with) each other.

Until recently, only a limited amount of studies was available into the long term effects of traffic related exposures, taking both noise and air pollution into account. Amongst the first studies mutually adjusting for road traffic noise and air pollution exposure, were the studies on road traffic noise and hypertension published in 2007 [151] and the study on published in 2009 [152]. Since then, the number of studies including both exposures has been increasing, with 9 studies identified in a first review on this topic, published in 2013 [153]. Since then, the increasing trend of studies coming available on this topic has continued. During the search period of this review an impressive amount of 43 new epidemiological research papers were published taking both exposures into account [7, 20, 21, 27, 32, 33, 37, 39, 42, 44, 45, 49, 50, 52, 55, 65, 69, 70, 73, 77-79, 85, 88, 96, 98, 99, 104, 108, 109, 112, 114, 116, 118, 119, 125-127, 133-136, 144]. In addition, 2 narrative reviews on the topic were published, in 2015 [129] and 2016 [106], respectively. The 2 recent reviews conclude that independent effects of environmental noise and air pollution (mainly in studies on cardiovascular health effects) have been shown [106, 129], while the review published in 2016 also points at recent research suggesting that these two exposures may also interact with each other.

Study populations (size)

The noise mapping requirements as prescribed by the Environmental Noise Directive has led to an increasingly wide availability of noise maps for urban areas, as well as to the increased availability of tools developed to perform noise calculations. This trend has led to a broader availability of noise exposure data, which, in combination with large health databases (e.g. cohorts and morbidity and mortality registration databases), has created new opportunities for environmental exposure-effect research. While until fairly recently, the number of large population studies into the health effects of long term noise exposure was still very limited, during the search period an impressive number of large studies have been performed, including over 30 studies with a study population size exceeding 10 000 subjects [1, 2, 4, 5, 7, 9, 10, 12, 27, 33, 37, 39, 43-45, 50, 52, 54, 73, 77, 85, 104, 108, 112, 118, 119, 122, 123, 125, 127, 136, 143, 144], of which at least 7 exceeded 100 000 persons [2, 10, 37, 39, 50, 77, 123]. Although, this includes studies from the same research groups, some of which based

their analysis on the same population database, with articles focusing e.g. on different endpoints. Larger studies can offer a benefit in terms of increased power, if not compromised by limitations in adjustment for confounding and quality (e.g. lower spatial resolution) of exposure assessment.

Prospective studies

The need for more longitudinal prospective studies has frequently been expressed. For studying the long term health effects of exposure, a prospective design is preferred above a cross-sectional design, since it has the strength of being capable to take into account the sequence in time, and thereby allows to answer the questions: “Did the exposure precede the health endpoint under study?” and “Are highly exposed persons at higher risk of *developing* the health effect of interest?”. If the answer to those questions is positive, there is more reason to assume such association may indeed be causal. Until recently, however, large prospective studies in this area of research were still extremely rare. Over the last few years, this is changing rapidly: During the search period over 10 prospective studies were published on non-auditory health effects of noise [2, 3, 8, 33, 39, 43, 63, 70, 104, 118, 119, 125,136].

Mental health effects

The focus of research in this area has been on *physical* health effects: A majority of the identified papers addressed non-auditory *physical* health effects, while a minority of 17 papers addressed *mental* health [1-14, 22, 109, 131] (either exclusively, or in combination with other (physical) health endpoints).

Studies addressing mental health effects included in this review reported associations between noise *annoyance* and depression and anxiety prevalence [1], impaired mental health [5], and with SF-36 mental health score [6], with SF-12 mental health factors [109] and with depressive symptoms and suicidal ideation [12] in adults, and incident mental health problems in children [3]. While in the above mentioned study reported an association between noise *annoyance* and SF-36 mental health score, however, no significant association with *modelled* road traffic noise exposure (L_{dn}) was found [6], while a weak association with modeled road traffic noise exposure was found in another study, however with a non-clinically relevant magnitude of effect [9]. In a large prospective study (N ≈ 190 000) road traffic noise during the night (L_{night}) was found associated with purchase of anxiolytic-hypnotic medication [2], while a smaller cross-sectional study (N ≈ 15 000) found no association between road traffic noise (L_{den}) and increased use of psychotropic medication [4]. In addition, a prospective study reported an association between road traffic noise exposure and depressive symptoms [8]. In line with this, a large case-control study (N ≈ 650 000) reported an association between road traffic noise and depression [10]. A large cross sectional study found an association between road traffic noise exposure and behavioral problems in children, particularly with hyperactivity/ inattention symptoms [7].

New and established health outcomes

A relatively large number of studies addressed the relationship between noise exposure and hypertension [16, 18, 20, 21, 26, 51, 66, 69, 81, 86, 131, 142], long term effects on blood pressure [18, 32, 60, 69, 78, 98, 144], and transient blood pressure elevations [41, 42, 72, 87, 91, 99, 110, 140]. New or more rarely addressed endpoints related to blood pressure were studied as well: hypertension mortality [27], pregnancy induced hypertension (see below) [112], hypotension and hypotension medication use [96]. Cardiovascular morbidity and

mortality was further studies in a range of epidemiological studies [25, 27, 33, 39, 57, 65, 71, 74, 77-79, 92, 104, 111, 116, 122, 123, 125, 132, 135]. Several studies investigated effects of noise on endocrine [61, 75, 76, 101, 140, 141] and metabolic outcomes [17, 127].

An emerging topic in non-auditory effect research is a hypothesized effect of environmental noise exposure on (indicators of) weight gain and obesity, with several studies reporting significant associations [43-45, 54, 63, 108, 114], including two studies with a prospective design [43, 63]. Furthermore, associations with diabetes type II were studied [27, 83, 133].

Relatively new or more rarely studied outcomes included new studies on respiratory outcomes, including asthma prevalence [37], and daily respiratory mortality [134], rheumatoid arthritis [50], and carcinogenic outcomes [118, 119, 126].

Birth outcomes were studied (low birth weight, small for gestational age, head circumference etc.) [49, 52, 73, 85], with inconsistent findings. While an association was found for particulate matter and term low birth weight, results for noise exposure were inconclusive [49]. However, while air pollution exposure was assessed at address level, noise was estimated 'in buffers of 50m and 250m' around the address. Different spatial resolution of air pollution and noise exposure may explain differences in results. Another study, however, confirmed the association between air pollution (NO_2) and birth outcomes (head and abdominal circumference), while traffic noise did not seem to affect birth size [85]. A negative association was found for community noise and term birth weight, and was largely un-changed after air-pollution adjustment [73]. An association was found between road traffic noise exposure and pregnancy complications (pre-eclampsia and pregnancy induced hypertension) [112].

Future research needs

More large prospective studies, and studies with intervention design are needed to further refine exposure response relationships and strengthen evidence, respectively, with specific attention for 'newer' endpoints. Larger studies should not compromise on exposure assessment quality. Crude exposure assessment may lead to biased results. High quality exposure assessment is warranted, with specific attention for combined exposure studies, where air pollution and noise should be assessed with a same high quality level and spatial resolution to allow disentanglement of effects.

REFERENCES

[1] Beutel, M.E., Jünger, C., Klein, E.M., Wild, P., Lackner, K., Blettner, M., et al. (2016). Noise Annoyance Is Associated with Depression and Anxiety in the General Population - The Contribution of Aircraft Noise. *PLoS ONE,* 11(5): e0155357.

[2] Bocquier, A., Cortaredona, S., Boutin, C., David, A., Bigot, A., Sciortino, V., et al (2014). Is exposure to night-time traffic noise a risk factor for purchase of anxiolytic-hypnotic medication? A cohort study. *European journal of public health*, 24(2): 298-303.

[3] Dreger, S., Meyer, N., Fromme, H., Bolte, G (2015). Environmental noise and incident mental health problems: A prospective cohort study among school children in Germany. *Environ. Res*, 143: 49.

[4] Halonen, J.I., Lanki T., Yli-Tuomi T., Turunen A.W., Pentti J., Kivimäki M., Vahtera J (2014). Associations of traffic noise with self-rated health and psychotropic medication use. *Scandinavian journal of work, environment & health*, 40(3): 235-243.

[5] Hammersen, F., Niemann, H., Hoebel, J (2016). Environmental Noise Annoyance and Mental Health in Adults: Findings from the Cross-Sectional German Health Update (GEDA) Study 2012. *Int J Environ Res Public Health*, 13(10).

[6] Héritier, H., Vienneau, D., Frei, P., Eze, I.C., Brink, M., Probst-Hensch N., Röösli M (2014). The association between road traffic noise exposure, annoyance and health-related quality of life (HRQOL). *Int J Environ Res Public Health*, 11(12): 12652-12667.

[7] Hjortebjerg, D., Andersen, A.M., Christensen, J.S., Ketzel, M., Raaschou-Nielsen, O., Sunyer, J., et al. (2016). Exposure to road traffic noise and behavioral problems in 7-year-old children: a cohort study. *Environmental Health Perspectives*, 124(2): 228-234.

[8] Orban, E., McDonald, K., Sutcliffe, R., Hoffmann, B., Fuks, K.B., Dragano, N., et al. (2016). Residential Road Traffic Noise and High Depressive Symptoms after Five Years of Follow-up: Results from the Heinz Nixdorf Recall Study. *Environmental Health Perspectives,* 124(5): 578-585.

[9] Roswall, N., Høgh, V., Envold-Bidstrup, P., Raaschou-Nielsen, O., Ketzel, M., Overvad, K., et al. (2015) Residential exposure to traffic noise and health-related quality of life-a population-based study. *PloS One*, 10(3): e0120199.

[10] Seidler, A., Hegewald, J., Seidler, A.L., Schubert, M., Wagner, M., Dröge, P., et al. (2017). Association between aircraft, road and railway traffic noise and depression in a large case-control study based on secondary data. *Environmental Research*, 152: 263-271.

[11] Sygna, K., Aasvang, G.M. Aamodt, G. Oftedal, B., Krog, N.H. (2014). Road traffic noise, sleep and mental health. *Environmental research,* 131: 17-24.

[12] Yoon, J.H., Won, J.U., Lee, W., Jung, P.K., Roh, J. (2014). Occupational noise annoyance linked to depressive symptoms and suicidal ideation: a result from nationwide survey of Korea. *PLoS One,* 21;9(8).

[13] Wright, B., Peters, E., Ettinger, U., Kuipers, E., Kumari, V (2014). Understanding noise stress-induced cognitive impairment in healthy adults and its implications for schizophrenia. *Noise Health*, 16(70): 166-176.

[14] Wright, B., Peters, E., Ettinger, U., Kuipers E., Kumari, V. (2016). Effects of environmental noise on cognitive (dys)functions in schizophrenia: A pilot within-subjects experimental study. *Schizophr Res*, 173(1-2):101-108.

[15] Abbasi, M., Monazzam, M.R., Akbarzadeh, A., Zakerian, S.A., Ebrahimi, M.H (2015). Impact of wind turbine sound on general health, sleep disturbance and annoyance of workers: a pilot- study in Manjil wind farm, Iran. *J Environ Health Sci Eng*, 12(13): 71.

[16] Akinseye, O.A., Williams, S.K., Seixas, A., Pandi-Perumal, SR., Vallon J., Zizi F., Jean-Louis G (2015). Sleep as a mediator in the pathway linking environmental factors to hypertension: a review of the literature. *Int J Hypertens,* Article ID 926414, 15p.

[17] Arlien-Søborg, M.C., Schmedes, A.S., Stokholm, Z.A., Grynderup, M.B., Bonde, J.P., Jensen, C.S. et al. (2016). Ambient and at-the-ear occupational noise exposure and serum lipid levels. *Int Arch Occup Environ Health*, 89(7): 1087-1093.

[18] Assunta, C., Ilaria, S., Simone de, S., Gianfranco, T., Teodorico, C., Carmina, S., et al. (2015). Noise and cardiovascular effects in workers of the sanitary fixtures industry. *Int J Hyg Environ Health*, 218(1): 163-168.

[19] Babisch W., Updated exposure-response relationship between road traffic noise and coronary heart diseases: a meta-analysis. Noise and Health, 2014. 16(68): p. 1-9.

[20] Babisch, W., Wolke, G., Heinrich, J., Straff, W (2014). Road traffic noise and hypertension: accounting for the location of rooms. *Environmental Research*, 133: 380-387.

[21] Babisch, W., Wolf, K., Petz, M., Heinrich, J., Cyrys J., Peters A (2014). Associations between traffic noise, particulate air pollution, hypertension, and isolated systolic hypertension in adults: the KORA study *Environmental Health Perspectives*, 122(5): 492-498.

[22] Baliatsas, C., van Kamp, I., Swart, W., Hooiveld, M., Yzermans, J (2016). Noise sensitivity: Symptoms, health status, illness behavior and co-occurring environmental sensitivities. *Environ Res*, 150: 8-13.

[23] Baliatsas, C., van Kamp, I., van Poll, R., Yzermans, J (2016). Health effects from low-frequency noise and infrasound in the general population: Is it time to listen? A systematic review of observational studies. *Sci Total Environ*: 557-558: 163-169.

[24] Banerjee, D. (2014). Association between transportation noise and cardiovascular disease: a meta-analysis of cross-sectional studies among adult populations from 1980-2010. *Ind. J. Public Health*, 58(2): 84-91.

[25] Banerjee, D., Das, P.P., Foujdar, A (2014). Association between road traffic noise and prevalence of coronary heart disease. *Environmental Monitoring & Assessment*, 186(5): 2885-2893.

[26] Banerjee, D., Das, P.P., Fouzdar, A (2014). Urban residential road traffic noise and hypertension: a cross-sectional study of adult population. *J Urban Health,* 91(6): 1144-1157.

[27] Barceló, M.A,. Varga, D., Tobias, A., Diaz, J., Linares, C., Saez, M (2016). Long term effects of traffic noise on mortality in the city of Barcelona, 2004-2007. *Environ Res*, 147: 193-206.

[28] Basner, M., Brink, M., Bristow, A., Kluizenaar, Y. de, Finegold, L., Hong, J., Janssen S.A., Matsui T., et al (2015). ICBEN review of research on the biological effects of noise 2011-2014. Noise & Health, 17: 57-82.

[29] Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *Lancet*, 383(9925): 1325-1332.

[30] Sound advice for public health. *Lancet*, 2014, 383(9925):1270.

[31] Belojevic, G. and Paunovic, K. (2016). Recent advances in research on non-auditory effects of community noise. *Srp Arh Celok Lek*., 144(1-2): 94-98.

[32] Bilenko, N., van Rossem, L., Brunekreef, B., Beelen, R., Eeftens, M., Hoek, G., et al. (2015). Traffic-related air pollution and noise and children's blood pressure: results from the PIAMA birth cohort study. *Eur J Prev Cardiol*., 22(1): 4-12.

[33] Bodin, T., Björk, J., Mattisson, K., Bottai, M., Rittner, R., Gustavsson, P., et al. (2016). Road traffic noise, air pollution and myocardial infarction: a prospective cohort study. *Int Arch Occup Environ Health*, 89(5):793-802.

[34] Brown, A.L (2015). Effects of road traffic noise on health: from Burden of Disease to effectiveness of interventions. *Procedia Environmental Sciences*, 30: 3-9.

[35] Brown, B., Rutherford, P., Crawford, P (2015). The role of noise in clinical environments with particular reference to mental health care: A narrative review. International Journal of Nursing Studies 52, 1514-1524.

[36] Burns, K.N., Sun, K., Fobil, J.N., Neitzel, R.L. (2016). Heart Rate, Stress, and Occupational Noise Exposure among Electronic Waste Recycling Workers. *Int J Environ Res Public Health*, 13(1).

[37] Cai, Y., Zijlema, W. (2016). Ambient air pollution, traffic noise and adult asthma prevalence: a BioSHaRE approach. *European Respiratory Journal*, DOI: 10.1183/13993003.02127-2015.

[38] Cairns, B.J., Baigent, C (2014). Air pollution and traffic noise: Do they cause atherosclerosis? *European Heart Journal*, 35(13): 826-828.

[39] Carey, I.M., Anderson, H.R., Atkinson, R.W., Beevers, S., Cook, D.G., Dajnak D, et al. (2016). Traffic pollution and the incidence of cardiorespiratory outcomes in an adult cohort in London. *Occup Environ Med*, 73(12): 849-856.

[40] Chang, T.Y., Beelen, R., Li, S.F., Chen, T.I., Lin, Y.J., Bao, B.Y., Liu, C.S. (2014). Road traffic noise frequency and prevalent hypertension in Taichung, Taiwan: a cross-sectional study. *Environmental Health*, 13(1): 37.

[41] Chang, T.Y., Liu, C.S., Hwang, B.F., Hsieh, H.H., Bao, B.Y., Chen, C.J., et al. (2015). Acute effects of noise exposure on 24-h ambulatory blood pressure in hypertensive adults. *J Hypertens*, 33(3): 507-514.

[42] Chang, L.T., Chuang, K.J., Yang, W.T., Wang, V.S., Chuang, H.C., Bao, B.Y., et al. (2015). Short-term exposure to noise, fine particulate matter and nitrogen oxides on ambulatory blood pressure: A repeated-measure study. *Environ Res*, 140: 634-640.

[43] Christensen, J.S., Raaschou-Nielsen, O., Tjønneland, A., Nordsborg, R.B., Jensen, S.S., Sørensen, T.I., Sørensen, M. (2015). Long-term exposure to residential traffic noise and changes in body weight and waist circumference: A cohort study. *Environ Res*, 143: 154-161.

[44] Christensen, J.S., Hjorteberg, D., Raaschou-Nielsen, O., Ketzel, M., Sørensen, T.I., Sørensen, M. (2016). Pregnancy and childhood exposure to residential traffic noise and overweight at 7 years of age. *Environment International*, 94: 170-176.

[45] Christensen, J.S., Raaschou-Nielsen, O., Tjønneland, A., Overvad, K., Nordsborg, R.B., Ketzel M, et al. (2016). Road traffic and railway noise exposures and adiposity in adults: A cross-sectional analysis of the Danish Diet, Cancer, and Health Cohort. *Environmental Health Perspectives*, 124(3): 329-335.

[46] Chum, A., O'Campo, P. (2015). Cross-sectional associations between residential environmental exposures and cardiovascular diseases. *BMC Public Health*; 15: 438.

[47] Crichton, F., Dodd, G., Schmid, G., Gamble, G., Petrie, K.J. (2014) Can expectations produce symptoms from infrasound associated with wind turbines? *Health Psychol,* 33(4): 360-364.

[48] Crichton, F., Dodd, G., Schmid, G., Gamble, G., Cundy, T., Petrie, KJ. (2014). The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound. *Health Psychol*, 33(12):1588-1592.

[49] Dadvand, P., Ostro, B., Figueras, F., Foraster, M., Basagaña, X., Valentín, A. et al. (2014). Residential proximity to major roads and term low birth weight: the roles of air pollution, heat, noise, and road-adjacent trees. *Epidemiology*, 25(4): 518-25.

[50] De Roos, A.J., Koehoorn, M., Tamburic, L., Davies, H.W., Brauer, M. (2014). Proximity to traffic, ambient air pollution, and community noise in relation to incident rheumatoid arthritis. *Environ Health Perspect*, 122(10): 1075-1080.

[51] De Souza, T.C., Périssé, A.R., Moura, M. (2015). Noise exposure and hypertension: investigation of a silent relationship. *BMC Public Health*, 15: 328.

[52] Díaz, J., Linares, Gil, C. (2016). Traffic Noise and Adverse Birth Outcomes in Madrid: A Time-series Analysis. *Epidemiology*, 27(1): e2-3.

[53] Domingo-Pueyo, A., Sanz-Valero, J., Wanden-Berghe, C. (2016). Disorders induced by direct occupational exposure to noise: Systematic review. *Noise and Health*, 18: 229-239.

[54] Dzhambov, A.M,, Dimitrova, D.D. (2016). Long-term self-reported exposure to occupational noise is associated with BMI-defined obesity in the US general population. *Am J Ind Med*, 59(11): 1009-1019.

[55] Dzhambov, A.M., Dimitrova, D.D. (2016). Exposures to road traffic, noise, and air pollution as risk factors for type 2 diabetes: A feasibility study in Bulgaria. *Noise and Health*, 18(82): 133-142.

[56] Dzhambov AM, Long-term noise exposure and the risk for type 2 diabetes: a meta-analysis. Noise and Health, 2015. 17(74): p. 23-33.

[57] Dzhambov AM, Dimitrova DD. Heart disease attributed to occupational noise, vibration and other co-exposure: Self-reported population-based survey among Bulgarian workers. Med Pr. 2016; 67(4):435-445.

[58] Dzhambov AM, Dimitrova DD, Exposure-response relationship between traffic noise and the risk of stroke: a systematic review with a meta-analysis. Arh Hig Rada Toksikol. 2016; 67: 136-151.

[59] Dzhambov AM, Dimitrova DD. Occupational noise and ischemic heart disease: A systematic review . Noise Health 2016;18:167-77.

[60] Dzhambov AM, Dimitrova DD. Children's blood pressure and its association with road traffic noise exposure - A systematic review with meta-analysis. Environmental Research 152 (2017) 244-255.

[61] Dzhambov AM. Workplace noise exposure and serum testosterone in men enrolled in the 1999-2004 National Health and Nutrition Examination Survey. Arh Hig Rada Toksikol 2016; 67(3):247-258.

[62] Dzhambov AM, Dimitrova DD. Urban green spaces' effectiveness as a psychological buffer for the negative health impact of noise pollution: a systematic review. Noise Health 2014; 16(70): 157-165.

[63] Eriksson C, Hilding A, Pyko A, Bluhm G, Pershagen G, Östenson CG, Long-term aircraft noise exposure and body mass index, waist circumference, and type 2 diabetes: A prospective study. Environmental Health Perspectives, 2014. 122: p. 687-694.

[64] Evandt J, Oftedal B, Krog NH, Nafstad P, Schwarze P, Aasvang GM. A population-based study on nighttime road traffic noiseand insomnia. Sleep 2016.

[65] Evrard AS, Bouaoun L, Champelovier P, Lambert J, Laumon B. Does exposure to aircraft noise increase the mortality from cardiovascular disease in the population living in the vicinity of airports? Results of an ecological study in France. Noise & Health 2015; 17(78): 328-336.

[66] Evrard AS, Lefèvre M, Champelovier P, Lambert J, Laumon B. Does aircraft noise exposure increase the risk of hypertension in the population living near airports in France? Occup Environ Med. 2016 Aug 1. pii: oemed-2016-103648.

[67] Filus W, Lacerda AB, Albizu E. Ambient Noise in Emergency Rooms and Its Health Hazards. Int Arch Otorhinolaryngol. 2015; 19(3): 205-209.

[68] Foraster, M., Basagana, X., Aguilera, I., Rivera, M., Agis, D., Bouso, L. et al. (2014). Association of long-term exposure to traffic-related air pollution with blood pressure and hypertension in an adult population-based cohort in Spain (the REGICOR study). *Environmental Health Perspectives*, 122(4): 404-411.

[69] Foraster, M., Künzli, N., Aguilera, I., Rivera, M., Agis, D., Vila, J. et al. (2014). High blood pressure and long-term exposure to indoor noise and air pollution from road traffic. *Environ Health Perspect*, 122(11): 1193-1200.

[70] Foraster, M., Eze, I.C., Vienneau, D., Brink, M., Cajochen, C., Caviezel, S., et al. (2016). Long-term transportation noise annoyance is associated with subsequent lower levels of physical activity. *Environ Int*, 91: 341-349.

[71] Gan WQ, Moline J, Kim H, Mannino DM: Exposure to loud noise, bilateral high-frequency hearing loss and coronary heart disease. Occup Environ Med 2016; 73(1): 34-41.

[72] Gallasch E, Raggam RB, Cik M, Rabensteiner J, Lackner A, Piber B, Marth E. Road and rail traffic noise induce comparable extra-aural effects as revealed during a short-term memory test. Noise Health 2016; 18: 206-213.

[73] Gehring U, Tamburic L, Sbihi H, Davies HW, Brauer M. Impact of noise and air pollution on pregnancy outcomes. Epidemiology. 2014 May;25(3):351-8.

[74] Girard SA, Leroux T, Verreault R, Courteau M, Picard M, Turcotte F, Baril J, Richer O. Cardiovascular disease mortality among retired workers chronically exposed to intense occupational noise. Int Arch Occup Environ Health. 2015; 88(1): 123-130.

[75] Green A, Jones AD, Sun K, Neitzel RL. The Association between Noise, Cortisol and Heart Rate in a Small-Scale Gold Mining Community-A Pilot Study. Int J Environ Res Public Health 2015; 12(8): 9952-9966.

[76] Hall SJ, Aisbett B, Tait JL, Turner AI, Ferguson SA, Main LC. The acute physiological stress response to an emergency alarm and mobilization during the day and at night. Noise Health 2016; 18(82): 150-156.

[77] Halonen JI, Hansell AL, Gulliver J, Morley D, Blangiardo M, Fecht D, et al. (2015). Road traffic noise is associated with increased cardiovascular morbidity and mortality and all-cause mortality in London. *European Heart Journal*, 36: 2653-2661.

[78] Halonen JI, Dehbi HM, Hansell AL, Gulliver J, Fecht D, Blangiardo M, et al. (2017). Associations of night-time road traffic noise with carotid intima-media thickness and blood pressure: The Whitehall II and SABRE study cohorts. *Environ Int*, 98: 54-61.

[79] Halonen JI, Blangiardo M, Toledano MB, Fecht D, Gulliver J, Anderson HR, Beevers SD, Dajnak D, Kelly FJ, Tonne C. Long-term exposure to traffic pollution and hospital admissions in London. Environ Pollut. 2016; 208(Pt A): 48-57.

[80] Halperin D. Environmental noise and sleep disturbances: A threat to health? Sleep Sci. 2014;7(4):209-212.

[81] Han ZX, Lei ZH, Zhang CL, Xiong W, Gan ZL, Hu P, Zhang QB. Noise monitoring and adverse health effects in residents in different functional areas of Luzhou, China. Asia Pac J Public Health.

[82] Harrison RV (2014). On the biological plausibility of Wind Turbine Syndrome. *Int J Environ Health Res*: 1-6.

[83] Heidemann, C., Niemann, H., Paprott, Du, Y. Rathmann, W. Scheidt-Nave, C.. (2014). Residential traffic and incidence of Type 2 diabetes: the German Health Interview and Examination Surveys. *Diabet Med*., 31(10):1269-76.

[84] Hemmingsen, J.G., Møller, P., Jantzen, K., Jönsson, B.A., Albin, M., Wierzbicka, A. et al. (2015). Controlled exposure to diesel exhaust and traffic noise - Effects on oxidative stress and activation in mononuclear blood cells. *Mutat Res*, 775: 66-71.

[85] Hjortebjerg, D., Andersen, A.M., Ketzel, M., Pedersen, M., Raaschou-Nielsen, O., Sørensen, M. (2016). Associations between maternal exposure to air pollution and traffic noise and newborn's size at birth: A cohort study. *Environ Int*, 95: 1-7.

[86] Huang D, Song X, Cui Q, Tian J, Wang Q, Yang K (2015). Is there an association between aircraft noise exposure and the incidence of hypertension? A meta-analysis of 16784 participants. *Noise and Health*, 17(75): 93-97.

[87] Ismaila, S.O. and Odusote, A. (2014). Noise exposure as a factor in the increase of blood pressure of workers in a sack manufacturing industry. *Beni-Suef University Journal of Basic and Applied Sciences*, 3 (2): 116-121.

[88] Jazani, R.K., Saremi, M., Rezapour, T., Kavousi, A., Shirzad, H. (2015). Influence of traffic-related noise and air pollution on self-reported fatigue. *Int J Occup Saf Ergon*, 21(2): 193-200.

[89] Jeffery, R.D., Krogh CM, Horner B. (2014). Industrial wind turbines and adverse health effects. *Can J Rural Med.* 19(1): 21-26.

[90] Kageyama, T., Yano, T., Kuwano, S., Sueoka, S., Tachibana, H. (2016). Exposure-response relationship of wind turbine noise with self-reported symptoms of sleep and health problems: A nationwide socioacoustic survey in Japan. *Noise and Health*, 18(81): 53-61.

[91] Kalantary S, Dehghani A, Yekaninejad MS, Omidi L, Rahimzadeh M (2015). The effects of occupational noise on blood pressure and heart rate of workers in an automotive parts industry. *ARYA Atheroscler*. 11(4): 215-219.

[92] Kersten, N., Backé, E. (2015). Occupational noise and myocardial infarction: considerations on the interrelation of noise with job demands. *Noise and Health*, 17(75): 116-122.

[93] Ravindra, K., Singh, T., Tripathy, J.P., Mor, S., Munjal, S., Patro, B., Panda. N. (2016) Assessment of noise pollution in and around a sensitive zone in North India and its non-auditory impacts. *Sci Total Environ*. 566-567: 981-987.

[94] Knopper L.D., Ollson, C.A., McCallum, L.C., Whitfield, Aslund, M.L., Berger, R.G., et al. (2014). Wind turbines and human health. *Front Public Health*, 2: 63.

[95] Kristiansen, J., Lund, S.P., Persson, R., Challi, R., Lindskov, J.M., Nielsen, P.M. (2016). The effects of acoustical refurbishment of classrooms on teachers' perceived noise exposure and noise-related health symptoms. *Int Arch Occup Environ Health*, 89(2): 341-350.

[96] Lercher, P., Widmann, U., Thudium, J. (2014). Hypotension and environmental noise: a replication study. *International Journal of Environmental Research & Public Health*, 11(9): 8661-8688.

[97] Li, Q., Qiao, F., Yu, L. (2016). Impacts of pavement types on in-vehicle noise and human health. *J Air Waste Manag Assoc.* 66(1): 87-96.

[98] Liu, C., Fuertes, E., Tiesler, C.M., Birk, M., Babisch, W., Bauer, C.P. et al. (2014). The associations between traffic-related air pollution and noise with blood pressure in children: results from the GINIplus and LISAplus studies. *International Journal of Hygiene & Environmental Health*, 217(4-5): 499-505.

[99] Meier, R., Cascio, W.E., Ghio, A.J., Wild, P., Danuser, B., Riediker, (2014). M. Associations of short-term particle and noise exposures with markers of cardiovascular and respiratory health among highway maintenance workers. *Environmental Health Perspectives*, 122(7): 726-732.

[100] Méline, J., Van Hulst, A., Thomas, F., Chaix, B. (2015). Road, rail, and air transportation noise in residential and workplace neighborhoods and blood pressure (RECORD Study). *Noise and Health*, 17(78): 308-319.

[101] Michaud, D.S., Feder, K., Keith, S.E., Voicescu, S.A., Marro, L., Than, J. et al. (2016). Self-reported and measured stress related responses associated with exposure to wind turbine noise. *J Acoust Soc Am*, 139(3): 1467-1479.

[102] Michaud DS, Feder K, Keith SE, Voicescu SA, Marro L, Than J. et al. (2016). Exposure to wind turbine noise: Perceptual responses and reported health effects. *J Acoust Soc Am*, 139(3): 1443-1454.

[103] Mohammadi H, Alimohammadi I, Roshani S, Pakzad R, Abdollahi MB, Dehghan SF. (2016). The Effect of Occupational Noise Exposure on Blood and Biochemical Parameters: A Case Study of an Insulator Manufacturer in Iran. *Electron Physician*, 8(1): 1740-1746.

[104] Monrad M, Sajadieh A, Christensen JS, Ketzel M, Raaschou-Nielsen O, Tjønneland A, Overvad K, Loft S, Sørensen M: Residential exposure to traffic noise and risk of incident atrial fibrillation: A cohort study. Environ Int 2016; 92-93: 457-463.

[105] Münzel T, Gori T, Babisch W, Basner M, Cardiovascular effects of environmental noise exposure. European Heart Journal, 2014. 35(13): p. 829-836a.

[106] Münzel T, Sørensen M, Gori T, Schmidt FP, Rao X, Brook J, Chen LC, Brook RD, Rajagopalan S. Environmental stressors and cardio-metabolic disease: part I-epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies. Eur Heart J. 2016.

[107] Nowakowska-Kotas M, Pokryszko-Dragan A, Brodowski M, Szydo M, Podemski R. (2015). Effects of noise and mental task performance upon changes in cerebral blood flow parameters. *Noise Health* 17(79): 422-428.

[108] Oftedal B, Krog NH, Pyko A, Eriksson C, Graff-Iversen S, Haugen M, et al. (2015). Road traffic noise and markers of obesity - A population-based study. *Environmental Research*, 138: 144-153.

[109] Oiamo TH, Luginaah N, Baxter J. (2015). Cumulative effects of noise and odour annoyances on environmental and health related quality of life. *Social Science & Medicine*, 146: 191-203.

[110] Paunovic, K., Stojanov, V., Jakovljevic, B., Belojevic, G. (2014). Thoracic bioelectrical impedance assessment of the hemodynamic reactions to recorded road-traffic noise in young adults. *Environmental Research,* 129: 52-58.

[111] Pearson, T., Campbell, M.J., Maheswaran, R. (2016). Acute effects of aircraft noise on cardiovascular admissions - an interrupted time-series analysis of a six-day closure of London Heathrow Airport caused by volcanic ash. *Spat Spatiotemporal Epidemiol*, 18: 38-43.

[112] Pedersen, M., Halldorsson, T.I., Olsen, S.F., Hjortebjerg, D., Ketzel, M., Grandström, C. et al. (2017). Impact of Road Traffic Pollution on Pre-eclampsia and Pregnancy-induced Hypertensive Disorders. *Epidemiology*, 28(1): 99-106.

[113] Potera, C. (2014). In the neighborhood: Metabolic outcomes among residents exposed to aircraft noise. *Environmental Health Perspectives*, 122(7).

[114] Pyko, A., Eriksson, C., Oftedal, B., Hilding, A., Östenson, C.G., Krog, N.H., et al. (2015). Exposure to traffic noise and markers of obesity. *Occupational & Environmental Medicine*, 72(8): 594-601.

[115] Recio, A., Linares, C., Banegas, J.R., Díaz, J. (2016). Road traffic noise effects on cardiovascular, respiratory, and metabolic health: An integrative model of biological mechanisms. *Environmental Research*, 146: 359-370.

[116] Recio, A., Linares, C., Banegas, J.R., Díaz, J. (2016). The short-term association of road traffic noise with cardiovascular, respiratory, and diabetes-related mortality. *Environmental Research*, 150: 383-390.

[117] Ristovska, G., Laszlo, H.E., Hansell, A.L. (2014) Reproductive outcomes associated with noise exposure - a systematic review of the literature. *Int J Environ Res Public Health*, 11(8): 7931-7952.

[118] Roswall, N., Eriksen, K.T., Hjortebjerg, D., Jensen, S.S., Overvad, K., Tjønneland, A., et al. (2015). Residential Exposure to Road and Railway Noise and Risk of Prostate Cancer: A Prospective Cohort Study. *PLoS One*, 10(8):e0135407.

[119] Roswall, N., Bidstrup, P.E., Raaschou-Nielsen, O., Jensen, S.S., Olsen, A., Sørensen, M. (2016). Residential road traffic noise exposure and survival after breast cancer - A cohort study. *Environmental Research*, 151: 814-820.

[120] Schmidt, F., Kolle, K., Kreuder, K., Schnorbus, B., Wild, P., Hechtner, M. (2015). Nighttime aircraft noise impairs endothelial function and increases blood pressure in patients with or at high risk for coronary artery disease. *Clinical Research in Cardiology*, 104:23-30.

[121] Schmidt JH, Klokker M. (2014). Health effects related to wind turbine noise exposure: a systematic review. *PLoS One*, 9(12): e114183.

[122] Seidler, A., Wagner, M., Schubert, M., Dröge, P., Pons-Kühnemann, J., Swart, E. et al. (2016). Myocardial Infarction Risk Due to Aircraft, Road, and Rail Traffic Noise. *Dtsch Arztebl Int*, 113(24): 407-414.

[123] Seidler, A., Wagner, M., Schubert, M., Dröge, P., Römer, K., Pons-Kühnemann, J., et al. (2016). Aircraft, road and railway traffic noise as risk factors for heart failure and hypertensive heart disease - a case-control study based on secondary data. *Int. J. Hyg. Environ. Health*, 219(8): 749-758.

[124] Skogstad, M., Johannessen, H.A., Tynes, T., Mehlum, I.S., Nordby, K.C., Lie, A. (2016). Systematic review of the cardiovascular effects of occupational noise. *Occupational Medicine*, 66(1): 10-16.

[125] Sørensen, M., Luhdorf, P., Ketzel, M., Andersen, Z.J., Tjonneland, A., Overvad, K., Raaschou-Nielsen, O. (2014). Combined effects of road traffic noise and ambient air pollution in relation to risk for stroke? *Environmental Research*, 133: 49-55.

[126] Sørensen M, Harbo Poulsen A, Ketzel M, Oksbjerg Dalton S, Friis S, Raaschou-Nielsen O. (2015). Residential exposure to traffic noise and risk for non-hodgkin lymphoma among adults. *Environ Res*, 142: 61-65.

[127] Sørensen M, Hjortebjerg D, Eriksen KT, Ketzel M, Tjønneland A, Overvad K, Raaschou-Nielsen O. Exposure to long-term air pollution and road traffic noise in relation to cholesterol: A cross-sectional study. *Environment International* 2015; 85: 238-243.

[128] Stansfeld and Shipley M. (2015). Noise sensitivity and future risk of illness and mortality. *Science of the Total Environment,* 520: 114-119.

[129] Stansfeld, S.A. (2015). Noise Effects on Health in the Context of Air Pollution Exposure. *Int J Environ Res Public Health,* 12(10): 12735-12760.

[130] Stansfeld, S., Clark, C.. (2015). Health Effects of Noise Exposure in Children. *Curr Environ Health Rep*. 2(2): 171-178.

[131] Tabraiz, S., Ahmad, S., Shehzadi, I., Asif, M.B. (2015). Study of physio-psychological effects on traffic wardens due to traffic noise pollution; exposure-effect relation. *J Environ Health Sci Eng*, 13: 30.

[132] Theorell T, Jood K, Järvholm LS, Vingård E, Perk J, Östergren PO, Hall C. (2016). A systematic review of studies in the contributions of the work environment to ischaemic heart disease development. *Eur J Public Health*, 26(3): 470-477.

[133] Tobías, A., Díaz, J., Recio, A., Linares, C. (2014). Traffic noise and risk of mortality from diabetes. *Acta Diabetologica*.

[134] Tobías, A., Recio, A., Díaz, J., Linares, C. (2014). Does traffic noise influence respiratory mortality? *European Respiratory Journal,* 44(3): 797-799.

[135] Tobías, A., Recio, A., Díaz, J., Linares, C. (2015). Noise levels and cardiovascular mortality: a case-crossover analysis. *Eur J Prev Cardiol*, 22(4): 496-502.

[136] Tonne, C., Halonen, J.I., Beevers, S.D., Dajnak, D., Gulliver, J., Kelly, F.J., et al. (2016). Long-term traffic air and noise pollution in relation to mortality and hospital readmission among myocardial infarction survivors. *Int J Hyg Environ Health*, 219(1):72-8.

[137] Trovato, G., Brischetto, D., Martines, G.F. (2014). Teens' obesity, noise and sleep deprivation: A perverse liaison. Let's move beyond "movida". *Obesity*, 22(5): 1209. (Letter to the editor).

[138] Van Kamp, I., Persson Waye, K. and Gidlöf-Gunnarsson, A. (2015). The Effects of Noise Disturbed Sleep in Children on Cognitive Development and Long Term Health. *J. Child Adolesc. Behav*, 3: 1.

[139] Vienneau, D., Schindler, C., Perez, L., Probst-Hensch, N., Roosli, M. (2015). The relationship between transportation noise exposure and ischemic heart disease: a meta-analysis. *Environmental Research*, 138: 372-380.

[140] Walker, E.D., Brammer, A., Cherniack, M.G., Laden, F., Cavallari, J.M. (2016). Cardiovascular and stress responses to short-term noise exposures-A panel study in healthy males. *Environmental Research*, 150: 391-397.

[141] Zare, S., Nassiri, P., Monazzam, M.R., Pourbakht, A., Azam, K., Golmohammadi, T. (2016). Evaluation of the effects of occupational noise exposure on serum aldosterone and potassium among industrial workers. *Noise and Health*, 18(80): 1-6.

[142] Zawilla N, Shaker D, Abdelaal A, Aref W (2014). Angiotensin-converting enzyme gene polymorphisms and hypertension in occupational noise exposure in Egypt. *Int J Occup Environ Health.* 20(3): 194-206.

[143] Zijlema, W.L., Morley, D.W., Stolk, R.P., Rosmalen, J.G.M. (2015). Noise and somatic symptoms: A role for personality traits? *International Journal of Hygiene and Environmental Health*, 218: 543-549.

[144] Zijlema, W., Cai, Y., Doiron, D., Mbatchou, S., Fortier, I., Gulliver, J., et al. (2016). Road traffic noise, blood pressure and heart rate: Pooled analyses of harmonized data from 88,336 participants. *Environmental Research,* 151: 804-813.

[145] Ancona, C., Golini, M.N., Mataloni, F., Camerino, D., Chiusolo, M., Licitra, G. et al. (2014). Health impact assessment of airport noise on people living nearby six Italian airports. *Epidemiologia e Prevenzione*, 38(3-4): 227-236.

[146] Dzhambov, A.M., Dimitrova, D.D. (2015). Evaluation of the social and economic burden of road traffic noise-attributed myocardial infarction in Bulgarian urban population. *Arh Hig Rada Toksikol.* 66(1): 15-21.

[147] Hänninen, O., Knol, A.B., Jantunen, M., Lim, T.A., Conrad, A., Rappolder, M. et al. (2014). Environmental burden of disease in Europe: Assessing nine risk factors in six countries. *Environmental Health Perspectives*, 122(5): 439-446.

[148] Paunovic, K., Belojevic, G. (2014). Burden of myocardial infarction attributable to road-traffic noise: a pilot study in Belgrade. *Noise and Health*, 16(73):374-379.

[149] Tobías, A., Recio, A., Díaz, J., Linares, C. (2015). Health impact assessment of traffic noise in Madrid (Spain). *Environ Res*, 137:136-140.

[150] Vienneau, D., Perez, L., Schindler, C., Lieb, C., Sommer, H., Probst-Hensch, N., et al. (2015). Years of life lost and morbidity cases attributable to transportation noise and air pollution: A comparative health risk assessment for Switzerland in 2010. *Int J Hyg Environ Health*, 218(6): 514-521.

[151] De Kluizenaar, Y., Gansevoort, R.T., Miedema, H.M., de Jong, P.E. (2007). Hypertension and road traffic noise exposure. *J Occup Environ Med*, 49:484-92.

[152] Beelen, R., Hoek, G., Houthuijs D., Van den Brandt P., Goldbohm R.A., Fischer, P., et al. (2009). The joint association of air pollution and noise from road traffic with cardiovascular mortality in a cohort study. *Occup. Environ. Med*, 66: 243–250.

[153] Tetreault, L.F., Perron, S., Smargiassi, A. (2013). Cardiovascular health, traffic-related air pollution and noise: are associations mutually confounded? A systematic review. *International Journal of Public Health*, 58: 649–666.