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Influence of noise exposure on cardiocerebrovascular disease in Korea

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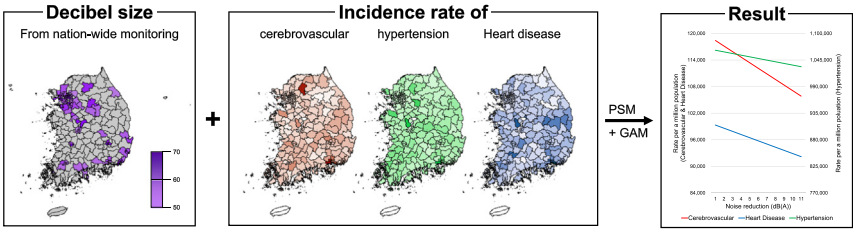
HIGHLIGHTS

- We analyzed the effects of noise exposure on cardiocerabrovascular disease.
- We proposed a framework that combined PSM with a GAM to reduce the sampling problem.
- Korean National Health Insurance Service database and noise data are used.
- When noise increases by 1 dB, caridocerebrovascular disease increases by 0.17–0.66%.
- We also conducted scenario analysis to measure the effect of noise reduction policy.

GRAPHICAL ABSTRACT



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ABSTRACT

Environmental noise pollution is an important social problem. Noise is known to have an adverse effect on human emotions and bodies. However, the methodology of previous studies did not consider selection bias in eliminating participants during the screening process. Therefore, for this study, we propose a framework that combines propensity score matching with a generalized additive model to reduce that sampling problem. Within this framework, we use health data from the National Health Insurance Service and noise data from the National Noise Information System in Korea. Using the proposed framework and data set, we analyze the effects of noise on cardiocerebrovascular disease. Our results show that, when daytime noise increases by 1 A-weighted decibel (dB(A)), cerebrovascular disease increases by 0.66%, hypertension increases by 0.17%, and heart disease increases by 0.38%. Moreover, we conducted a scenario analysis to investigate the effects of noise reduction policies. When noise levels are reduced to meet regulatory targets, cerebrovascular diseases decrease by 2077 per million people, high blood pressure decreases by 5705 per million people, and heart disease decreases by 1151 per million people. Our results thus provide information about noise exposure–response functions in Korea that could be used to establish noise reduction policies.

1. Introduction

Many countries around the world have achieved economic development through urbanization and industrialization. However, the problems of development, including environmental pollution, are emerging along with the benefits. Among environmental pollutants, noise is one problem incurred by urbanization and industrialization. *Noise* is a sound that is physically irregular in the vibration waveform and does not repeat. According to the European Union (EU), about 40% of the EU population was exposed to road traffic noise in excess of 55 A-weighted decibels (dB(A)),[1] 20% was exposed to more than 65 dB (A) in the daytime, and 30% was exposed to more than 55 dB

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[1] The human ear is less sensitive to sounds below 1000 Hz even when the sound is loud. If the frequency is low, humans perceive the sound as quiet. Simply put, dB(A) represents the experience of human hearing.

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(A) during the night in 2011. According to Federal Interagency Committee on Noise (1992), 70 dB is a radio, TV, or vacuum cleaner, 60 dB is conversation in a restaurant or office, and 50 dB is a quiet city or conversational noise in a house. The EU predicts that the population exposed to excess noise will continue to increase over time.

Previous studies have defined noise as unwanted sounds, following the British Standards Association, or sounds harmful to the human body mentally and physically, following the American National Standards Institute. Both definitions reflect that noise affects both social conflicts and health. As noise grows, related disputes intensify, such as conflict between neighbors. According to Noise in New York City Neighborhoods (DiNapoli, 2016), the number of noise complaints in 2016 rose 117% from 2010, reaching 424,400. Traffic noise, such as road noise, railway noise, and aircraft noise, affects residential environments. The effects of noise on the body can be divided into auditory and non-auditory effects. A typical auditory effect is hearing loss, which reduces working concentration, disrupts communication, and increases the likelihood of accidents. The non-auditory health effects of noise include anxiety, sleep disturbance, cognitive impairment, and cardiovascular disease (Babisch, 2006; Basner et al., 2014; Ising and Kruppa, 2004; Kawada et al., 1998; Lusk et al., 2004; Miedema and Vos, 2007). According to Liu et al. (2018), noise affects insulin sensitivity impairment. Noise also increases the likelihood of other non-auditory health effects (Fyhri and Aasvang, 2010) that can cause discomfort and stress, lower daytime labor productivity, and increase the likelihood of developing cardiocerebrovascular diseases such as hypertension and myocardial infarction.

Therefore, many epidemiological studies of noise have been conducted (Babisch et al., 2001; Babisch et al., 2003; Belojević et al., 2008; Gopinath et al., 2011; Münzel et al., 2014). Studies that analyzed the effects of noise on health found relationships between traffic noise and stress hormones (Babisch et al., 2001), night traffic noise and arterial hypertension (Belojević et al., 2008), occupational noise and cardiovascular disease (Gan et al., 2011), and environmental noise and sleep quality (Hume et al., 2012). In addition, Belojević et al. (2008) and Gopinath et al. (2011) showed that noise exposure correlated significantly with the incidence of cardiocerebrovascular disease. However, most previous studies suffered from selection bias, and few studies have quantitatively analyzed the effects of noise on cardiocerebrovascular disease in Korea.

Therefore, we analyzed the quantitative effects of noise on health while minimizing selection bias. For our analysis, we used a framework combining propensity score matching (PSM) with a generalized additive model (GAM) to reduce selection bias in both data collection and analysis and measure the effects of noise on health. In addition, we conducted a scenario analysis to show how the incidence of disease among people changes when the noise level is reduced to regulation levels. Within those research frameworks, we used longitudinal insurance claim data from the Korean National Health Insurance Service (NHIS) database and noise data from the National Noise Information System (NNIS). Overall, we used cohort data to analyze the effects of noise on cerebrovascular diseases, high blood pressure, and heart disease. The results of this study can be used to show the national government, local governments, and environmental groups the present noise situation in Korea, to establish a policy that improves the living environment, and to measure the health benefits of improving the noise environment.

The rest of this paper is organized as follows. Section 2 reviews previous studies to establish the current situation and issues with noise regulation in Korea. Section 3 describes our research methodology, and Section 4 explains the data we used. Section 5 describes our results and scenario analysis. We conclude our discussion in Section 6.

2. Background

2.1. Current noise situation in Korea

In Korea, the Noise and Vibration Control Law was enacted in 1990 to guarantee a quiet life for citizens and prevent conflicts. The Noise and Vibration Control Law specifies different noise standards for each land use, as detailed in Appendix Table A1. Nevertheless, Korea continues to experience noise-related social problems. According to the National Environmental Conflict Resolution Commission of the Ministry of Environment in Korea (http://ecc.me.go.kr/), 85% of all dispute cases between 1991 and 2017 were related to noise.

In response, and to protect the living environment and public health in Korea, a noise monitoring network was installed in 2002 to measure the achievement of noise and vibration standards. In addition, Korea has designated a noise limit for aircraft and regulates traffic noise and vibration for roads and railroads. Table 1 shows the noise levels measured in 2016 by the environmental noise monitoring network system in Korea by land use types. Residential and commercial areas from 44 cities were monitored. Industrial areas from 32 cities were monitored in the ordinary area, and 31 cities in the roadside area. Industrial areas met noise regulations, but residential areas did not, especially residential area A.

2.2. Influence of noise exposure on health

Over the years, the association between long-term noise exposure and the occurrence of death or severe disease has been well documented. It is well known that noise not only causes mental distress such as annoyance and sleep disturbance but also causes a high risk of cardiovascular, hypertensive, and other diseases (Münzel et al., 2014). Tobías et al. (2015) reported that an increase of 1 dB(A) in daily noise levels caused a 6.6% increase in the risk of death. We here focus on the relationship between noise and cardiocerebrovascular disease, which we categorized according to the data we used and our methodology for analysis (Table 2). Specifically, previous studies used indirect indicators such as traffic volume, objective indicators such as decibels, or subjective noise perceptions such as noise annoyance. Several studies used structural equation modeling to identify the relationship between noise and health status (annoyance or sleep disturbance), and other studies compared and analyzed groups exposed and unexposed to noise. We also review some studies conducted in Korea, mainly on workplace noise and aircraft noise.

We first review studies using indirect or objective indicators or subjective perceptions of noise. Babisch et al. (2001) analyzed the effects of noise on 801 women aged 30–35 using indirect indicators of noise such as traffic volume. For health data, they used adrenaline and noradrenaline concentrations in the urine of the subjects, and they found that noise affected physiological arousal. Belojević et al. (2008) analyzed the correlation between noise and arterial hypertension (AH) in 2503 adults using an objective index of decibels as the noise exposure data. After analyzing the family history of AH, age, body mass index (BMI), smoking habits, physical activity, and alcohol consumption as control variables, they found that night noise was associated with the incidence of AH in men. Moreover, Cai et al. (2017) studied the relationship between road traffic noise and cardiovascular disease risk using two European cohorts (HUNT3, Lifelines) and real noise sound pressure levels. They found that an increase in daytime noise of 5.1 dB (A) caused an increase of 1.1% in high-sensitivity C-reactive protein, 0.7% in triglycerides, and 0.5% in high-density lipoprotein, which are all associated with cardiovascular disease. Two studies considered subjective noise perceptions or how people react to noise. One was Gopinath et al. (2011); they measured the effects of noise on cardiovascular disease (CVD) mortality in 2942 subjects aged 55 years and older and found that subjects who did not use hearing protection had 53% and 75% more CVD and angina, respectively, than those who did. The other