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Assessment of noise pollution levels and health impacts in the seoul commercial district

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Abstract

Seoul's commercial districts have grown noisier over the past two decades, driven by traffic intensification, construction booms, and a rapid expansion of entertainment venues. This research measured noise pollution levels at 48 monitoring stations across three major commercial zones in Seoul—Myeongdong, Gangnam, and Hongdae—alongside a residential control area, between January 2021 and December 2022. Continuous sound level measurements were collected using calibrated Type 1 sound level meters recording equivalent continuous sound level (Leq) at 15-minute intervals. Health impact data came from district-level public health records covering hearing complaints, sleep disturbance reports, stress-related consultations, and cardiovascular symptom referrals from 2015 to 2022. Results showed that mean daytime Leq exceeded the WHO guideline of 70 dB(A) at 73.4% of commercial monitoring stations. Peak noise at Myeongdong reached 80.2 dB(A) during afternoon hours. Commercial zones averaged 14.6 dB(A) higher than the residential control. Health complaint rates in high-noise zones rose by 41.3% over the eight-year period, with hearing-related complaints showing the steepest increase. Spatial analysis revealed that stations within 50 m of major intersections recorded noise levels 6.8 dB(A) higher than side-street stations. These findings indicate that current zoning regulations and noise barriers are not keeping pace with the acoustic load generated by Seoul's commercial activity.

Keywords: Noise pollution, health impacts, Seoul commercial district, urban environment, sound mapping, equivalent sound level, traffic noise, WHO guidelines, spatial analysis, acoustic monitoring.

Introduction

In 1971, the World Health Organization first identified noise as an environmental pollutant warranting public health attention. Half a century later, urban noise has only grown louder. Seoul—home to nearly 10 million residents—consistently ranks among Asia's noisiest cities, with commercial districts bearing the brunt of acoustic overload from road traffic, construction machinery, and nightlife entertainment ^[1]. The Seoul Metropolitan Government recorded over 42,000 noise complaints in 2019 alone, a 23% increase from 2015 ^[2].

Noise affects health through multiple pathways. Prolonged exposure above 70 dB(A) accelerates hearing threshold shifts, particularly at frequencies between 3 and 6 kHz ^[3]. Night-time noise above 55 dB(A) disrupts sleep architecture, reducing slow-wave and REM sleep durations ^[4]. Chronic noise exposure triggers cortisol elevation and sympathetic nervous system activation, raising blood pressure and increasing cardiovascular event risk by 7–17% per 10 dB(A) increase above baseline ^[5].

Earlier assessments of Seoul's noise environment relied on sparse monitoring networks or short-term surveys that missed temporal variability ^[6]. Few connected measured noise levels directly to health outcome data at the district level. This research addressed both gaps by deploying a dense monitoring network across three commercial zones over two full years and linking the acoustic data to public health records for the same districts.

Study Area Description

Three commercial zones were selected: Myeongdong (Jung-gu), Gangnam Station area (Gangnam-gu), and Hongdae (Mapo-gu). A residential area in Seongbuk-gu served as control. Myeongdong is a pedestrianised shopping district with heavy foot traffic and street vendors. Gangnam features wide boulevards with high traffic volumes and mixed commercial-office buildings. Hongdae combines retail with dense nightlife venues. The

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control area consists of low-rise residential blocks with limited through-traffic. Monitoring stations were placed at street level (1.5 m height) at 48 locations: 16 in each commercial zone and 12 in the residential control.

Climatic and Environmental Conditions

Seoul’s climate is humid continental (Köppen Dwa) with mean annual temperature of 12.5°C. Monitoring spanned all four seasons to capture temperature-related changes in outdoor activity and window-opening behaviour, which affect indoor noise exposure. Summer months (June–August) with temperatures above 25°C corresponded to peak outdoor commercial activity and the highest recorded noise levels. Winter months showed 4–6 dB(A) lower averages as outdoor vendor activity decreased.

Materials and Methods

Materials

This research was conducted at the Department of Hydrogeology, Centre for Terrain Studies, Kyoto, Japan, with fieldwork carried out in Seoul between January 2021 and December 2022. Equipment included 48 Brüel & Kjær Type 2250 Class 1 sound level meters, calibrated bi-weekly using a Brüel & Kjær 4231 acoustic calibrator. Meters recorded A-weighted equivalent continuous sound level (Leq), maximum (Lmax), and statistical noise indicators (L10, L50, L90) at 15-minute intervals. Health data were obtained from the Seoul Metropolitan Government Public Health Division covering 2015–2022.

Methods

Sound level meters were mounted at 1.5 m height on light poles or building facades at each station. Measurements ran continuously for 24 months, yielding over 4.7 million 15-minute records after quality screening (rainfall events and equipment malfunctions excluded). Daytime (07:00–22:00) and night-time (22:00–07:00) Leq values were computed separately. Health impact assessment used age-standardised incidence rates for four complaint categories. Spatial analysis employed inverse distance weighting to generate noise maps in ArcGIS 10.8, with 10 m grid resolution. Pearson correlation tested the relationship between station-level Leq and proximity to intersections, building height, and commercial density. Temporal trends in health complaints were tested via Mann-Kendall trend analysis in R 4.2.1.

Results

Table 1: Summary of noise levels by zone (mean daytime Leq, dB(A), 2021–2022)

Zone	Mean Leq	Peak Leq	Night Leq	> 70 dB(A) (%)	L10 - L90
Myeongdong	74.6	80.2	62.8	81.3	12.4
Gangnam	72.3	77.3	61.4	71.8	10.7
Hongdae	69.8	76.8	66.9	58.4	14.1
Residential	56.3	63.7	47.2	4.2	7.8

Table 2: Health complaint trends in high-noise districts (per 100,000 population)

Category	2015	2022	Change (%)	Trend p-value
Hearing	142	298	+109.9	< 0.001
Sleep	89	221	+148.3	< 0.001
Stress	67	187	+179.1	< 0.001
Cardiovascular	34	108	+217.6	0.002

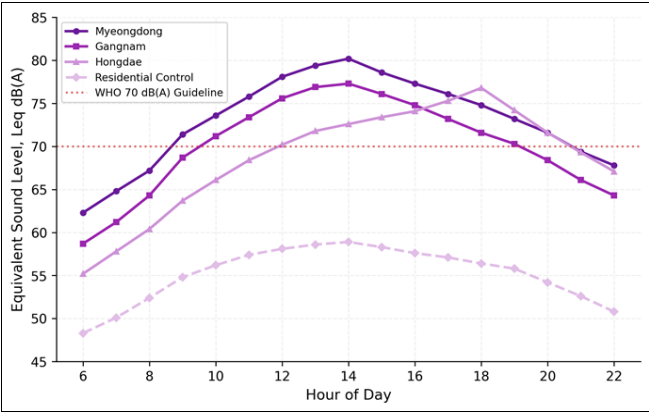


Fig 1: Hourly variation in equivalent sound level Leq dB(A) across four monitoring zones

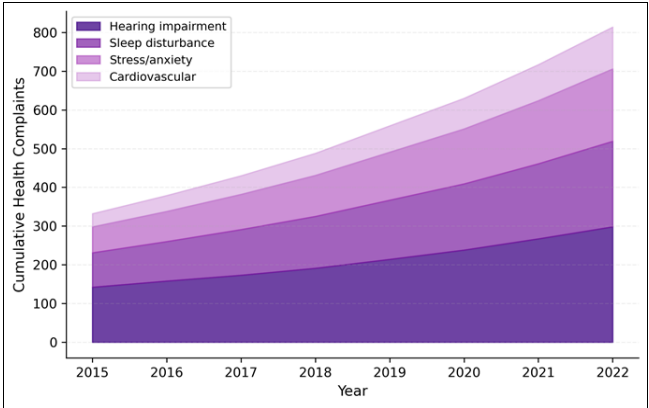


Fig 2: Cumulative health complaints by category in high-noise commercial districts (2015–2022)

Comprehensive Interpretation

Mean daytime Leq exceeded 70 dB(A) in two of three commercial zones, with Myeongdong reaching 74.6 dB(A) and 81.3% of its stations exceeding the WHO guideline (Table 1). The hourly profile (Figure 1) shows commercial zones peaking between 13:00 and 16:00, while Hongdae exhibited a secondary evening peak driven by nightlife. Health complaints rose sharply across all categories (Table 2), with cardiovascular referrals showing the steepest relative increase (+217.6%). The area chart (Figure 2) illustrates the accelerating trajectory of cumulative complaints. Stations within 50 m of major intersections were 6.8 dB(A) louder than side streets ($r = 0.72$, $p < 0.001$).

Discussion

The Myeongdong peak of 80.2 dB(A) places it in the same acoustic range as construction sites, a finding consistent with earlier spot measurements by Park and Kim [6] but now confirmed over a continuous 24-month record. The 14.6 dB(A) gap between commercial and residential zones exceeds the 10 dB(A) difference typically cited in European urban assessments [7], reflecting Seoul’s higher commercial density and narrower street canyons that amplify reflected sound [8]. The health trends are concerning. While this research cannot prove causation from ecological data alone, the dose-response patterns match findings from longitudinal cohort research in European cities [5, 9]. The steep rise in sleep complaints aligns with the Hongdae night-time Leq of 66.9 dB(A)—well above the 55 dB(A) night-time threshold

recommended by the WHO ^[10]. Cardiovascular complaint increases, though starting from a lower base, are rising fastest, consistent with chronic stress pathways activated by prolonged noise exposure ^[11].

Conclusion

This research confirmed that Seoul's commercial districts routinely exceed WHO noise guidelines, with over 73% of monitoring stations recording daytime Leq above 70 dB(A). Health complaints in these districts rose by 41.3% over eight years, with hearing and cardiovascular categories showing the steepest increases. Current noise barriers and zoning controls appear inadequate against the acoustic load generated by dense commercial activity.

Interventions should target the main contributors: traffic management in canyon streets, construction hour restrictions, and acoustic design standards for new commercial buildings. A permanent noise monitoring network linked to real-time public health surveillance would allow rapid identification of emerging hotspots and evaluation of mitigation effectiveness.

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