Universal Journal of Public Health 13(6): 1458-1464, 2025 http://www.hrpub.org
DOI: 10.13189/ujph.2025.130605

Impact of Acoustic Pollution on Cardiovascular Diseases in Chile: Risk Analysis

Daniel Inostroza Briones[1,*], Alexandr Gorielov Salas[2]

[1]Faculty of Veterinary Medicine and Agronomy, University of the Americas, Chile
[2]Superintendency of Pensions, Alameda Libertador Bernardo O´Higgins Avenue 1449, Santiago, Chile

Received June 26, 2025; Revised September 29, 2025; Accepted October 14, 2025

Cite This Paper in the Following Citation Styles

(a): *[1] Daniel Inostroza Briones, Alexandr Gorielov Salas, "Impact of Acoustic Pollution on Cardiovascular Diseases in Chile: Risk Analysis," Universal Journal of Public Health, Vol. 13, No. 6, pp. 1458 - 1464, 2025. DOI: 10.13189/ujph.2025.130605.*

(b): *Daniel Inostroza Briones, Alexandr Gorielov Salas (2025). Impact of Acoustic Pollution on Cardiovascular Diseases in Chile: Risk Analysis. Universal Journal of Public Health, 13(6), 1458 - 1464. DOI: 10.13189/ujph.2025.130605.*

Abstract In public health, the impact of noise pollution is a growing threat, given the estimated population exposure of 130 million people with ambient noise levels exceeding 65 dB. The WHO describes a direct relationship between ambient noise and the development of ischemic heart disease, due to noise overstimulating the autonomic nervous system and neuroendocrine system, increasing levels of cortisol and norepinephrine, which lead to the development of cardiovascular pathologies. In Chile, the Ministry of the Environment estimated that in the city of Santiago, 3.7% of ischemic heart diseases were attributable to high levels of ambient noise. The purpose of the study is to estimate the impact of exposure to ambient noise on cardiovascular morbidity during 2018-2020 in Chile. A secondary data analysis of cardiovascular diseases in individuals aged 15-65 years registered by the Department of Statistics and Health Information was conducted, along with data on the population exposed to ambient noise from records of the Ministry of the Environment for the period 2018-2020 in Chile. Ambient noise data and emergency consultations of a cardiovascular type were quantitatively described, calculating the risk for ambient noise and the number of attributable cases. A total of 1,029,796 consultations for circulatory causes were observed, obtaining a global population rate of 2.04 per 100 exposed to ambient noise. Risks for road traffic were calculated for: Acute Myocardial Infarction, Cerebrovascular Accident, and Hypertensive Crisis, obtaining 1,410, 5,879, and 8,551 attributable cases for their respective causes. In Chile, cardiovascular diseases account for over 25% of total causes of death, mainly associated with high rates of hypertension, acute myocardial infarction, and cerebrovascular accident. During the period of 2018-2020, the average dB recorded for ambient noise exceeded the threshold established by the WHO, which could be considered a risk factor for heart disease.

Keywords Acoustic Pollution, Cardiovascular Diseases, Environmental Health, Ambient Noise, Environmental Risks

1. Introduction

It is estimated that more than 130 million people are exposed to environmental noise levels that exceed 65 dB, and a large part of this population suffers from acoustic pollution values above the limits established by the World Health Organization (WHO) [1, 2]. The effects of acoustic pollution on public health and the relationship with the increase in the prevalence and incidence of cardiovascular diseases and hypertension are investigated as an environmental risk factor [3, 4]. The main acoustic pollutant described is traffic noise, which has been associated with a higher risk of developing ischemic heart diseases, identifying a relative risk (RR) of 1.08 (95% CI: 1.01-1.015). Furthermore, it is described that with an increase of 10 dB of traffic noise in the range of 40-80 dB, an RR = 1.36 is obtained [5].

Epidemiological studies indicate that noise is a cardiovascular risk factor, associated with a stress response, which causes a response from the autonomic nervous system with activation of the sympathetic system and the neuroendocrine system, increasing circulating cortisol and norepinephrine, leading to a low-intensity inflammatory state that, when prolonged over time, can increase the development of heart diseases [6, 7].

The Ministry of Health of Chile (MINSAL) [8] describes cardiovascular disease as the leading cause of death in the Metropolitan Region, with 151.79 cases per hundred thousand inhabitants. In addition, the rate of hospital discharge for ischemic disease fluctuates between 127.9 cases per hundred thousand inhabitants, with a distribution of 40% for acute myocardial infarction, 33% for chronic ischemic heart disease, 24% for angina pectoris, and for other acute ischemic pathologies, 3%, identifying a mortality of 6.3% associated with acute myocardial infarction, being this described as the leading cause of death in Santiago de Chile. In addition, from the Ministry of Environment (MMA) [9], it was reported that only in Santiago, Chile, 3.7% of ischemic heart diseases are attributable to exposure to high levels of environmental noise, the main source being noise emission from traffic, mainly from transit and vehicle flow. It was also estimated that 19% of the population is exposed to unacceptable noise levels during the day and at night, with increases of up to 29% of the population exposed to unacceptable decibel levels.

The study aims to estimate the impact of exposure to environmental noise from road traffic on cardiovascular morbidity, by describing exposure to environmental noise and analyzing trends in emergency consultations for cardiovascular issues, to know the cases attributable to environmental pollution in Chile during the period from 2018 to 2020.

2. Materials and Methods

2.1. Design and Study Population

An ecological cross-sectional study design was conducted, analyzing secondary data on cardiovascular morbidity in individuals aged 15 to 65 years who presented for emergency consultations for cardiovascular pathology in public health systems in the cities of Santiago, Concepción, Valparaíso and Viña del Mar in Chile, cities where daytime and nighttime environmental noise monitoring was conducted during the period from 2018 to 2020.

2.2. Sources of Information for Data Collection

The analyzed data comes from two sources, the first being from the Emergency Care Registration System of the Department of Statistics and Information of the Ministry of Health (DEIS), from which data on patients treated for circulatory causes were obtained, considering the causes of: acute myocardial infarction (AMI), cerebrovascular accident (CVA), hypertensive crisis, and other circulatory causes. The second source corresponded to the Ministry of Environment of Chile (MMA), from which records of environmental noise monitoring from active stations were extracted for the study period.

2.3. Data Analysis

A quantitative description of the data on emergency consultations for cardiovascular diseases and environmental noise was carried out for the communes that had environmental noise monitoring during the study period. The global exposure rate was calculated using the formula TG = N°Consultations / Population > 15 years. Subsequently, the data were analyzed and described by comparing them with the values proposed by the WHO [10], as acceptable for population health. This resulted in the value of population attributable risk using the formula PAR% = [Exposure Prevalence (RR – 1) / 1 + (RR – 1)] * 100, which allowed for the calculation of the number of attributable cases of emergency consultations for cardiovascular pathology due to exposure to environmental noise using the formula AC= (Cases VC * AR), where AC corresponds to attributable cases, VC cases are the observed frequency of cardiovascular cases, and AR is the attributable risk.

2.4. Limitations and Biases of the Study

The main limitation of the study is the proposed design, which contemplates the bias due to ecological fallacy.

The coverage of environmental noise measurement in Chile is not homogeneous, and there may be a higher level of contamination, which could be considered a bias that underestimates the total number of attributable cases; this bias was controlled by the analysis of data from the population coming from cities that had environmental noise monitoring.

The main confounding variables identified were, other environmental variables, such as temperature and atmospheric chemical pollutants that can have a similar impact on the population, and this bias was controlled by what was proposed by Rockhill et al. [11], who describe the population attributable fraction using the formula P (D) - ∑cP (D|C, E) P (C) / P (D), where P (D) is the average probability of disease in the population (exposed and non-exposed) during a specific time interval, and ∑cP (D|C, E) P (C) represents the marginal conditional probability of disease given non-exposure averaged over confounding factors; therefore, the estimated risks were adjusted for the presence of these pollutants. In addition, the quality of measurement of exposure to environmental noise is controlled through precise measurements, given that an official source responsible for controlling the quality of daytime and nighttime noise was used.

Confounding bias related to other risk factors, such as smoking, obesity, sedentary lifestyle, alcoholism, and other diseases such as diabetes was also identified.

The DEIS system does not classify cardiovascular diseases according to ICD 10[1], which presents a bias due to misclassification.

2.5. Ethical Implications

The type of study design did not present ethical issues, as all the information used is anonymous and extracted from public information databases.

3. Results

In Chile during the period 2018-2020, a total of 1,129,796 consultations for circulatory causes were recorded (Table 1), and a total of 1,008,977 cases were observed in the group of 15-65 years.

Table 1. Distribution and classification of emergency consultations by circulatory cause in Chile for the study period

	2018	2019	2020
Cases of AMI	15,002	17,166	17,216
Cases of CVA	136,780	39,035	36,812
Cases of HTN	114,594	28,543	108,299
Cases of severe arrhythmias	25,287	112,951	26,328
Other circulatory causes	146,040	162,059	143,684
Total consultations	437,703	359,754	332,339
Cases group of 15-65 years	330,146	351,569	327,262

Source: own elaboration from DEIS.

The population of the municipalities in Chile exposed to environmental noise reached a total of 6,401,806 individuals (Figure 1), of which, for the year 2020, there were a total of 130,719 consultations in emergency care according to the municipalities under study. The rate of global observed consultations for cardiovascular pathology was 2.04 per 100 exposed to environmental noise.

The MMA of Chile has a total of 14 environmental noise monitoring stations, distributed in 10 stations in Santiago, 2 in Concepción, and 2 in Valparaíso, from which information was obtained for the analysis of environmental noise. The environmental noise monitoring network measures traffic noise, which is considered as the indicator of continuous equivalent sound pressure level (Equivalent Level) LEq., which corresponds to the temporal average of the sound pressure squared. High levels of environmental noise exceeding 55 dB were obtained for most of the monitoring stations (Figure 2), only between 1:00 hrs to 6:00 hrs were levels of noise recorded below 55 dB at the Ñuñoa and Independencia stations, while in Cerro Navia, Concepción Centro, and Providencia, lower levels were recorded between 1:00 hrs and 5:00 hrs.

Using environmental registration data for the exposed population, an average of 2.7 million people were exposed to daytime environmental noise of 68.21 dB and nighttime noise of 68.21 dB during the study period in the cities of Chile where monitoring is conducted (Table 2).

The estimated prevalence for the population exposed to environmental noise was 11.92%, with the highest prevalence of exposure being the population of the Santiago commune with 24.93%.

In the communes with environmental noise measurement, there were a total of 7,405 consultations attributed to HTN for the period 2018-2020, with a lower limit (LL) of 3,022 and an upper limit (UL) of 12,090, with the commune of San Bernardo presenting the highest number of consultations attributed to HTN with a total of 440 (LL 176 - UL 704) consultations. Of the consultations attributed to cases of AMI, a total of 1,410 cases were obtained (LL 176 - UL 2,643), with the commune of Puente Alto presenting the highest number of cases, recording 189 cases (LL 24 - UL 355); on the other hand, the commune with the fewest cases was Padre Las Casas with 1 consultation attributed to AMI (LL 0 - UL 3). For the consultations attributed to CVA, a total of 5,879 cases were evidenced (LL 1,260 - UL 10,498), with the commune of Temuco presenting the highest number of cases, with 711 attributed consultations (LL 152 - UL 1,270); conversely, the commune of Macul had the lowest number of cases, with 6 cases (LL 1 - UL 11).

The relative risk was obtained through ranges proposed by the WHO [4], for three circulatory causes due to road traffic noise. The AR was calculated, considering a global rate of 12%, (Table 3). From the AR results obtained, it was evidenced that the communes of Viña del Mar and Valparaíso presented the highest values regarding HTN with 539 and 342 cases respectively; conversely, the commune of Providencia had the lowest number of attributable cases for HTN with 29 cases. For attributable cases of AMI, the commune that presented the highest AR was Concepción with a total of 142 cases, followed by Santiago with 110 cases for AMI; conversely, the communes of Las Condes and Ñuñoa presented the lowest number of attributable consultations for AMI with 7 and 9 cases. For CVA, it was obtained that the commune with the highest AR was Santiago with 692 attributable cases, followed by the commune of San Miguel with 663 and Concepción with 651 attributable cases for CVA due to environmental noise; however, the communes of El Bosque, Ñuñoa, Las Condes, and Cerro Navia presented the least number of attributable cases with 32, 33, 36, and 38 AR attributable for CVA due to environmental noise.

1 DEIS http://cognos.deis.cl/ibmcognos/cgi-bin/cognos.cgi?b_action=cognosViewer&ui.action=run&ui.object=/content/folder%5B@name=%27PUB%27%5D/folder%5B@name=%27REPORTES%27%5D/folder%5B@name=%27Atenciones%20de%20Urgencia%27%5D/report%5B@name=%27Atenciones%20Urgencia%20-%20Vista%20por%20semanas%20-%20Servicios%27%5D&ui.name=Atenciones%20Urgencia%20-%20Vista%20por%20semanas%20-%20Servicios&run.outputFormat=&run.prompt=true#

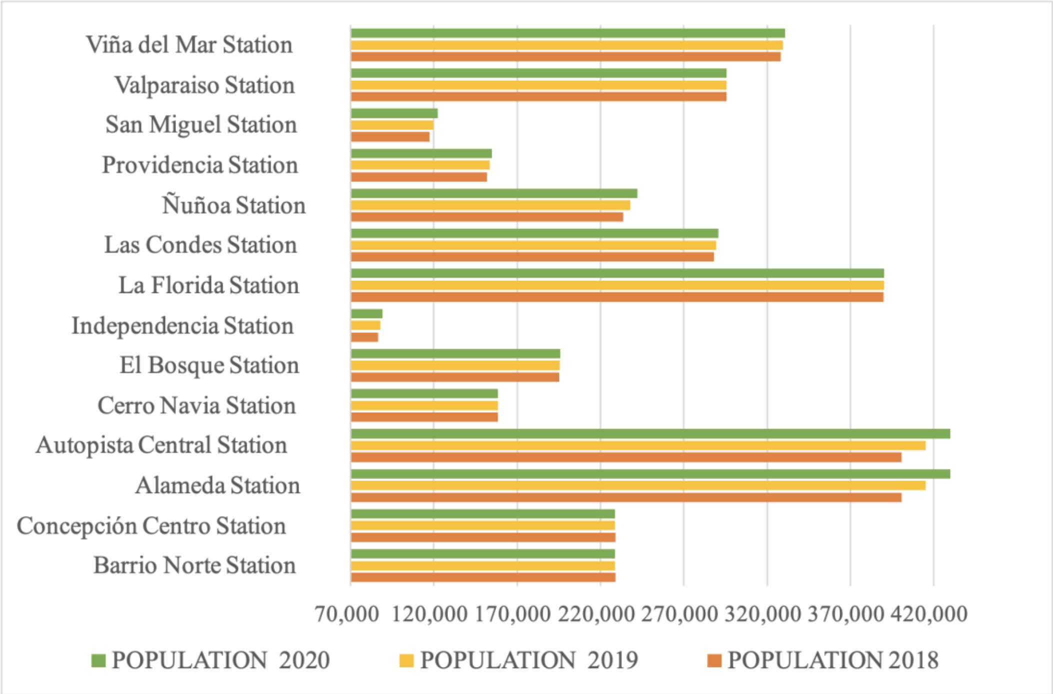

Figure 1. Population exposed to environmental noise in Chile in the period of 2018-2020

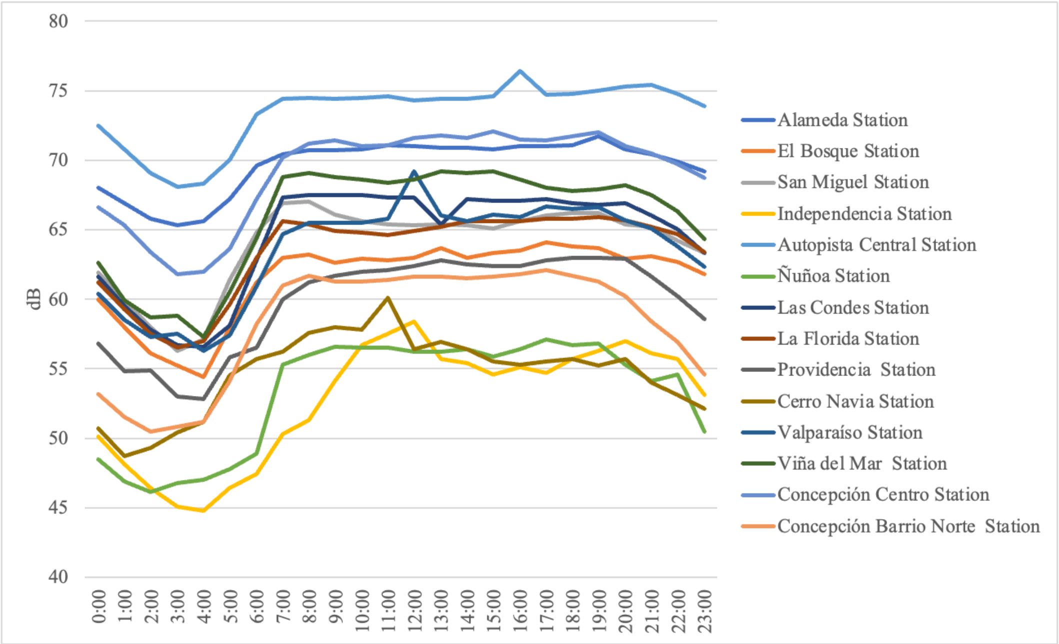

Figure 2. Average equivalent noise level in the 14 monitoring stations

Table 2. Exposed population to environmental noise in Chile during 2018-2020

Year	Exposed population	Environmental noise	
		Daytime noise	Nighttime noise
2018	2,422,312	69.74 dB	66.05 dB
2019	2,090,335	69.96 dB	65.15 dB
2020	3,590,216	64.93 dB	57.27 dB

Source: own elaboration with data from the National Health Survey Chile (ENS) and the Ministry of the Environment (MMA).

Table 3. Relative risk and attributable risk for circulatory causes

Causes	RR	CI 95%	AR	CI 95%
HTN	1.05	1.02 – 1.08	8,551	3,241 – 13,682
AMI	1.08	1.01 – 1.15	1,410	1 – 2,643
CVA	1.14	1.03 – 1.25	5,879	1,260 – 10,498

Source: WHO and own study data.

4. Discussion

Of the risk factors attributable to cardiovascular diseases in Chile, it has been described that 70% of deaths due to cardiovascular causes can be prevented through the intervention of potentially modifiable risk factors, highlighting among them smoking, excessive salt consumption, low consumption of fruits and vegetables, sedentary leisure time, alcohol consumption, obesity, arterial hypertension, and diabetes mellitus [12]. Additionally, psychosocial and environmental risk factors that include daytime and nighttime noise are considered potentially preventable risk factors [2].

Environmental noise pollution is described as one of the main harmful environmental risk factors for cardiovascular health worldwide [2]. Multiple epidemiological studies of risk analysis allowed the creation of the guidelines proposed by the WHO [1, 5, 10], where the RR for different types of cardiovascular causes due to prolonged exposure to high levels of dB from daytime and nighttime environmental noise is identified, with the causes of HTN, CVA, and AMI recognized as the main ones related to the pollutant resulting from vehicle traffic emissions [13]. This information was crucial in the research, as knowing the RR of the studied risk factor allowed obtaining the population AR for the population of Chile, where a greater relationship of cases of HTN attributable to environmental noise was obtained during the study period, being the most consulted cause in health services from 2018 to 2020, in addition to being the most frequent for different age groups, an alarming situation from the perspective of public health management, given that in Chile the main cause of death, with 25% of cases, has been described as heart diseases related to high rates of arterial hypertension and is also described as the third cause of loss of healthy years of life [14, 15], having an economic impact attributable to the diagnosis and treatment of cardiovascular diseases estimated at $1.4 billion dollars, which represents 4.2% of the total health expenditure for Chile [16]. The heart diseases related to the high national mortality rate are due to strokes and acute myocardial infarction, with 46.4 and 44.8 per 100,000 inhabitants, of which 70% of the cases are attributable to modifiable risk factors [17].

Scientific evidence describes a greater relationship of exposure to nighttime noise from traffic with alterations in cardiovascular health, where continuous exposure during nighttime alters the sleep of individuals, this stage being key in the development of hypertension, because during sleep blood pressure continuously decreases favoring the long-term restoration of the cardiovascular system. Therefore, repeated autonomic awakenings due to noise prevent the drop in blood pressure contributing to the risk of developing hypertension [18]. Moreover, hypertension is related as a main factor of morbidity and mortality of cardiovascular risk, as it increases the risk of acute myocardial infarction and cerebrovascular accidents [15]. In Chile, it is considered one of the conditions with the highest disease burden, having a greater impact on people over 35 years old and being associated with the population of lower socioeconomic resources, evidence that can be observed in the study where a higher rate of consultations related to HTN was observed in communes of Chile that presented lower socioeconomic levels [19, 20]. The consultations related to CVA represented the second leading cause for the study period, according to Roa et al. [21], and CVA is the second leading cause of death worldwide and the leading cause of disability, being described in Chile as the main cause of death and the first specific cause of years of life adjusted for disability in the population over 74 years old. According to Sørensen et al. [22], exposure to noise from residential traffic is associated with a higher risk of CVA in the population over 64.5 years, showing an increase in risk for every 10 dB increase in noise level, where the evidence observed in Chile is alarming given the daytime and nighttime dB records obtained in this study, since the WHO guidelines [4, 10], establish acceptable levels for daytime <65 dB and nighttime <55 dB, which highlights the impact that acoustic pollution may be having on the local population.

Of the other circulatory causes recorded by the DEIS, such as severe arrhythmia, it was not possible to obtain the population-attributable risk, due to lack of data related to the RR.

The study considered the traffic of vehicles for Chile, given that the records of environmental noise establish it as the main source of noise in the site where the monitoring equipment is installed [9]; however, in the country, there are other sources of environmental noise, such as air traffic, railway, port noise, and occupational noise, so it is likely that there is a greater RR than described by the WHO guidelines [1, 2, 4], mainly due to the conditions under which the data is obtained, which may be underestimating the national situation regarding the risk of exposure to environmental noise.

The exposure of the population to environmental noise leads to a chronic stress stimulus, which affects the autonomic nervous system, leading to an increase in heart rate, an increase in blood pressure, and an increase in norepinephrine concentrations, causing an increase in cortisol release, which impacts the low-grade inflammatory state that, sustained over time, generates a gradual increase in blood pressure [7]. Considering that the causes of CVA and AMI are the main causes of cardiovascular death in Chile, this study becomes relevant, given that an intervention in mitigation measures for the pollutant would have an effect on reducing at least 8,500 cases of consultations related to HTN, 5,800 cases of CVA, and 1,400 cases of AMI.

5. Conclusions and Recommendations

The data obtained in the study can present a significant variation from the national reality given the design that leads to ecological fallacy, for this reason it becomes imperative to conduct prospective cohort studies to know the relative population risk of Chile considering the different sources of environmental noise emissions and the main confounding factors related to heart diseases among them smoking, diet, sedentary lifestyle, alcohol consumption, comorbidities such as diabetes mellitus and other environmental pollutants.

Another limitation of the study is related to individual perception of the sound stimulus, since the noise waves when emitted do not maintain their intensity; therefore, there are factors that can modify the exposure such as the location of the population and the quality of acoustic insulation.

Due to the economic impact of heart diseases on the population of Chile, it is imperative to establish a regulation of environmental noise through public policies where environmental noise monitoring is carried out that covers the entire national territory, with the purpose of mitigating and controlling the rates of cardiovascular consultations.

REFERENCES

[1] Berglund B., Lindvall T., Schwela D., & World Health Organization (WHO)., “Occupational and Environmental Healt Team. Guidelines for community noise,” World Health Organization, 1999, pp. 9-93. URL: https://iris.who.int/handle/10665/66217

[2] Gjestland T., & Evensen K., “World Health Organization’s guidelines for environmental noise,” 14th ICBEN Congress on noise as a Public Health Problem, June 18-22, 2023, pp. 1-9. URL: https://www.icben.org/2023/presenting35.pdf

[3] Mendis S., Puska P., Norrving B., World Health Organization, World Heart Federation. et al., “Global atlas cardiovascular disease prevention and control,” World Health Organization, Geneva, 2011, pp. 2-57. URL: https://iris.who.int/handle/10665/44701

[4] Charakida M., Deanfield JE, “Nighttime aircraft noise exposure: flying towards arterial disease,” European Heart Journal, vol. 34, no. 45, pp. 3472-3474, 2013. DOI: 10.1093/eurheartj/eht339

[5] Kempen EV., Casas M., Pershagen G., Foraster M., “WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary,” Int J Environ. Res Public Health, vol. 15, no. 2, pp. 379, 2018. DOI: 10.3390/ijerph15020379

[6] Escobar C., Divisón JA., “Noise and cardiovascular disease,” SEMERGEN, vol. 42, no. 6, pp. e65-e66, 2016. DOI: 10.1016/j.semerg.2015.11.011

[7] Babisch W., “Cardiovascular effects of noise,” Noise Health, vol. 13 no. 52, pp. 201-204, 2011. DOI: 10.4103/14631741.80148.

[8] Aranda C., Muñoz R., Palta E., Moreno C., Chávez R., Araya F., Sota A., Yáñez M., MINSAL., “Health diagnosis of the Metropolitan Region 2014,” SEREMI, Región Metropolitana. Retrieved February 25, 2025, from: https://www.gobiernosantiago.cl/wp- content/uploads/2014/12/Seremi-de-Salud-Región-Metropolitana-Diagnóstico-de-Salud-de-la-Región-Metropolitana-2014-Diciembre-2014.pdf

[9] Ministerio de Medio Ambiente de Chile (MMA)., “Ambient noise,” Retrieved February 25, 2025, from: https://ruido.mma.gob.cl/estrategia-mma/

[10] WHO Europe., “Environmental noise guidelines for the European Region,” World Health Organization Regional Office for Europe, 2018, pp. 2-7.

[11] Rockhill B, Newman B, Weinberg C., “Use and misuse of population attributable fractions,” Am J Public Health, vol. 88, no. 1, pp. 15-19, 1998. DOI: 10.2105/ajph.88.1.15.

[12] Troncoso-Pantoja C., Martínez-Sanguinetti M., Ulloa N., Celis-Morales C. “Cardiovascular disease cases can be attributed to risk factors that could be modified with lifestyle changes,” Rev. Med. Chile, vol. 148, no. 1, 2020. DOI: 10.4067/S0034-98872020000100126

[13] Information sheets of the World Health Organization., “Cardiovascular diseases (CVDs),” World Health Organization. 2021. Retrieved February 25, 2025, from: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

[14] Fuentes M., Marzzano A., Canals M., Torres R., Cáceres D., Alvarado S., “Identification of daily environmental noise patterns in two different urban sites in Santiago, Chile,” Revista médica de Chile, vol. 148, no. 5, pp. 582-593, 2020. DOI: 10.4067/S0034-98872020000500582

[15] MINSAL., “Informe Encuestas. Nacional de Salud 2016-2017: Riesgo cardiovascular,” Ministerio de Salud: Santiago de Chile, pp. 10-15, 2018. Retrieved February 25, 2025, from: http://epi.minsal.cl/resultados-encuestas/

[16] World Heart Federation (WCC). El costo de las enfermedades cardiacas en América Latina supera los $ 30 mil millones de dólares. 2016. Retrieved September 2, 2025,

from https://world-heart-federation.org/wp- content/uploads/2017/05/spanish-press-release.pdf

[17] Yusuf S., Joseph P., Rangarajan S., Islam S., Mente A., Hystad P., et al., "Modifiable risk factors, cardiovascular disease, and mortality in 155,722 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study," The Lancet., vol. 395, no. 10226, pp. 795-808, 2019. DOI: 10.1016/S0140-6736(19)32008-2

[18] Haralabidis AS., Dimakopoulou K., Vigna-Taglianti F., Giampaolo M., Borgini A., Dudley ML., Pershagen G., Bluhm G., Houthuijs D., Babisch W., Velonakis M., Katsouyanni K., Jarup L., Consortium H., "Acute effects of night-time noise exposure on blood pressure in populations living near airports," Eur Heart J., vol. 29, no. 5, pp. 658-664. 2008. DOI: 10.1093/eurheartj/ehn013.

[19] Rojek M., Rajzer MW., Wojciechowska W., Drozdz T., Skalski P., Pizoń T., Januszewicz A., Czarnecka D., "Relationship between long-term exposure to aircraft noise, blood pressure profile, and arterial stiffness," Journal of Hypertension, vol. 37, no. 7, pp. 1350-1358, 2019. DOI: 10.1097/HJH.0000000000002060

[20] Petermann F., Durán E., Labraña A., Martínez MA., Leiva AM., Garrido-Méndez A., Poblete-Valderrama F., DíazMartínez X., Salas C., Celis-Morales C., "Risk factors associated with the development of hypertension in Chile," Revista médica de Chile, vol. 145, no. 8, pp. 996-1004, 2017. DOI: 10.4067/s0034-98872017000800996

[21] Roa S., Otto ME., Ascencio E., "An epidemiological characterization of patients with acute stroke in a single Chilean hospital using diagnosis-related group registers," Medwave, vol. 19, no. 6, pp. e7668, 2019. DOI: 10.5867/medwave.2019.06.7668.

[22] Sørensen M., Hvidberg M., Andersen ZJ., Nordsborg RB., Lillelund KG., Jakobsen J., Tjonneland A., Overvad K., Raaschou-Nielsen O., "Road traffic noise and stroke: a prospective cohort study," Eur Heart J., vol. 32, no. 6, pp. 737-744, 2011. DOI: 10.1093/eurheartj/ehq466.