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A Systematic Review of Impacts of the COVID-19 Pandemic on Acoustic Environments

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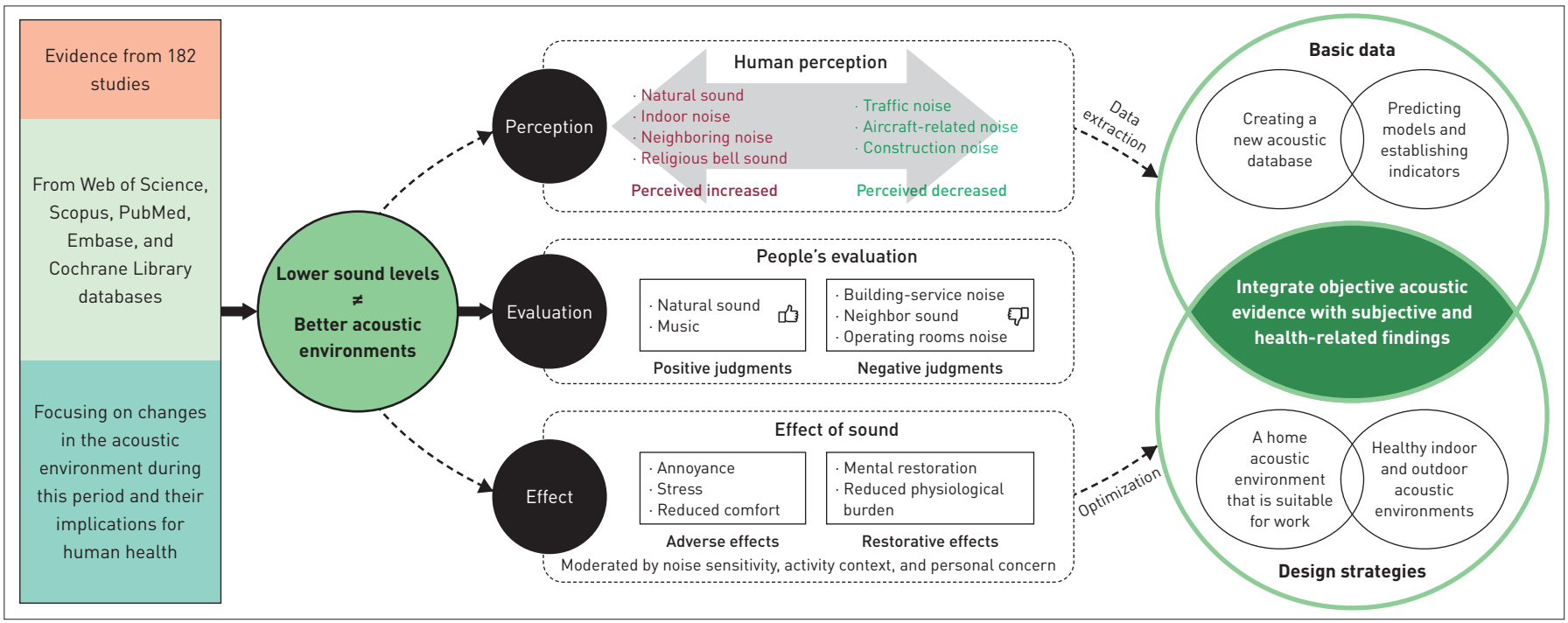
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GRAPHICAL ABSTRACT



ABSTRACT

The COVID-19 pandemic triggered global lockdowns, imposing stringent restrictions on travel, social interaction, and access to public spaces, altering acoustic environments and influencing human wellbeing. This research systematically examines changes in the acoustic environment during this period and their implications for human health. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, 182 studies published between 2020 and 2025 were retrieved from the Web of Science, Scopus, PubMed, Embase, and Cochrane Library databases. Results revealed a significant difference between cities included in the Global Cities Index (–5.8 dBA) and other cities (–13.8 dBA). Across sound source categories, urban, anthropogenic, and aircraft noise showed mean changes of –10.1 dBA, –10.7 dBA, and –11.2 dBA, respectively. In contrast, certain functional indoor

environments exhibited increases in sound levels, particularly medical spaces (+5.3 dBA). Research attention also increasingly shifted to indoor soundscapes. Compared with the pre-restriction period (2014–2019), studies on indoor soundscapes increased to 3.53 times, while studies on outdoor soundscapes increased to 2.97 times during 2020–2025. The research focus evolved from objective acoustic measurements to perception and health-related outcomes. Indoor noise exposure in home-based working and learning environments was associated with reduced comfort, decreased cognitive performance, and increased annoyance, whereas natural sounds or music were linked to improved psychological well-being and restorative experiences. Objective acoustic measurements, sound-source characteristics, contextual factors, subjective soundscape evaluations, and health-related outcomes should be considered together to understand the relationships between acoustic environments and human experience, well-being, and health.

KEYWORDS

Acoustic Environment; Lockdown; Sound Level; Perception; Health; Soundscape; Noise Exposure; Systematic Review

HIGHLIGHTS

- Sound-level variations across urban settings inform noise control and soundscape design
- The number of papers on indoor soundscape rose 3.53-fold in 2020–2025 compared with 2014–2019
- As urban noise levels decreased, people perceived natural sounds as more prominent
- Perceptions of acoustic environments and annoyance, stress, and mental health warrant greater study

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1 Introduction

The concept of soundscape was first introduced in the 1960s[1]. The International Organization for Standardization (ISO) defines soundscape as the "acoustic environment as perceived and/or understood by a person, in context"[2]. This concept emphasizes that soundscape exists through human perception of the acoustic environment. The acoustic environment is complex and multifactorial, with various sound sources integrated and transmitted across structural settings to people from different backgrounds[3].

The dimensions of soundscape perception were initially proposed by Östen Axelsson et al. in their pioneering study in 2010[4]. Through principal component analysis, they identified pleasantness and eventfulness as the two core dimensions of soundscape perception. This model was incorporated into the ISO 12913–3 series of standards as the foundational framework for soundscape research[5]. In this model, pleasantness primarily relates to a positive experience of the acoustic environment, while eventfulness reflects the dynamic character and richness of the soundscape. Existing research has confirmed that physical acoustic parameters (e.g., sound pressure level)[6], psychoacoustic parameters (e.g., loudness)[7], perceived loudness[8], and type of sound source[9] all significantly affect human perception of soundscape.

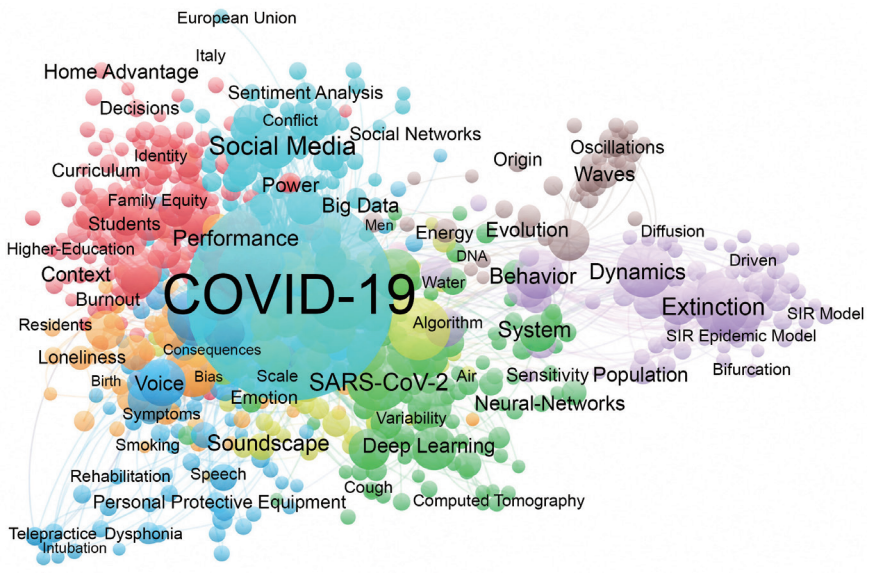
Different sound sources are perceived differently by people. For example, natural sounds are perceived as more pleasant and relaxing[10], indicating that introducing natural sounds can enhance soundscape quality[11]. Natural sounds reduce perceived loudness of traffic and breaker noises[11], which is favorable for humans because noise has detrimental effects on human health[12]. Environmental noise may lead to annoyance, sleep disturbance, daytime sleepiness, and hearing impairment[13–14]. Moreover, noise can increase the occurrence of hypertension and cardiovascular disease and impair cognitive performance in schoolchildren[12]. In 2019, the World Health Organization (WHO) updated its environmental noise guidelines to promote public awareness of the health impacts of exposure to environmental noise[15]. The WHO strongly recommended reducing the day-evening-night-weighted sound pressure level (L_{den}) produced by road traffic, railways, and aircraft below 53 dB, 54 dB, and 45 dB, respectively, as the noises above these levels were associated with adverse health effects[15].

On January 30, 2020, the WHO declared the coronavirus disease 2019 (COVID-19) outbreak a public health emergency of international concern[16]. In early 2020, many countries and cities implemented containment measures, mobility restrictions[17], and remote working arrangements[18]. These measures reshaped environments by

altering human activity and transportation. Notably, modifications in soundscapes were among the most pronounced environmental changes observed during this period[19], with implications for people's perceptions of the acoustic environment and their physical and mental health[20]. Although ambient sound levels generally declined during this period[21], noise complaints[22] and annoyance[23] increased in some contexts. These findings indicate that the relationship between acoustic change and human response is not linear: reduced sound levels may coexist with increased sensitivity, annoyance, distraction, or altered soundscape expectations. A systematic synthesis is therefore needed to clarify what kinds of acoustic changes occurred, how people perceived these changes, and which health-related outcomes were reported.

Figure 1 depicts an analysis and visualization of relationships among keywords in the research literature in the field of acoustic environment during the restriction period using VOSviewer (visualization of similarities). This software was developed by Nees Jan Van Eck and Ludo Waltman[24] to facilitate the easy creation and visualization of bibliometric maps that are convenient to interpret. The analysis set a minimum threshold of five occurrences for keywords in titles and abstracts. We found that in addition to "COVID-19" and sound-relevant terms, the most frequent keywords were "noise," "education," "behavior," "social media," "mental health," and "care". This keyword structure suggests that acoustic environment research during the restriction period was not limited to objective sound-level monitoring, but was also closely related to human behavior, residential experience, mental health, and everyday perception. These themes further indicate the need to integrate objective acoustic evidence with subjective and health-related findings.

Fig. 1 Keyword co-occurrence analysis of sound-related studies during the study period.



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Previous reviews primarily focused on environmental pollution[25], environmental strategies and policies[26], and soundscape materiality concepts and their nexuses with the United Nations' Sustainable Development Goal focus areas[20] during the early stages of the restriction period. Concurrently, several studies discussed how acoustic environments changed during this period, offering narrative or non-systematic reviews[27]. Despite the growing body of literature, an updated synthesis integrating acoustic environment changes, soundscape perception, and health-related outcomes remains limited. Therefore, the present review aims to provide a broader and updated synthesis of global studies, with particular emphasis on the relationships among acoustic environment changes, human perception, residential living environments, and physical and mental health-related outcomes.

Specifically, this systematic review aims to provide a global and quantitative synthesis of sound level changes in acoustic environments during the restriction period, particularly regarding differences across cities with varying urban development contexts. In addition, the review compares sound-level variations across different sound sources and indoor and outdoor environments. Furthermore, this review systematically integrates objective acoustic measurements with evidence related to human perception and physical and mental health. Accordingly, this systematic review was organized around the following analytical framework: 1) changes in acoustic environments and sound sources during the restriction period; 2) subjective perceptions and soundscape evaluations associated with these acoustic changes; and 3) potential impacts on physical and mental health, well-being, stress, and related human responses. By integrating acoustic measurements with perceptual and health-related evidence, this review moves beyond a purely level-based interpretation of acoustic environmental change and examines how objective and subjective dimensions jointly explain the impacts of sound environments on people.

2 Methodology

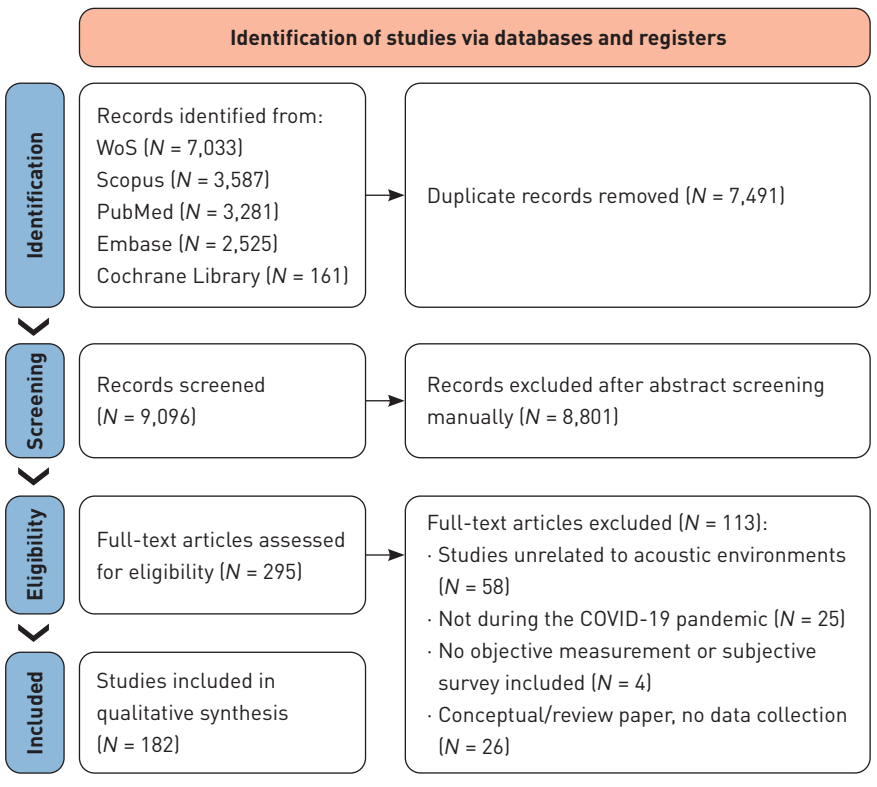
2.1 Search Strategy

This study was conducted as a systematic review and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Given the substantial heterogeneity among the included studies in acoustic indicators, environmental settings, perceptual evaluation methods, and reported outcomes, the findings were systematically

summarized and compared. The findings were synthesized using descriptive quantitative tabulation, thematic analysis, and bibliometric visualization methods. PRISMA was used as the reporting framework to improve transparency and completeness[28]. Figure 2 displays the study-selection flow diagram for this review.

Studies were identified using the Web of Science (WoS), Scopus, PubMed, Embase, and Cochrane Library databases, manual scanning of reference lists, and consultation with experts. Using multiple databases is a common approach in systematic reviews[28]. The aforementioned databases have proven effective in covering most relevant soundscape literature[29–30]. Given the interdisciplinary nature of acoustic environment research during the study period, a relatively broad search strategy was adopted at the initial stage to maximize retrieval of potentially relevant studies. In these databases, the following query was submitted: (TS= (acoustic OR acoustical OR acoustics OR sound OR soundscape OR noise OR voice)) AND TS= (COVID-19 OR corona OR novel coronavirus OR SARS-CoV-2 OR epidemic OR pandemic). Here, TS refers to the topic search field, which includes searches title, abstract, author keywords, and Keywords Plus. The period covered by this review extends from December 31, 2019, to December 31, 2025, encompassing the COVID-19 outbreak and subsequent changes in acoustic environments. Although the COVID-19 outbreak was officially reported on December 31, 2019[31], the emergence of related literature was subject to an inevitable publication delay. Accordingly, journal articles published from February 3, 2020 onward were considered, as this date corresponds to the publication of the earliest studies identifying the novel coronavirus associated with COVID-19[32–33]. The WHO response timeline for COVID-19 ended in March 2022[31]. In addition, related studies were still being published in 2025, so articles published through December 31, 2025 were considered. The reference lists of all selected studies were also screened and manually searched for additional publications. The abstracts were independently reviewed by two researchers/authors, and full text was obtained for suitable articles. Disagreements about inclusion or exclusion were resolved by consensus.

Fig. 2 PRISMA flowchart showing the search strategy for article screening in this systematic review.



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2.2 Selection Criteria

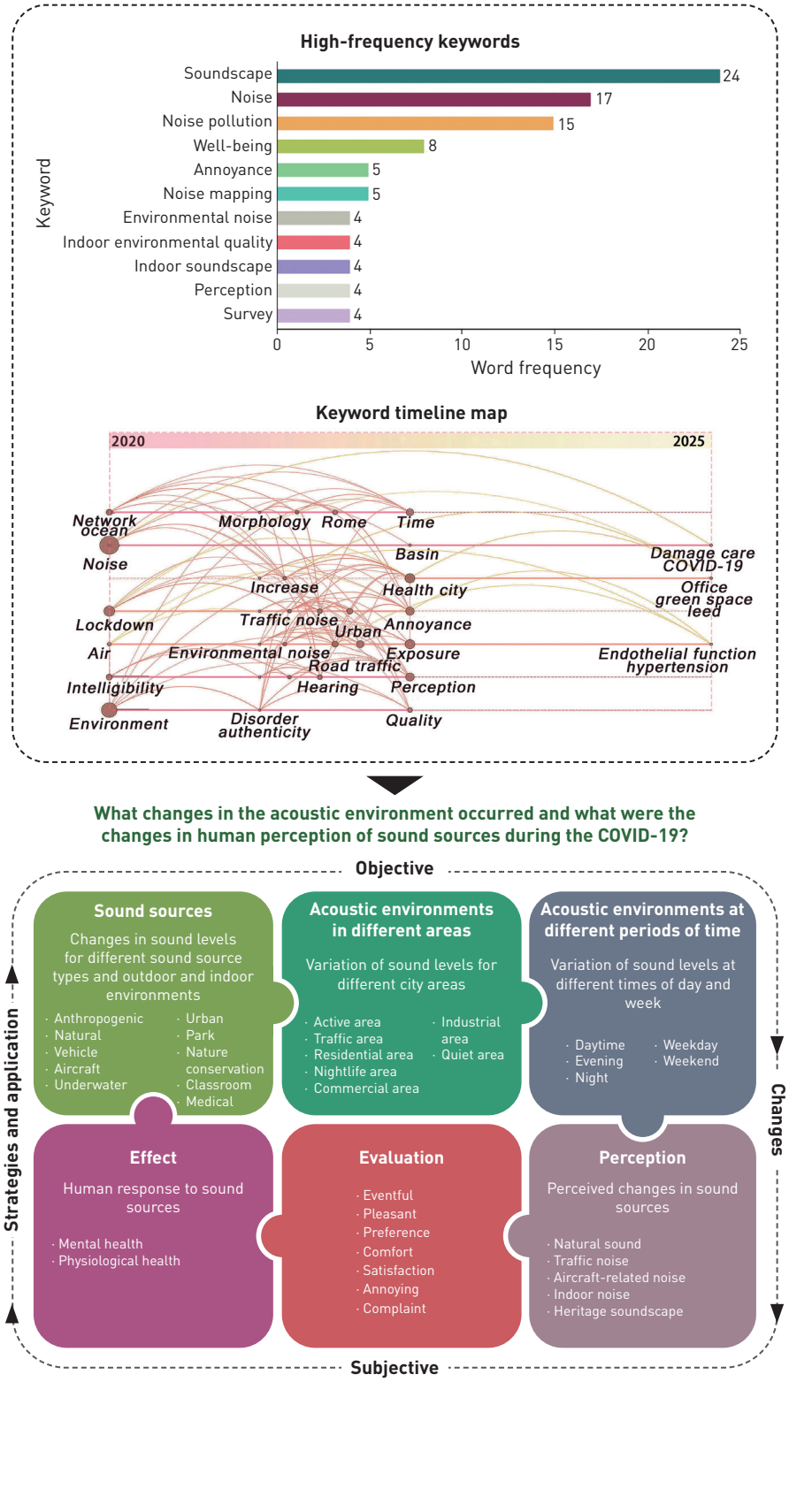
Literature concerning acoustic environments during the period covered by this review was searched, indicating the following eligibility and inclusion criteria: 1) studies should be conducted during the restriction period or in comparison with the pre-restriction period; 2) studies should involve assessments of acoustic environments, soundscape characteristics, or changes in environmental sound conditions; 3) studies involving soundscape dimensions or perceptual evaluations related to acoustic environments, with reference to ISO 12913-1[2]; 4) objective acoustic measurements and subjective perceptual evaluations were considered; 5) studies should evaluate people's perceptions, experiences, or responses to acoustic environments, including soundscape appraisal, annoyance, stress, sleep, mental health, well-being, residential environmental experience, and related health outcomes. Only peer-reviewed journals published in English were considered, and no geographic restrictions were applied. Studies were analyzed for the following information: 1) methods (i.e., soundscape assessment, social or socio-acoustic survey, and laboratory study); 2) research sites; 3) period; 4) type of sound sources investigated in laboratory or field studies; 5) sound metrics (sound level); 6) perceptual attributes; 7) evaluation of indicators; and 8) noise control and soundscape optimization strategy. Based on the inclusion criteria, only relevant aspects of the selected studies were extracted and discussed.

3 Results

After data collection, the data of 182 eligible studies were processed using CiteSpace[34]. Keyword co-occurrence, burst, and

clustering analyses were conducted to identify research hotspots and emerging fronts. As presented in Fig. 3, the most frequent keywords were “soundscape,” “noise,” “noise pollution,” “well-being,” “annoyance”, etc. Figure 3 also illustrates the temporal evolution of research hotspots. The analysis indicates that the research field gradually shifted from objective acoustic environment research to human perception and health-related research. Accordingly, the literature was organized into objective sound-level changes and subjective human responses. Meanwhile, Fig. 3 presents the research framework. The results are organized into three sections: 1) variation in sound levels for different environments, 2) perceived changes in sound sources, and 3) effect on mental and physical health. Section 3.1 describes objective changes in sound levels, while Sections 3.2 and 3.3 focus on human perceptions and related health outcomes.

Fig. 3 Keyword analysis and research framework of the acoustic environment during the period covered by this review.



3.1 Changes in Acoustic Environments During the Restriction Period

3.1.1 Changes in Sound Levels for Different Countries and Cities

Among the five continents, most relevant studies were conducted in Europe (44.6%), followed by North and South America (32.1%), Asia (14.3%), Oceania (5.4%), and Africa (3.6%). Additionally, the sound level variations of different sound sources and outdoor and indoor environments were studied for urban (29.5%), anthropogenic (21.3%), underwater (16.4%), vehicle (6.6%), aircraft (4.9%), natural (1.6%), park (11.5%), nature conservation (1.6%), medical (3.3%), and classroom (3.3%) sounds. About 90.6% of the studies exhibited a decrease in sound levels compared with the pre-restriction period, while the remaining 9.4% reported either an increase or no change.

Our study compared the reduction in sound levels using a Mann–Whitney test between cities included in the Global Cities Index (GCI) and other cities during the restriction period. Data analysis was performed using SPSS 25.0. The GCI ranks 125 cities based on 27 criteria published by Kearney and the Chicago Council on Global Affairs[35]. Cities included in the GCI are evaluated in terms of economic potential, human capital, global integration, infrastructure, the natural environment, and the sociocultural environment. We found a significant difference ($p < 0.05$) in sound level changes between cities ranked in the GCI and unranked ones, with mean changes of −5.8 dBA for cities included in the GCI and −13.8 dBA for other cities.

3.1.2 Changes in Sound Levels for Different Sound Sources and Outdoor and Indoor Environments

To compare the number of studies on human perception of outdoor and indoor soundscapes before and after the restriction period, relevant articles published between 2014 and 2025 were retrieved from the WoS database. The search used terms relating to

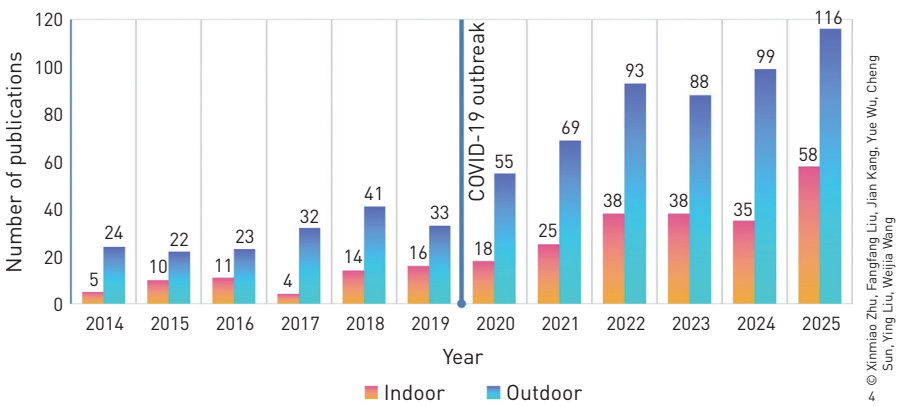
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"soundscape" and "outdoor/indoor environment" (Fig. 4).

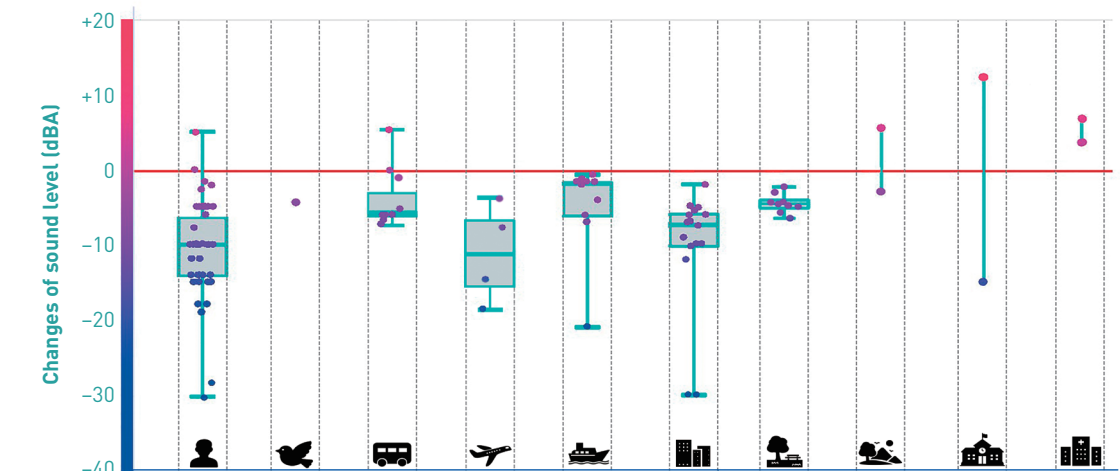
The number of publications has exhibited an increasing trend since 2020. A comparison between the baseline period (2014–2019) and the six years during 2020–2025 shows that the total number of studies on indoor soundscapes increased to 3.53 times, while those on outdoor soundscapes increased to 2.97 times.

The results were categorized according to the different types of sound sources (i.e., anthropogenic, urban, natural, vehicle, aircraft, and underwater) and outdoor and indoor environments (i.e., park, nature conservation, classroom, and medical). Figure 5 summarizes quantitative findings from the included studies.

Overall, sound levels showed a general decreasing trend across most sound sources and environments during the restriction period. Among the sound source categories, anthropogenic, vehicle, aircraft, and urban sounds exhibited notable reductions, with mean changes of −10.7 dBA, −4.0 dBA, −11.2 dBA, and −10.1 dBA, respectively, indicating substantial declines in human mobility and transportation activities. Across environmental contexts, parks exhibited minor decreases (mean = −4.3 dBA), whereas nature conservation areas showed a slight increase in sound levels (mean = +1.5 dBA). Indoor environments displayed mixed patterns: classrooms showed a slight overall decrease (mean = −1.2 dBA), while medical environments experienced an increase in sound levels (mean = +5.3 dBA), which may reflect intensified healthcare activities during the study period.



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Value	Changes in sound levels of different sound source (dBA)						Changes in sound levels of different outdoor and indoor environment (dBA)			
Maximum	+5.0	—	+5.4	−3.7	−0.7	−2.0	−2.0	+6.0	+12.6	+7.0
Median	−10.0	−4.1	−6.0	−11.2	−1.8	−7.2	−4.2	—	—	—
Minimum	−30.5	—	−7.3	−18.6	−21.0	−30.0	−5.9	−3.0	−15.0	+3.6
Mean	−10.7	−4.0	−4.0	−11.2	−4.7	−10.1	−4.3	+1.5	−1.2	+5.3

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Fig. 4 Annual numbers of publications on indoor and outdoor soundscapes.

Fig. 5 Variation in sound levels for different sound sources and outdoor and indoor environments.

3.1.2.1 Changes for Different Types of Sound Sources

1) Anthropogenic noise: In some studies, reductions in anthropogenic noise were found during the study period. Most relevant studies reported that the decrease in sound levels associated with human activities ranged from 1.0 dBA to 30.5 dBA. However, one study reported an increase in anthropogenic sound levels due to additional human activities (e.g., family gatherings, emergency services) caused by the curfew[36].

2) Urban noise: Different studies have described this type of sound source as city/urban noise/sound. Numerous studies have demonstrated that urban noise has decreased during the study period. Specifically, the decrease in sound levels observed in different cities varied from 0.5 dBA to 30.0 dBA.

3) Natural sound: Decreases in natural sound levels were detected during the study period. In Bochum, Germany, the pronounced

peaks for the bioacoustics index (quantifying total sound activities of biological sources) diminished markedly[37]. Reduced bird-song levels may explain the decline in biophonic activity[38]. Birdsong was found to decrease by approximately 4.0 dBA across the San Francisco Bay Area[38]. This phenomenon may reflect the Lombard effect[39], in which birds hold breeding territories in areas with higher noise levels and sing higher-amplitude songs[40]. Reduced background noise during this period may have contributed to lower bird-song levels.

4) Vehicle noise: Vehicle noise also changed as a result of the restrictions on movement and traffic. Road traffic noise decreased by 0.1–7.3 dBA in most cities, although localized increases of approximately 4.0–6.0 dBA were observed in areas where vehicle speeds increased[41]. In some areas, traffic noise remained unchanged because traffic flow was unaffected by mobility restrictions[42]. Increases in sound levels were caused by emergency services, such as emergency sirens[36].

5) Aircraft noise: With mobility restrictions and airport closures, the noise caused by aircraft has declined dramatically. Noise levels during the study period were found to be 3.7–18.6 dBA lower than the levels recorded before the restriction period.

6) Underwater noise: Due to the pandemic, commercial shipping activities have declined worldwide, resulting in lower underwater noise levels in the associated environment. The range of reduction is 0.7–21.0 dBA.

3.1.2.2 Changes for Different Outdoor and Indoor Environments

1) Sound in parks: Several studies reported a decrease ranging from 2.0 dBA to 5.9 dBA in sound levels in the acoustic environments of parks during the study period. The decreased sound levels can be explained by restrictions on outdoor activities during this period, indicating that fewer people visited the park; therefore, sound levels in the parks were lower.

2) Sound in nature conservation areas: Sound levels in nature conservation areas were reduced by 1.0–3.0 dBA during the study period. However, in the Blue Hills Reserve in Boston, USA, the sound levels increased by 4.0–6.0 dBA[43], which was possibly due to the reduction in traffic volume but an increase in traffic speeds. Increased outdoor activities may also have elevated sound levels in nature conservation areas.

3) Noise in classrooms: Some schools adopted online teaching models, resulting in less classroom activity and lower sound levels[44]. However, public policy in Spain recommended hourly air changes to meet infection-control requirements, increasing background noise levels in classrooms with a natural ventilation strategy by 6.4 dBA and 12.6 dBA at the University of Granada[45].

4) Noise in medical spaces: Increased sound levels were observed in medical spaces. In nursing homes[46] and operating rooms[47], the noise level increased by 3.0–7.0 dBA during the restriction period compared with baseline conditions. The background noise levels in intensive care units (ICUs) ranged from 58.1 dBA to 73.9 dBA, exceeding guideline values set by the WHO[48]. This may be attributed to intensified healthcare activities, air changes, and cleaning activities. Meanwhile, the staff in hospitals used disposable shoe covers—personal protective equipment—which considerably altered the spectral characteristics of walking sounds and made footsteps noisier[49]. Open-window ventilation may also have increased hospital noise levels.

3.1.2.3 Changes in Sound Levels for Different City Areas/Land Use Types

During the study period, the magnitude of sound-level change at different locations was affected by geographic location. Variations in sound levels across different sound source types within different city areas have not been studied. As illustrated in Table 1, 10 studies compared the changes in sound levels across various city areas/land use types[17,21,51–58]. These studies classified land use types in different urban areas based on relevant normative standards of cities, such as those provided by the Ruhr Regional Association in Germany[50], the National Ambient Noise Monitoring Network (NANMN)[17,51], and the laws and decrees of Buenos Aires, Argentina[52].

Applying a classification approach similar to those described in previous studies[21,54], the measurement locations were grouped into seven categories based on their land-use characteristics and dominant sound sources. The active areas are defined as the region where human activities combined with traffic have a major impact on the acoustic environment (such as plazas). Commercial areas include shopping malls and roadside retail shops. Traffic areas are primarily found on major roads, where road traffic noise is the dominant sound source. Industrial areas consist of clusters of factories. Residential areas serve as habitats for residents. Quiet areas typically comprise parks or areas with greenery that tend to have a relatively low background noise (lack of traffic sources). Nightlife areas are mostly filled with pedestrian streets, pubs, clubs, and tourist attractions.

Sound levels decreased across 7 urban area types (i.e., active, commercial, traffic, industrial, residential, quiet, and nightlife areas) during the study period, with average reductions ranging from 3.3 dBA to 8.8 dBA. A comparison of the means of sound level

Table 1: Variation in sound levels in different city areas/land use types

Location	Sound-level changes of various city areas/land use types (dBA)							Source
	Active	Commercial	Traffic	Industrial	Residential	Quiet	Nightlife	
Girona, Catalonia, Spain	−10.0	—	−8.0	—	—	−15.0	−10.0	Ref. [53]
Chinhat, Bengaluru, Chennai, New Delhi, WBPCB, Kolkata, and Hyderabad, India	—	−6.9	—	−0.5	−5.5	+0.4	—	Ref. [51]
London, UK	−6.6	—	−4.5	—	—	−3.6	—	Ref. [21]
Madrid, Spain	−11.2	—	−7.4	—	—	−1.0	—	Ref. [54]
Chelsea, Massachusetts, USA	—	−6.0	—	—	−3.0	—	—	Ref. [55]
Kanpur, India	—	−6.0	—	−6.0	−18.1	−13.0	—	Ref. [56]
Ruhr, Germany	−5.2	−3.9	—	—	−5.0	—	—	Ref. [57]
Barcelona, Spain	−7.0	−7.0	−5.0	—	—	—	−9.0	Ref. [17]
Buenos Aires, Argentina	—	—	−1.4	—	−2.7	—	−3.9	Ref. [52]
Rio de Janeiro, Brazil	−12.5	—	−4.0	—	—	—	—	Ref. [58]
Average difference	−8.8	−6.0	−5.1	−3.3	−6.9	−6.4	−7.6	—
Standard deviation	2.9	1.3	2.4	3.9	6.4	7.1	3.3	—

changes for the 10 studies showed that the smallest reduction was in industrial areas (−3.3 dBA), whereas the greatest mean reduction occurred in active areas (−8.8 dBA). Active areas showed the greatest reduction in sound levels due to decreased leisure and commercial activities during this period.

3.1.2.4 Changes in sound levels at different times of day and week

Table 2 demonstrates the relevant studies on changes in sound levels during the study period at different times of the day (i.e., daytime, evening, and night) and week (i.e., weekday, weekend)[17,52–57,59–68]. Variations in sound levels across time periods for different sound source types remain insufficiently investigated.

During the day, the change in sound level was greater in daytime, corresponding to an average decrease of 6.7 dBA, as people moved less during the day than before the restriction period and work shifted to remote arrangements[18]. Sound levels dropped by an average of 4.4 dBA on weekends and 3.9 dBA on weekdays. Greater weekend reductions may reflect decreased outdoor activities during the study period.

3.2 Perceptual Responses to Acoustic Environment Changes

Perceptions of different sound sources also changed during the restriction period. The following section illustrates people's perceptions of natural sound, traffic noise, aircraft-related noise, indoor noise, and heritage soundscapes, respectively.

3.2.1 The Perception of Natural Sound

People perceived natural sound sources more prominently during the study period. However, findings were inconsistent. Some people positively evaluated natural sounds[69], while others found them annoying[70]. During the study period, urban residents in 29 Chinese provinces preferred natural sounds (e.g., natural flowing water, wind-blowing leaves, bird songs, heavy rain)[71]. However, a survey in London[70] found that birdsongs from pigeons (*Columba livia*) and robins (*Erithacus rubecula*) were annoying

Table 2: Variation in sound levels at different times of day and week

Location	Sound-level changes of different times of day and week (dBA)					Source
	Daytime (ΔL_d)	Evening (ΔL_e)	Night (ΔL_n)	Weekday	Weekend	
Girona, Catalonia, Spain	−5.0	−5.0	−10.0	—	—	Ref. [53]
A busy urban central Stockholm, Sweden	−2.5	−3.3	−4.0	−1.9	−2.9	Ref. [59]
Kanpur, India	−14.0	—	−9.0	—	—	Ref. [56]
Córdoba, Spain	−10.0	−10.0	−5.0	—	—	Ref. [60]
Ruhr, Germany	−3.7	−7.7	—	−5.1	−6.5	Ref. [57]
Barcelona, Spain	−5.5	−7.9	−6.6	—	—	Ref. [17]
Urban zones under the flight tracks in Lima, Peru	−4.5	−8.0	−12.0	—	—	Ref. [61]
Lyon, Aix-Marseille Provence, Grenoble-Alpes, Saint Etienne, Toulouse, France	−4.9	−5.0	−5.2	−4.9	−5.8	Ref. [62]
The Tisler reef near the border between Norway and Sweden	−8.9	—	−1.9	—	—	Ref. [63]
Port of Koper, Slovenia	−3.3	−4.1	−4.0	—	—	Ref. [64]
Chelsea, Massachusetts, USA	—	—	—	−2.9	−1.0	Ref. [55]
Madrid, Spain	−4.7	−4.5	−5.4	−4.5	−6.0	Ref. [54]
Milan, Italy	−3.5	−9.8	−7.0	—	—	Ref. [65]
Ensenada de La Paz, Mexico	−20.7	−0.2	—	—	—	Ref. [66]
Buenos Aires, Argentina	−2.3	—	−4.1	—	—	Ref. [52]
Istanbul, Turkey	−11.5	−13.1	−5.9	—	—	Ref. [67]
Vancouver, Canada	−2.3	−2.6	−1.9	—	—	Ref. [68]
Average difference	−6.7	−6.2	−5.9	−3.9	−4.4	—
Standard deviation	5.1	3.5	2.9	1.4	2.4	—

NOTE

ΔL_d: change in day noise level (A-weighted L_{eq}); ΔL_e: change in evening noise level (A-weighted L_{eq}); ΔL_n: change in night noise level (A-weighted L_{eq}). According to Directive 2002/49/EC, the standard reference periods are daytime (07:00–19:00), evening (19:00–23:00), and nighttime (23:00–07:00). However, the specific time intervals vary across studies. The study in Girona, Spain, adopted 07:00–21:00, 21:00–23:00, and 23:00–07:00, respectively, whereas the studies in Lima, Peru, and the Port of Koper, Slovenia, adopted 06:00–18:00, 18:00–22:00, and 22:00–06:00, respectively.

during this period. Chinese and British studies reported contrasting evaluations of birdsong, possibly reflecting cultural differences. However, various bird species exist in diverse regions, and people may perceive these birdsongs differently.

3.2.2 The Perception of Traffic Noise

Outdoor traffic noise was perceived as lower during the restriction period than during the baseline period. Previously traffic-dominated locations became more pleasant when traffic

levels declined[72]. However, sounds such as ambulance and police sirens were highly disliked by urban residents in China[71]. Notably, ambulance sirens and police car sounds were more disliked than road traffic noise. This suggests that positive or negative feelings originating from sounds can impact soundscape preferences.

3.2.3 The Perception of Aircraft-Related Noise

The reduction in the number of flights at airports during the study period led to a general perception of lower sound levels of aircraft-related noise. One study found that 58.8% of respondents reported no annoyance from such noise[73]. Meanwhile, complaints about airport noise decreased among people living adjacent to airports. Short-term reductions in aircraft-related noise exposure may reverse the adverse effects of such noise on arterial stiffness and blood pressure[74]. A study in two suburbs of Krakow, Poland, found that decreases in aircraft-related noise exposure were accompanied by significant decreases in noise annoyance, 24-hour systolic (p = 0.034) and diastolic (p = 0.003) blood pressure, and pulse wave velocity (p = 0.001).

3.2.4 The Perception of Indoor Noise

People perceived more indoor noise, such as noise coming from occupants in the same suite (i.e., roommates, family) and neighboring noise (e.g., talking/shouting, TV/music activities)[69–70,75]. For home workers, noise was a major source of negative experiences[69–70]. A study in Canada found that 35% of respondents were more annoyed by indoor noise[75]. A qualitative study in London found negative impacts were most frequently reported for working from home (55% of participants), followed by relaxation activities (40.6%), sexual activities (30.1%), and home exercise (20.1%)[76]. Moreover, poor indoor acoustic conditions reduced productivity during the study period[77]. Noise interference during reading and examinations reduced students' satisfaction[78]. Higher home noise levels negatively affected adolescents' learning[79]. However, indoor comfort was affected by different sound sources. Higher comfort scores were associated with greater dominance of natural sounds and music, as well as reduced noise from neighbors and/or a lower sensitivity to noise when working at home[69].

3.2.5 The Perception of Heritage Soundscapes

Restrictions on public gatherings suspended church services. With reduced human activity, including decreased traffic and construction noise, religious bell sounds became more perceptually prominent[80]. However, people perceived the Berlin Wall Memorial as quieter than before the restriction period[81], likely due to compositional changes such as fewer tourists and altered on-site activities. The restriction period also affected heritage festival soundscapes[82]. The cancellation of cultural and heritage festivals silenced typical on-site soundscapes, leading to a perceived reduction of these sound sources[83]. This shift reduced sensory experiences and weakened socio-cultural belonging in heritage soundscapes[84].

3.3 Effect on Mental and Physical Health

Widespread fear and anxiety during the study period contributed to unstable mental conditions and fatigue, leading to elevated stress levels in the later period[85–86]. Beyond general psychosocial burden, acoustic changes specific to the restriction period also played a role in mental health disturbances. Unexpected sounds, such as ambulance sirens and repeated public health announcements, were reported as anxiety-provoking stimuli[87]. Their sudden emergence, combined with limited habituation and constant reminders of infection risks, further intensified psychological distress and irritation[87].

3.3.1 The Impact of Acoustic Environment on Mental and Physical Health Across Different Places

1) Home-based working and learning environments: Mobility restrictions and home-based routines altered people's lifestyles. However, work-from-home settings were found to lack adequate sound insulation and ergonomic and technological support, leading to multiple health complaints[88]. Rooms exposed to noisy urban areas were perceived as more annoying and less appropriate for both work and relaxation. A study in Chinese cities found that outdoor man-made noise, neighbor sounds, and building-service noise were negatively associated with perceived comfort during work and relaxation ($p < 0.05$)[89]. Complex indoor soundscapes were also linked to decreased learning efficiency, with 45.7% of respondents reporting a perceived decrease in learning efficiency[90]. Among college students, higher exposure to mechanical sounds during prolonged home stay was negatively associated with self-rated health ($p < 0.001$)[91]. An online survey of home workers in the United Kingdom and Italy found that spaces with fewer building-service sounds were considered significantly more appropriate for home working and relaxation ($p < 0.05$)[92]. Another study in London indicated that ideal indoor soundscapes were characterized by privacy and control, quietness, and pleasant sounds[93].

2) Campus environments: Due to the centralized management within the campus, students' anxiety levels showed significant correlations with the loudness of perceived sound (r = 0.19, $p < 0.01$)

and overall acoustic satisfaction ($r = -0.16$, $p < 0.05$)[94]. In addition, favorable acoustic conditions during online teaching and learning activities were found to be positively associated with students' academic performance ($\beta = 0.21$, $p < 0.01$)[95].

3) Medical spaces: In ICUs, exposure to both human and mechanical noise disrupted medical procedures and conversations, contributing to negative emotions among nurses, including anxiety and depression[96]. Background noise levels were significantly correlated with perceived stress ($r = 0.23$) and irritation ($r = 0.26$) among nurses on duty ($p < 0.05$)[48]. Furthermore, noise levels ($L_{eq,\,24\,h}$) were correlated with the hospital admission rate, the ICU admission rate, and average cumulative incidence rate over 14 days[97]. As noise can reflect increased human activity, it may serve as an indirect indicator of heightened transmission risk and greater disease burden.

4) Suburban areas near the airport: Reductions in air traffic substantially decreased aircraft noise exposure. Evidence suggests that this reduction during the reduced-air-traffic period was associated with arterial stiffness and blood pressure[74]. A study conducted in two suburbs of Krakow, Poland, found significant decreases in noise annoyance, 24-hour systolic ($p = 0.034$) and diastolic blood pressure ($p = 0.003$), and pulse wave velocity ($p = 0.001$) following reductions in aircraft noise exposure[74]. However, a survey conducted near Tan Son Nhat Airport in Ho Chi Minh City, Vietnam, found that although monitored aircraft noise levels decreased, aircraft noise still had a significant direct effect on annoyance ($\beta = -0.13$, $p = 0.031$), suggesting that increased stress, anxiety, and time spent at home played important roles[98]. These findings indicate that public responses to noise are shaped both by sound levels and by contextual or personal factors.

3.3.2 Individual Differences and Noise Sensitivity

Psychological responses to acoustic environments were moderated by individual characteristics. Individuals with greater concern about public-health conditions reported heightened perception of both traffic noise ($r_s = 0.192$, $p = 0.045$) and natural sounds ($r_s = 0.300$, $p = 0.002$)[42]. Annoyance levels were correlated with attention to environmental sounds ($\rho = 0.35$, $p < 0.05$)[99]. Noise sensitivity was correlated with stress ($r = 0.092$, $p = 0.003$) and anxiety score ($r = 0.101$, $p = 0.001$)[67], and negatively associated with perceived acoustic comfort ($\rho = -0.31$, $p < 0.001$) and psychological well-being ($\rho = -0.25$, $p < 0.001$)[69]. In contrast, acoustic comfort showed a positive correlation with perceived psychological well-being ($\rho = 0.28$, $p < 0.001$)[69].

Populations with certain neurophysiological and behavioral disorders, such as misophonia[100], may be more susceptible to auditory and movement-related triggers and hypervigilance, because people with misophonia can have intense physiological and emotional responses to specific patterns of auditory stimuli, regardless of their physical properties[101]. Approximately half of the patients reported anxiety triggered by everyday sounds from family members, pets, or neighbors, indicating that hypersensitivity and hypervigilance may exacerbate health impacts under prolonged confinement[101].

3.3.3 Noise Complaint Behavior

Changes in the acoustic environment during the study period influenced people's noise-complaint behavior. The number of noise complaints changed during the study period, with trends varying among countries. In Hangzhou, China, noise complaints exhibited a dynamic spatial evolution, characterized by initial diffusion, intensified clustering in urban cores during the restriction period, and subsequent redistribution after restrictions were lifted[102]. Some studies in London found that noise complaints, including home, neighbor, and traffic noise, increased significantly by 48% to 100%[22,70]. Similarly, Montreal reported a significant increase in complaints during the restriction period compared with baseline conditions ($\chi^2 = 26.74$, $p < 0.01$)[103]. In contrast, Dallas, Texas, USA, experienced a 13.6% reduction in noise complaints during the study period compared to the pre-restriction period[104]. These differences may be partly explained by variations in urban form and land use. Dallas is characterized by low density development and dispersed residential patterns[105]; the majority of the population lives in suburban areas and may therefore be exposed to less noise from neighbors. In contrast to Dallas, London's high population density increases the likelihood of exposure to neighbor-related noise[106].

3.3.4 Restorative Potential of Natural Soundscapes and Music

Under increased psychological stress, natural soundscapes demonstrated significant restorative potential. Studies conducted in Burleigh Heads National Park, Australia[85] and Xixi Wetland National Park, China[86], showed that natural soundscapes significantly promoted mental restoration, through four dimensions of extent, fascination, being away, and compatibility ($p < 0.05$).

Music also played a compensatory role during social isolation. During this period, individuals often evoked nostalgia through music and other media, including films, series, audiobooks, and videos, which helped alleviate social stress and feelings of isolation[107]. Public recognition of music's value for well-being increased during this period[108]. Music helped reduce stress and anxiety among

patients, caregivers, and hospital staff during the restriction period[109]. Background music in public health settings improved waiting-time perception, emotional experience, and environmental atmosphere for both citizens and healthcare staff[110]. Meanwhile, changes in music-listening behavior were also observed among young people, with nearly half of the participants reporting increased listening frequency and duration[111].

4 Discussion

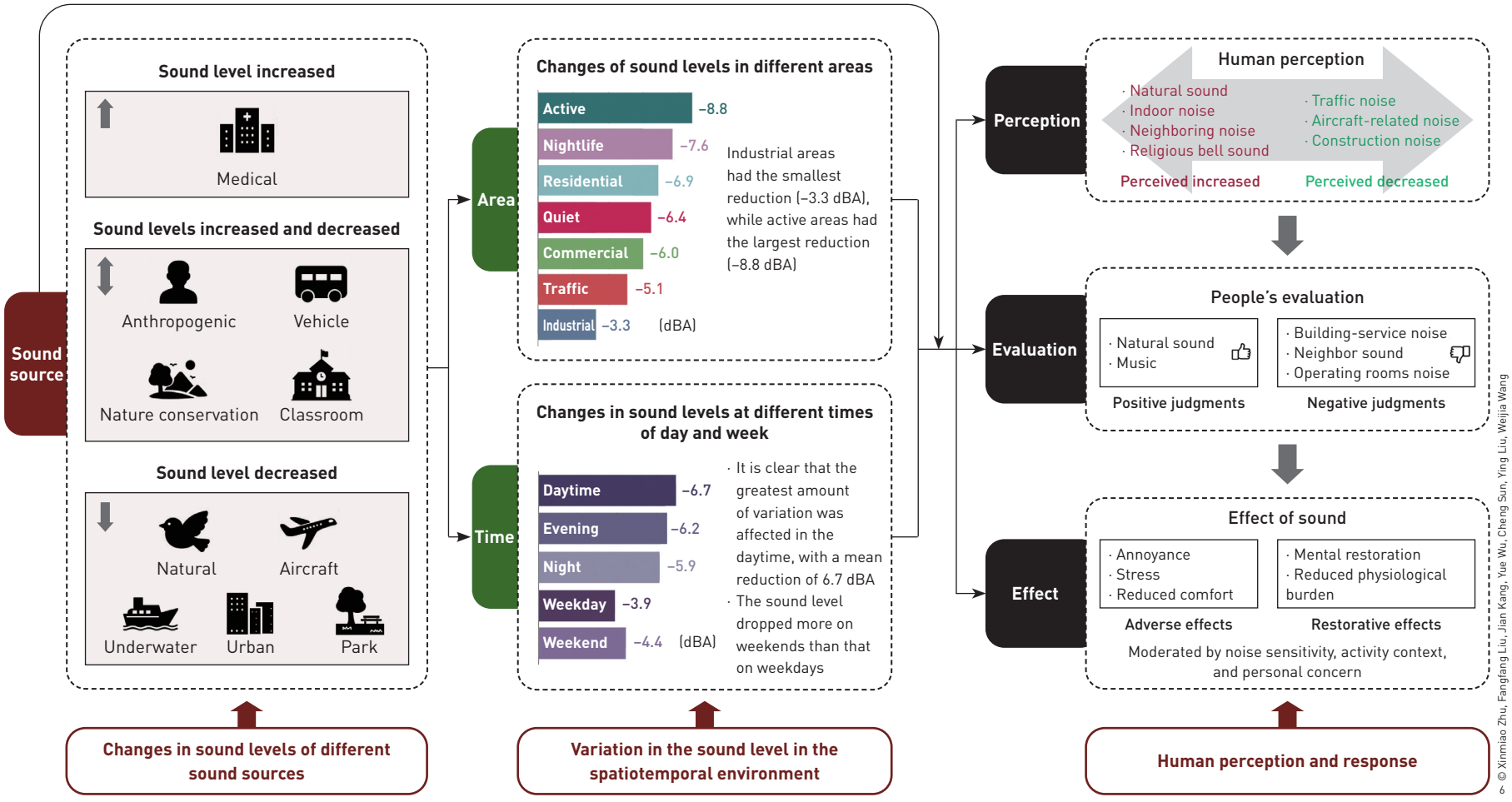
4.1 Interpretation of Findings

The reviewed studies investigated changes in acoustic environments and human perceptions during the study period using acoustic measurements, social surveys, and experiments. As shown in Fig. 6, changes in the levels of different sound sources were monitored, and these changes were perceived by people and were associated with their mental and physical health.

Reductions in natural sound levels[38] and sounds associated with human activities were detected[36,44,51,67,81] (Fig. 6). However, quieter outdoor environments increased attention to natural sounds during this period[62,72]. Acoustic environmental quality cannot be judged by decibel reduction alone. Therefore, reduced sound levels did not necessarily improve acoustic experiences, highlighting complex relationships among acoustic indicators, perception, and health.

Several studies reported positive effects of natural sounds[10–11]. However, one study found that natural sounds engendered negative emotions in specific contexts[70]. These discrepancies may reflect the influence of environmental and socio-cultural contexts on acoustic evaluations. Meanwhile, the level of annoyance was positively correlated with stress, noise sensitivity, and anxiety scores ($p < 0.05$)[67,99], underscoring the association of subjective perception with noise exposure and health effects. These findings indicate that acoustic environment research has evolved beyond traditional noise control toward more human-centered perspectives integrating perception and well-being. Accordingly, this review argues for an integrated framework for evaluating acoustic environments. Such a framework should include at least

Fig. 6 Conceptual framework of acoustic-environment changes across spatiotemporal contexts and human responses.



four dimensions: sound-source composition, objective sound-level changes, subjective soundscape perception, and health-related outcomes (Fig. 6).

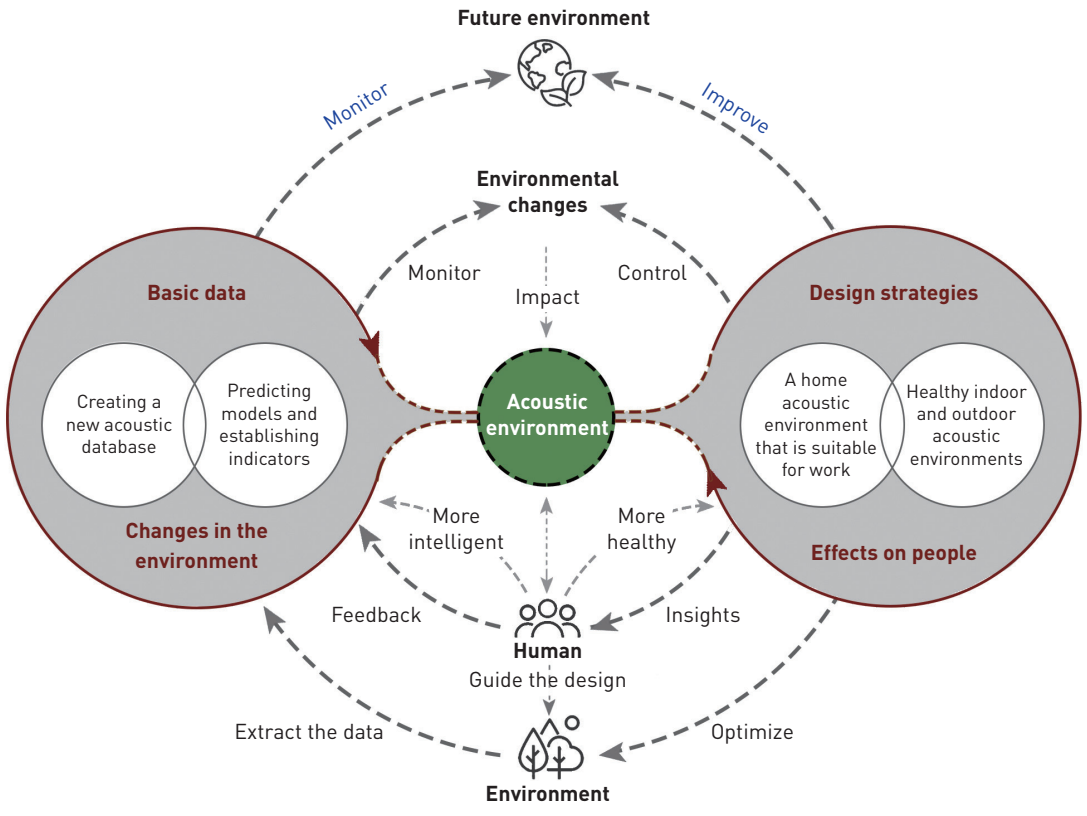
4.2 Application of Acoustic Environment Research

The reviewed period altered human interactions with multiple environmental systems, including acoustic environments, energy, emissions, and urban activities[112]. These changes highlighted the importance of methodological implications for acoustic environment research. Figure 7 illustrates future directions for acoustic environment research. The following discussion addresses the monitoring of baseline data and related design strategies.

1) Sound-level indicators remain indispensable for quantifying environmental change, identifying exposure patterns, and comparing acoustic conditions across countries, cities, sound sources, and spatial contexts. To anticipate future hazards and promote human and environmental health, it is necessary to establish appropriate data and monitoring systems[113]. The establishment of standardized acoustic databases and predictive models is important for future acoustic environment research and management[114]. Consequently, there is an urgent need to anticipate likely thresholds and tipping points in the health-environment nexus through data, monitoring and warning systems, improved models, and metrics[113]. Additionally, combined with soundscape descriptors and predictive simulation methods[41], these tools can support evaluation of soundscape changes, improve environmental assessment efficiency, and strengthen the relationship between objective acoustic measurements and subjective perception.

2) Subjective soundscape evaluation should be incorporated into acoustic environment assessment more systematically. Perceptual indicators such as pleasantness, eventfulness, annoyance, comfort, and acoustic satisfaction provide information that cannot be derived from sound pressure levels alone. Environmental sound quality should be evaluated through contextual and perceptual dimensions rather than sound pressure levels alone[115]. Existing research has constructed soundscape descriptors and prediction models linking acoustic environments with subjective perception[116]. Future acoustic environment studies should avoid separating "measurement-based" and "perception-based" approaches, and instead examine how they jointly shape human responses.

Increased home-based working, online learning, and prolonged residential stay have drawn greater attention to indoor environmental quality. Remote working, online learning, and prolonged residential stay increased exposure to indoor and neighborhood sounds, often causing annoyance, stress, and dissatisfaction[92]. These findings highlight the importance of residential acoustic design for working and learning activities. Traditional noise control measures, including sound insulation



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Fig. 7 Conceptual framework of acoustic environment application.

and sound absorption[117], remain important for reducing unwanted indoor noise. Meanwhile, increasing attention should be given to positive soundscape strategies, such as introducing natural sounds, music[10], and sound masking approaches[118] to improve psychological well-being. In subsequent periods, greater demand for restorative environments and access to nature has also been observed[119]. Emerging technologies, including virtual reality and audiovisual integration systems, may further support immersive restorative soundscape experiences. Overall, greater attention should be given to residential acoustic design and the integration of emerging technologies in future indoor environment design.

Overall, this review challenges an overly simplified understanding of acoustic-environmental improvement. A quieter environment is not necessarily a better environment. A better acoustic environment should be defined by joint consideration of lower harmful noise exposure, appropriate sound-source composition, positive or acceptable soundscape perception, and beneficial or non-harmful health-related outcomes.

4.3 Limitations

Quantitative meta-analysis was not feasible because of substantial methodological heterogeneity among studies. In addition, the review did not consider a book search. As demonstrated in Fig. 1, research on acoustic environments during this period involves multiple disciplines. Therefore, interdisciplinary research should be conducted in the future. Scholars found that people's perceptions of urban noise can be affected by different urban development patterns, including population, industrial structure, built-up areas, transport networks, commuting, and natural landscape factors[120]. Meihui Ba and Jian Kang found that fragrant trees affect the perception of traffic noise, corresponding to an increase in overall street comfort, a reduction in the annoyance caused by traffic noise, and an improvement in auditory and olfactory satisfaction[121]. Therefore, further studies on the effects of other environmental factors, such as urban development patterns[120] and odors[121], are required to fully understand the acoustic environment.

5 Conclusions

This systematic review synthesized 182 studies on acoustic environment changes during the years of 2020–2025 and their effects on people. The main conclusions are as follows.

1) 90.6% of the studies exhibited a decrease in sound levels, while the remaining 9.4% reported either an increase or no change. There was a significant difference ($p < 0.05$) in sound level changes between cities ranked in the GCI (−5.8 dBA) and other cities (−13.8 dBA). Across sound source categories, anthropogenic, urban, and aircraft noise showed mean changes of −10.7 dBA, −10.1 dBA, and −11.2 dBA, respectively. In contrast, certain functional indoor environments exhibited increases in sound levels, particularly medical spaces (+5.3 dBA).

2) More attention was paid to indoor soundscapes. Compared with the baseline period (2014–2019), the number of studies on indoor soundscapes increased to 3.53 times, while studies on outdoor soundscapes increased to 2.97 times during 2020–2025. With remote working, online learning, and prolonged stay at home, indoor noise, neighbor sounds, building-service noise, and activity-related sounds became more prominent in people's everyday acoustic experience.

3) Sound-level reduction alone is insufficient for judging acoustic environmental quality. Although many outdoor sound levels decreased during the study period, quieter environments did not always lead to better soundscape experiences. Lower outdoor sound levels made indoor, neighbor, mechanical, or emergency-related sounds more noticeable, and were associated with annoyance, distraction, stress, and reduced comfort.

4) The health-related evidence supports the need to integrate objective and subjective perspectives. Indoor noise exposure in home-based working and learning environments was linked to reduced comfort, decreased cognitive performance, and increased annoyance ($p < 0.05$), while reductions in environmental noise and the presence of natural sounds and music were associated with improved psychological well-being and restorative experiences ($p < 0.05$). In healthcare settings, increased sound levels reflected intensified medical activities and were associated with stress and irritation among healthcare workers.

Acoustic environment assessment should consider objective acoustic measurements, sound-source characteristics, contextual factors, subjective soundscape evaluations, and health-related outcomes together. Such an integrated perspective is essential for understanding the relationships between acoustic environments and human experience, comfort, well-being, and health.

ELECTRONIC SUPPLEMENTARY MATERIAL

Supplementary material is available in the online version of this article at https://doi.org/10.15302/J-LAF-2026-0054.

Competing interests | The authors declare that they have no competing interests.

REFERENCES

[1] Southworth, M. (1969). The sonic environment of cities. *Environment and Behavior*, *1*(1), 49–70.

[2] International Organization for Standardization (2014). *ISO 12913-1:2014 Acoustics—Soundscape—Part 1: Definition and conceptual framework*.

[3] Hasegawa, Y., & Lau, S.-K. (2022). Comprehensive audio-visual environmental effects on residential soundscapes and satisfaction: Partial least square structural equation modeling approach. *Landscape and Urban Planning*, *220*, 104351.

[4] Axelsson, Ö., Nilsson, M. E., & Berglund, B. (2010). A principal components model of soundscape perception. *The Journal of the Acoustical Society of America*, *128*(5), 2836–2846.

[5] International Organization for Standardization (2025). *ISO/TS 12913-3:2025 Acoustics—Soundscape—Part 3: Data analysis*.

[6] Sudarsono, A. S., Lam, Y. W., & Davies, W. J. (2016). The effect of sound level on perception of reproduced soundscapes. *Applied Acoustics*, *110*, 53–60.

[7] Oberman, T., Latini, A., Aletta, F., Gozzi, G., Kang, J., & Torresin, S. (2025). Human sounds and associated tonality disrupting perceived soundscapes in protected natural areas. *Scientific Reports*, *15*(1), 28759.

[8] Aletta, F., Oberman, T., Mitchell, A., Erfanian, M., & Kang, J. (2023). Soundscape experience of public spaces in different world regions: A comparison between the European and Chinese contexts via a large-scale on-site survey. *The Journal of the Acoustical Society of America*, *154*(3), 1710–1734.

[9] Uebel, K., Ratcliffe, E., Buchan, C., Butler, S. J., Hanley, N., Higney, A., & Marselle, M. (2025). Natural soundscapes are associated with mental well-being via capacity-building and capacity-restoring pathways. *Journal of Environmental Psychology*, *106*, 102735.

[10] Lee, H. M., Liu, Y., & Lee, H. P. (2020). Assessment of acoustical environment condition at urban landscape. *Applied Acoustics*, *160*, 107126.

[11] Hong, J. Y., Ong, Z.-T., Lam, B., Ooi, K., Gan, W.-S., Kang, J., ... Tan, S.-T. (2020). Effects of adding natural sounds to urban noises on the perceived loudness of noise and soundscape quality. *Science of The Total Environment*, *711*, 134571.

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

[13] Miedema, H. M., & Oudshoorn, C. G. (2001). Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives*, *109*(4), 409–416.

[14] Orikpete, O. F., Leton, T. G., & Momoh, O. L. Y. (2021). Exploring the perception and impact of helicopter noise: A case study of Mgbuoshimini community, Nigeria. *Scientific African*, *13*, e00943.

[15] World Health Organization. (2019, January 30). *Environmental noise guidelines for the European Region*.

[16] World Health Organization. (2020, January 22). *WHO Director-General's statement on IHR Emergency Committee on novel coronavirus (2019-nCoV)*.

[17] Bonet-Solà, D., Martínez-Suquía, C., Alsina-Pagès, R. M., & Bergadà, P. (2021). The soundscape of the COVID-19 lockdown: Barcelona noise monitoring network case study. *International Journal of Environmental Research and Public Health*, *18*(11), 5799.

[18] Beck, M. J., & Hensher, D. A. (2020). Insights into the impact of COVID-19 on household travel and activities in Australia—The early days of easing restrictions. *Transport Policy*, *99*, 95–119.

[19] Challéat, S., Farrugia, N., Froidevaux, J. S. P., Gasc, A., & Pajusco, N. (2024). A dataset of acoustic measurements from soundscapes collected worldwide during the COVID-19 pandemic. *Scientific Data*, *11*(1), 928.

[20] Hasegawa, Y., & Lau, S.-K. (2022). A qualitative and quantitative synthesis of the impacts of COVID-19 on soundscapes: A systematic review and meta-analysis. *Science of The Total Environment*, *844*, 157223.

[21] Aletta, F., Oberman, T., Mitchell, A., Tong, H., & Kang, J. (2020). Assessing the changing urban sound environment during the COVID-19 lockdown period using short-term acoustic measurements. *Noise Mapping*, *7*(1), 123–134.

[22] Tong, H., Aletta, F., Mitchell, A., Oberman, T., & Kang, J. (2021). Increases in noise complaints during the COVID-19 lockdown in spring 2020: A case study in Greater London, UK. *Science of The Total Environment*, *785*, 147213.

[23] Michaud, D. S., Marro, L., Denning, A., Shackleton, S., Toutant, N., & McNamee, J. P. (2022). Annoyance toward transportation and construction noise in rural suburban and urban regions across Canada. *Environmental Impact Assessment Review*, *97*, 106881.

[24] van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538.

[25] Shakil, M. H., Munim, Z. H., Tasnia, M., & Sarowar, S. (2020). COVID-19 and the environment: A critical review and research agenda. *Science of The Total Environment*, *745*, 141022.

[26] Ekanayake, A., Rajapaksha, A. U., Hewawasam, C., Anand, U., Bontempi, E., Kurwadkar, S., ... Vithanage, M. (2023). Environmental challenges of COVID-19 pandemic: Resilience and sustainability – A review. *Environmental Research*, *216*, 114496.

[27] Asensio, C., Pavón, I., & de Arcas, G. (2022). How the COVID-19 pandemic muted and remixed the world's acoustics for a while. *Current Pollution Reports*, *8*(4), 328–340.

[28] Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., ... Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLOS Medicin*e, *6*(7), e1000100.

[29] Kang, J., Aletta, F., Gjestland, T. T., Brown, L. A., Botteldooren, D., Schulte-Fortkamp, B., ... Lavia, L. (2016). Ten questions on the soundscapes of the built environment. *Building and Environment*, *108*, 284–294.

[30] Aletta, F., Oberman, T., & Kang, J. (2018). Associations between positive health-related effects and soundscapes perceptual constructs: A systematic review. *International Journal of Environmental Research and Public Health*, *15*(11), 2392.

[31] World Health Organization. (n.d.). *Timeline: WHO's COVID-19 response*.

[32] Wu, F., Zhao, S., Yu, B., Chen, Y.-M., Wang, W., Song, Z.-G., ... Zhang, Y.-Z. (2020). A new coronavirus associated with human respiratory disease in

China. *Nature*, *579*(7798), 265–269.

[33] Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., ... Shi, Z.-L. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*, *579*(7798), 270–273.

[34] Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*, *57*(3), 359–377.

[35] Lohmeyer, R., Treppte, S., Buckstaff, B., & Longhi, M. (2024). *Resurgent in a world at risk: 2024 global cities report*. *Kearney*.

[36] Roy, K. S., Sharma, J., Kumar, S., & Kumar, M. R. (2021). Effect of coronavirus lockdowns on the ambient seismic noise levels in Gujarat, northwest India. *Scientific Reports*, *11*(1), 7148.

[37] Haselhoff, T., Hornberg, J., Fischer, J. L., Lawrence, B. T., Ahmed, S., Gruehn, D., & Moebus, S. (2022). The acoustic environment before and during the SARS-CoV-2 lockdown in a major German city as measured by ecoacoustic indices. *The Journal of the Acoustical Society of America*, *152*(2), 1192–1200.

[38] Derryberry, E. P., Phillips, J. N., Derryberry, G. E., Blum, M. J., & Luther, D. (2020). Singing in a silent spring: Birds respond to a half-century soundscape reversion during the COVID-19 shutdown. *Science*, *370*(6516), 575–579.

[39] Brumm, H., & Zollinger, S. A. (2011). The evolution of the Lombard effect: 100 years of psychoacoustic research. *Behaviour*, *148*(11/13), 1173–1198.

[40] Derryberry, E. P., Gentry, K., Derryberry, G. E., Phillips, J. N., Danner, R. M., Danner, J. E., & Luther, D. A. (2017). White-crowned sparrow males show immediate flexibility in song amplitude but not in song minimum frequency in response to changes in noise levels in the field. *Ecology and Evolution*, *7*(13), 4991–5001.

[41] Aletta, F., Brinchi, S., Carrese, S., Gemma, A., Guattari, C., Mannini, L., & Patella, S. M. (2020). Analysing urban traffic volumes and mapping noise emissions in Rome (Italy) in the context of containment measures for the COVID-19 disease. *Noise Mapping*, *7*(1), 114–122.

[42] Aletta, F., & Van Renterghem, T. (2021). Associations between personal attitudes towards COVID-19 and public space soundscape assessment: An example from Antwerp, Belgium. *International Journal of Environmental Research and Public Health*, *18*(22), 11774.

[43] Terry, C., Rothendler, M., Zipf, L., Dietze, M. C., & Primack, R. B. (2021). Effects of the COVID-19 pandemic on noise pollution in three protected areas in metropolitan Boston (USA). *Biological Conservation*, *256*, 109039.

[44] Montoya-Belmonte, J., & Navarro, J. M. (2020). Long-term temporal analysis of psychoacoustic parameters of the acoustic environment in a university campus using a wireless acoustic sensor network. *Sustainability*, *12*(18), 7406.

[45] de la Hoz-Torres, M. L., Aguilar, A. J., Ruiz, D. P., & Martínez-Aires, M. D. (2021). Analysis of impact of natural ventilation strategies in ventilation rates and indoor environmental acoustics using sensor measurement data in educational buildings. *Sensors*, *21*(18), 6122.

[46] Martin, J. L., Hernandez, D., Cadogan, M. P., Brody, A. A., Alessi, C. A., Mitchell, M. N., ... Chodosh, J. (2021). Environmental noise in New York City long-term care facilities: A window into the COVID-19 pandemic. *Journal of the American Medical Directors Association*, *22*(5), 974–976.

[47] Levin, M., Zhou, K., Sommer, E. C., McHugh, T., & Sommer, D. D. (2021). Ambient noise levels and wireless headsets for communication in aerosolizing otolaryngology surgery during COVID-19. *Otolaryngology–Head and Neck Surgery*, *165*(4), 528–531.

[48] Song, Z., & Lee, P.-J. (2024). Voice use of nurses working in the intensive care unit during the COVID-19 pandemic. *Intensive and Critical Care Nursing*, *82*, 103620.

[49] Song, Z., Lee, P.-J., & Hampton, T. (2022). Acoustic environments of intensive care units during the COVID-19 pandemic. *Applied Acoustics*, *199*, 109037.

[50] Regionalverband Ruhr (2020). *Flächennutzungskartierung, Daten für die Stadt- und Regionalplanung* [Land use mapping, data for urban and regional planning].

[51] Mimani, A., & Singh, R. (2021). Anthropogenic noise variation in Indian cities due to the COVID-19 lockdown during March-to-May 2020. *The Journal of the Acoustical Society of America*, *150*(5), 3216–3227.

[52] Said, G., Arias, A., Carilli, L., & Stasi, A. (2020). Urban noise measurements in the city of Buenos Aires during the mandatory quarantine. *The Journal of the Acoustical Society of America*, *148*(5), 3149–3152.

[53] Alsina-Pagès, R. M., Bergadà, P., & Martínez-Suquía, C. (2021). Changes in the soundscape of Girona during the COVID lockdown. *The Journal of the Acoustical Society of America*, *149*(5), 3416–3423.

[54] Asensio, C., Pavón, I., & de Arcas, G. (2020). Changes in noise levels in the city of Madrid during COVID-19 lockdown in 2020. *The Journal of the Acoustical Society of America*, *148*(3), 1748–1755.

[55] Walker, E. D., Lee, N. F., Scammell, M. K., Feuer, A. P., Power, M. B., Lane, K. J., ... Levy, J. I. (2021). Descriptive characterization of sound levels in an environmental justice city before and during a global pandemic. *Environmental Research*, *199*, 111353.

[56] Mishra, A., Das, S., Singh, D., & Maurya, A. K. (2021). Effect of COVID-19 lockdown on noise pollution levels in an Indian city: A case study of Kanpur. *Environmental Science and Pollution Research*, *28*(33), 46007–46019.

[57] Hornberg, J., Haselhoff, T., Lawrence, B. T., Fischer, J. L., Ahmed, S., Gruehn, D., & Moebus, S. (2021). Impact of the COVID-19 lockdown measures on noise levels in urban areas—A pre/during comparison of long-term sound pressure measurements in the Ruhr area, Germany. *International Journal of Environmental Research and Public Health*, *18*(9), 4653.

[58] Gevú, N., Carvalho, B., Fagerlande, G. C., Niemeyer, M. L., Cortês, M. M., & Torres, J. C. B. (2021). Rio de Janeiro noise mapping during the COVID-19 pandemic period. *Noise Mapping*, *8*(1), 162–171.

[59] Rumpler, R., Venkataraman, S., & Göransson, P. (2020). An observation of the impact of COVID-19 recommendation measures monitored through urban noise levels in central Stockholm, Sweden. *Sustainable Cities and Society, 63*, 102469.

[60] Redel-Macías, M. D., Aparicio-Martinez, P., Pinzi, S., Arezes, P., & Cubero-Atienza, A. J. (2021). Monitoring sound and its perception during the lockdown and de-escalation of COVID-19 pandemic: A Spanish study. *International Journal of Environmental Research and Public Health*, *18*(7), 3392.

[61] Montano, W., & Gushiken, E. (2020). Lima soundscape before confinement

and during curfew. Airplane flights suppressions because of Peruvian lockdown. *The Journal of the Acoustical Society of America*, *148*(4), 1824–1830.

[62] Munoz, P., Vincent, B., Domergue, C., Gissinger, V., Guillot, S., Halbwachs, Y., & Janillon, V. (2020). Lockdown during COVID-19 pandemic: Impact on road traffic noise and on the perception of sound environment in France. *Noise Mapping*, *7*(1), 287–302.

[63] De Clippele, L. H., & Risch, D. (2021). Measuring sound at a cold-water coral reef to assess the impact of COVID-19 on noise pollution. *Frontiers in Marine Science*, *8*, 674702.

[64] Čurović, L., Jeram, S., Murovec, J., Novaković, T., Rupnik, K., & Prezelj, J. (2021). Impact of COVID-19 on environmental noise emitted from the port. *Science of The Total Environment, 756*, 144147.

[65] Zambon, G., Confalonieri, C., Angelini, F., & Benocci, R. (2021). Effects of COVID-19 outbreak on the sound environment of the city of Milan, Italy. *Noise Mapping*, *8*(1), 116–128.

[66] Leon-Lopez, B., Romero-Vivas, E., & Viloria-Gomora, L. (2021). Reduction of roadway noise in a coastal city underwater soundscape during COVID-19 confinement. *The Journal of the Acoustical Society of America*, *149*(1), 652–659.

[67] Şentop Dümen, A., & Şaher, K. (2020). Noise annoyance during COVID-19 lockdown: A research of public opinion before and during the pandemic. *The Journal of the Acoustical Society of America*, *148*(6), 3489–3496.

[68] Yu, X., Jarvis, I., Davis, Z., van den Bosch, M., & Davies, H. (2023). Reductions in community noise levels in Vancouver, Canada, during pandemic lockdown and association with land cover type. *Environmental Research*, *237*, 117064.

[69] Torresin, S., Albatici, R., Aletta, F., Babich, F., Oberman, T., Stawinoga, A. E., & Kang, J. (2022). Indoor soundscapes at home during the COVID-19 lockdown in London – Part II: A structural equation model for comfort, content, and well-being. *Applied Acoustics*, *185*, 108379.

[70] Lee, P. J., & Jeong, J. H. (2021). Attitudes towards outdoor and neighbour noise during the COVID-19 lockdown: A case study in London. *Sustainable Cities and Society*, *67*, 102768.

[71] Liu, J., Xu, J., Wu, Z., Cheng, Y., Gou, Y., & Ridolfo, J. (2021). Soundscape preference of urban residents in China in the post-pandemic era. *Frontiers in Psychology*, *12*, 750421.

[72] Mitchell, A., Oberman, T., Aletta, F., Kachlicka, M., Lionello, M., Erfanian, M., & Kang, J. (2021). Investigating urban soundscapes of the COVID-19 lockdown: A predictive soundscape modeling approach. *The Journal of the Acoustical Society of America*, *150*(6), 4474–4488.

[73] Amoatey, P., Al-Harthy, I., Al-Jabri, K., Al-Mamun, A., Baawain, M. S., & Al-Mayahi, A. (2022). Impact of COVID-19 pandemic on aircraft noise levels, annoyance, and health effects in an urban area in Oman. *Environmental Science and Pollution Research*, *29*(16), 23407–23418.

[74] Wojciechowska, W., Januszewicz, A., Drożdż, T., Rojek, M., Bączalska, J., Terlecki, M., ... Rajzer, M. (2022). Blood pressure and arterial stiffness in association with aircraft noise exposure: Long-term observation and potential effect of COVID-19 lockdown. *Hypertension*, *79*(2), 325–334.

[75] Andargie, M. S., Touchie, M., & O'Brien, W. (2021). Case study: A survey of perceived noise in Canadian multi-unit residential buildings to study long-term implications for widespread teleworking. *Building Acoustics*, *28*(4), 443–460.

[76] Torresin, S., Ratcliffe, E., Aletta, F., Albatici, R., Babich, F., Oberman, T., & Kang, J. (2022). The actual and ideal indoor soundscape for work, relaxation, physical and sexual activity at home: A case study during the COVID-19 lockdown in London. *Frontiers in Psychology*, *13*, 1038303.

[77] Guo, X., Wu, H., Chen, Y., Chang, Y., & Ao, Y. (2023). Gauging the impact of personal lifestyle, indoor environmental quality and work-related factors on occupant productivity when working from home. *Engineering, Construction and Architectural Management*, *30*(8), 3713–3730.

[78] Puyana-Romero, V., Díaz-Márquez, A. M., Ciaburro, G., & Hernández-Molina, R. (2023). The acoustic environment and university students' satisfaction with the online education method during the COVID-19 lockdown. *International Journal of Environmental Research and Public Health*, *20*(1), 709.

[79] Chere, B., & Kirkham, N. (2021). The negative impact of noise on adolescents' executive function: An online study in the context of home-learning during a pandemic. *Frontiers in Psychology*, *12*, 715301.

[80] Spennemann, D. H. R., & Parker, M. (2022). To ring or not to ring: What COVID-19 taught us about religious heritage soundscapes in the community. *Heritage*, *5*(3), 1676–1686.

[81] Jordan, P., & Fiebig, A. (2021). COVID-19 impacts on historic soundscape perception and site usage. *Acoustics*, *3*(3), 594–610.

[82] Parker, M., Spennemann, D. H. R., & Bond, J. (2024). The effect of the COVID-19 pandemic on heritage festival soundscapes—A critical review of literature. *Current Pollution Reports*, *10*(2), 277–285.

[83] Tiatco, A. (2022). Philippine Catholic festivals during the COVID-19 pandemic: Performing live in the 'new' normal. *Contemporary Theatre Review*, *32*(3–4), 296–304.

[84] Parker, M., & Spennemann, D. H. R. (2021). Stille Nacht: COVID and the ghost of Christmas 2020. *Heritage*, *4*(4), 3081–3097.

[85] Qiu, M., Sha, J., & Utomo, S. (2021). Listening to forests: Comparing the perceived restorative characteristics of natural soundscapes before and after the COVID-19 pandemic. *Sustainability*, *13*(1), 293.

[86] Qiu, M., & Zhang, J. (2021). Exploring the perceived restorativeness of natural soundscapes under the global pandemic of COVID-19: A moderated mediation model. *PLoS ONE*, *16*(8), e0256855.

[87] Kusto, J. (2024). When new sounds come. The sociocultural effects of city soundscape change based on the example of the pandemic. *Avant*, *15*(3), 1–11.

[88] Manu, S., Burgholz, T. M., Nabilou, F., Rewitz, K., El-Mokadem, M., Yadav, M., ... Christoforou, R. (2024). A state-of-the-art, systematic review of indoor environmental quality studies in work-from-home settings. *Building and Environment*, *259*, 111652.

[89] Li, J., Huang, Y., Han, R., Zhang, Y., & Kang, J. (2025). Indoor soundscape perception and soundscape appropriateness assessment while working at home: A comparative study with relaxing activities. *Buildings*, *15*(15), 2642.

[90] Lin, D., Li, T., & Liang, H. (2024). Semantic differential analysis of effects of indoor soundscapes on learning efficiency during online home-based classes. *PLoS ONE*, *19*(8), e0306812.

[91] Dzhambov, A. M., Lercher, P., Stoyanov, D., Petrova, N., Novakov, S., & Dimitrova, D. D. (2021). University students' self-rated health in relation to perceived acoustic environment during the COVID-19 home quarantine. *International Journal of Environmental Research and Public Healt*h, *18*(5), 2538.

[92] Torresin, S., Albatici, R., Aletta, F., Babich, F., Oberman, T., & Kang, J. (2022). Associations between indoor soundscapes, building services and window opening behaviour during the COVID-19 lockdown. *Building Services Engineering Research & Technology*, *43*(2), 225–240.

[93] Torresin, S., Ratcliffe, E., Aletta, F., Albatici, R., Babich, F., Oberman, T., & Kang, J. (2022). The effect of indoor soundscape on sexual wellbeing during the COVID-19 lockdown in London: A thematic analysis of remote workers' experiences. *The Lancet*, *400*, S80.

[94] Huang, L., Li, J., Kang, J., Liu, F., Yang, M., & Zhang, Y. (2025). Understanding the nexus between anxiety and acoustic perception in university students: A quasi-experimental study during pandemic-induced lockdown. *Behavioral Sciences*, *15*(3), 262.

[95] Hoang, P. N., Samara, M., Shannawi, S., Dayupay, J. P., Jarrah, H., Olvida, C. F., ... Ras, S. N., Jr. (2022). The influence of lighting, noise, and temperature on the academic performance of students amid COVID-19 pandemic. *International Journal of Learning, Teaching and Educational Research*, *21*(9), 415–440.

[96] Song, Z., & Lee, P. J. (2026). Impact of acoustic environment in intensive care unit on nurses' well-being during COVID-19: A qualitative interview study. *Intensive and Critical Care Nursing*, *92*, 104189.

[97] Díaz, J., López-Bueno, J. A., Culqui, D., Asensio, C., Sánchez-Martínez, G., & Linares, C. (2021). Does exposure to noise pollution influence the incidence and severity of COVID-19?. *Environmental Research*, *195*, 110766.

[98] Nguyen, T., Nguyen, T. T. H. N., Morinaga, M., Hiraguri, Y., & Morihara, T. (2025). Assessing annoyance and sleep disturbance related to changing aircraft noise context: Evidence from Tan Son Nhat Airport. *International Journal of Environmental Research and Public Health*, *22*(8), 1296.

[99] Terasawa, H., Matsubara, M., Goudarzi, V., & Sadakata, M. (2021). Music in quarantine: Connections between changes in lifestyle, psychological states, and musical behaviors during COVID-19 pandemic. *Frontiers in Psychology*, *12*, 689505.

[100] Schröder, A., Vulink, N., & Denys, D. (2013). Misophonia: Diagnostic criteria for a new psychiatric disorder. *PLoS ONE*, *8*(1), e54706.

[101] Ferrer-Torres, A., & Giménez-Llort, L. (2021). Confinement and the hatred of sound in times of COVID-19: A Molotov cocktail for people with misophonia. *Frontiers in Psychiatry*, *12*, 627044.

[102] Chu, S., Wang, Y., Liu, J., & Hong, X.-C. (2025). Pandemic-induced shifts in urban noise perception: A spatial-temporal analysis in a Chinese megacity. *Journal of Environmental Management*, *391*, 126584.

[103] Trudeau, C., Tarlao, C., & Guastavino, C. (2023). Montreal soundscapes during the COVID-19 pandemic: A spatial analysis of noise complaints and residents' surveys. *Noise Mapping*, *10*(1), 20220169.

[104] Yildirim, Y., & Arefi, M. (2021). Noise complaints during a pandemic: A longitudinal analysis. *Noise Mapping*, *8*(1), 108–115.

[105] Lee, R. J. (2021). Vacant land, flood exposure, and urbanization: Examining land cover change in the Dallas-Fort Worth metro area. *Landscape and Urban Planning*, *209*, 104047.

[106] Tong, H., Li, M., & Kang, J. (2022). Relationships between building attributes and COVID-19 infection in London. *Building and Environment*, *225*, 109581.

[107] Wulf, T., Breuer, J. S., & Schmitt, J. B. (2022). Escaping the pandemic present: The relationship between nostalgic media use, escapism, and well-being during the COVID-19 pandemic. *Psychology of Popular Media*, *11*(3), 258–265.

[108] Cabedo-Mas, A., Arriaga-Sanz, C., & Moliner-Miravet, L. (2021). Uses and perceptions of music in times of COVID-19: A Spanish population survey. *Frontiers in Psychology*, *11*, 606180.

[109] Zanders, M., Lee, M.-S., Zhang, J., Gravish, J., Giraldo, A., & Zambonini, J. P. (2024). Environmental Music Therapy (EMT) to reduce stress and anxiety with patients, caregivers, and hospital staff during the COVID pandemic. *Music and Medicine*, *16*(1).

[110] Jacobsen, S., Beck, B., & Lindvang, C. (2022). Background music improves experience of COVID-19 vaccination for citizens and vaccination staff—A pilot study. *Music and Medicine*, *14*(4), 238–244.

[111] Kaplan-Neeman, R., Kreiser, N., Ross, S., & Muchnik, C. (2023). Listening habits to music during COVID-19 pandemic: Is there a risk to hearing?. *Journal of the American Academy of Audiology*, *34*(7–8), 135–142.

[112] Diffenbaugh, N. S., Field, C. B., Appel, E. A., Azevedo, I. L., Baldocchi, D. D., Burke, M., ... Wong-Parodi, G. (2020). The COVID-19 lockdowns: A window into the Earth system. *Nature Reviews Earth & Environment*, *1*(9), 470–481.

[113] Public Health And Environmental Research and Education Subcommittee of the National Science Foundation. (2021). *Environmental and human health: Research priorities*.

[114] Dance, S., & McIntyre, L. (2021). The Quiet Project—UK acoustic community's response to COVID19 during the easing of lockdown. *Noise Mapping*, *8*(1), 32–40.

[115] Kang, J. (2017). From dBA to soundscape indices: Managing our sound environment. *Engineering Management*, *4*(2), 184–192.

[116] Aletta, F., Kang, J., & Axelsson, Ö. (2016). Soundscape descriptors and a conceptual framework for developing predictive soundscape models. *Landscape and Urban Planning*, *149*, 65–74.

[117] D'Alessandro, F., Asdrubali, F., & Mencarelli, N. (2015). Experimental evaluation and modelling of the sound absorption properties of plants for indoor acoustic applications. *Building and Environment*, *94*, 913–923.

[118] Brown, A. L. (2012). A review of progress in soundscapes and an approach to soundscape planning. *International Journal of Acoustics and Vibration*, *17*(2), 73–81.

[119] Bhalla, R., Chowdhary, N., & Ranjan, A. (2021). Spiritual tourism for psychotherapeutic healing post COVID-19. *Journal of Travel & Tourism Marketing*, *38*(8), 769–781.

[120] Tong, H., & Kang, J. (2021). Relationship between urban development patterns and noise complaints in England. *Environment and Planning B: Urban Analytics and City Science*, *48*(6), 1632–1649.

[121] Ba, M., & Kang, J. (2019). Effect of a fragrant tree on the perception of traffic noise. *Building and Environment*, *156*, 147–155.

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新冠肺炎（COVID-19）疫情对声环境影响的系统综述

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摘要

新冠肺炎（COVID-19）疫情促使各国实施防控措施，严格限制了人员出行、社会交往及公共空间使用。上述措施改变了声环境，并对人类福祉产生了影响。本研究系统梳理了疫情期间声环境的变化及其对健康的影响。研究遵循系统评价和Meta分析优先报告条目（PRISMA）规范，检索Web of Science、Scopus、PubMed、Embase和Cochrane Library数据库，纳入2020年至2025年间发表的182篇文献。结果表明，与疫情前相比，疫情期间不同类型城市的声级下降幅度存在显著差异：纳入全球城市指数（Global Cities Index）的城市平均变化量为−5.8 dBA，而其他城市平均变化量为−13.8 dBA。按声源类型划分，城市噪声、人为活动噪声和航空噪声的平均变化量分别为−10.1 dBA、−10.7 dBA和−11.2 dBA。相比之下，部分功能性室内环境声级有所升高，其中医疗空间声级平均增加5.3 dBA。与此同时，学术界对室内声景的关注持续增强。与疫情前（2014—2019年）相比，2020—2025年室内声景和室外声景研究的论文发表总量分别达到此前的3.53倍和2.97倍。研究重点逐渐由客观声学测量转向人的主观感知与健康相关内容。居家办公与学习环境中的室内噪声暴露与舒适度降低、认知表现下降及烦恼度增加显著相关，而自然声与音乐则与心理健康改善及恢复性体验增强相关。未来研究应整合客观声学测量、声源特征、情境因素、主观声景评价及健康相关的多维指标，以深入理解声环境与人的体验、福祉及健康之间的内在关系。

关键词

声环境；封控；声级；感知；健康；声景；噪声暴露；系统综述

文章亮点

- 不同城市空间的声级变化可为城市噪声控制与声景设计提供实证依据
- 2020—2025年室内声景相关研究发表数量较2014—2019年增至3.53倍
- 随着城市噪声水平降低，人们对自然声的感知更加突出
- 声环境感知与烦恼度、压力及心理健康之间的关联机制有待深入研究

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