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Research Paper

Exploring the Relationship Between Stress Levels and Sound Environment Preferences: Toward Pandemic-Resilient Urban Park Design

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Abstract
This study aims to examine how the Burden of COVID-19 (BUC), depression (DEP), and stress (STR) are related to soundscape preferences (City Voice/traffic, Music, Voice of Nature/birdsong) and to distil design implications for pandemic-resilient urban parks. This cross-sectional online study with N = 323 university students used a 60-s 3D animation of a constant green pedestrian way with three randomized audio conditions (City Voice, Music, Voice of Nature). Psychological variables were assessed with DASS-21 subscales (DEP, STR) and a 10-item BUC index. To minimize loudness confounds, audio was loudness-normalized (BS.1770-5) and participants completed a brief headphone screening before trials. Analyses reported Cronbach's α, Pearson correlations, exact p values, and FDR control. The study showed that BUC correlated positively with Music ($r = .288, p < .001$), DEP ($r = .213, p < .001$), and STR ($r = .186, p = .001$), but not with City Voice or Voice of Nature. DEP correlated positively with Music ($r = .174, p = .002$) and Voice of Nature ($r = .492, p < .001$). STR correlated positively with Voice of Nature ($r = .377, p < .001$). City Voice showed no reliable associations with BUC, DEP, or STR. All effects with $p \leq .002$ remained after FDR control. Park and streetscape projects should buffer traffic noise, foreground pleasant natural acoustics (e.g., water features, habitat for birds/insects), and consider opt-in, curated music zones during crises to support self-regulation and recovery. Sound-attentive design can extend restorative experiences to communities with limited access to large green spaces, supporting equitable mental-health resilience during public-health emergencies. However, findings should be interpreted with caution given the student sample, correlational design, and single-item soundscape preference measures. The study isolates the auditory contribution to restoration under controlled loudness in a virtual park, links pandemic burden to sound preferences, and translates results into actionable soundscape guidelines for pandemic-ready urban design.

Keywords: *Soundscape, Environmental noise, Nature sounds, Music, Stress reduction, Depression, COVID-19, Urban park design, Resilience.*

INTRODUCTION

Over the past ten years, there has been growing attention toward researching soundscapes and understanding how the acoustic environment impacts human well-being (P. Wang, He, Yang, Li, & Chen, 2022). Studies have revealed a substantial link between the physiological and psychological changes that different sounds can induce, as highlighted by the work of Cui et al., (2022). For instance, their research indicates that music can alleviate residents' psychological distress. Simultaneously, the presence of traffic sounds and the psychological state of residents can significantly influence the overall

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satisfaction with the auditory environment. Conversely, technological sounds are generally perceived as displeasing, as noted by Lavandier and Defreville (2006). Similarly, the research conducted by Jeon et al., (2021) highlights that the general level of preference for an urban soundscape plays a crucial role in meeting potential restorative criteria. Furthermore, other studies have demonstrated the positive perception of natural sounds, with evidence suggesting that exposure to nature sounds can assist individuals in recovering from symptoms of psychological stress, as observed by Alvarsson et al., (2010).

Various studies have underscored the importance of public spaces and urban greenery as essential components of resilient infrastructure during crises (El Khateeb & Shawket, 2022; Honey-Rosés et al., 2021; Marques, McIntosh, Muthuveerappan, & Herman, 2022).While existing research has highlighted the beneficial effects of exposure to nature on health and well-being, there remains a limited comprehension of individuals' favored soundscapes and their perceived stress levels during highly demanding situations, such as the ongoing pandemic. Additionally, inadequate attention has been devoted to exploring the significance of the acoustic environment in terms of its suitability for recreational activities and effective measurement techniques. Hence, this study seeks to investigate the preferred soundscape in an outdoor green setting and its potential correlation with stress levels during the COVID-19 pandemic, particularly within a virtual natural environment. By examining the sound preferences of individuals experiencing varying levels of stress, this research aims to elucidate the interplay between soundscapes, stress, and well-being amidst the unparalleled circumstances of the pandemic.

LITERATURE REVIEW

Nature and Restoration

Extensive research supports the advantages of nature exposure and engagement with natural environments (G. N. Bratman et al., 2012; Brown & Grant, 2005; Haluza et al., 2014; Terry Hartig et al., 2011; Van den Bosch & Ode Sang, 2017; Ward Thompson, 2011), contributing to improved mental health and overall well-being (Berman, Jonides, & Kaplan, 2008; Gregory N. Bratman et al., 2015; Hansen, et al., 2017; T. Hartig et al., 2014; Hunter et al., 2019).

A mounting body of evidence suggests that exposure to natural settings and green spaces can alleviate both physical and psychological stress (Ewert & Chang, 2018; Haluza et al., 2014; Hansmann et al., 2007; Korpela et al., 2008; Mantler & Logan, 2015; Ulrich et al., 1991).

Natural environments contribute to human health and well-being by alleviating stress through various mechanisms. They offer opportunities for physical activity (Hug et al., 2009), with research demonstrating the positive effects of exercise in direct contact with nature (Pretty et al., 2005). Outdoor exercise is found to be more rejuvenating and stress-reducing compared to indoor activities (Hug et al., 2009), and walking in green spaces is associated with improved emotional well-being (Barton et al., 2009). Furthermore, green spaces can have a positive impact on health by fostering social cohesion and decreasing stress levels (de Vries et al., 2013).

Beil and Hanes (2013) conducted a study exploring the impact of four urban environments categorized as Very Natural, Mostly Natural, Mostly Built, and Very Built on measures of physiological and psychological stress. Their results reinforced the notion that natural settings were more effective than built environments in reducing stress levels, as evidenced by changes in salivary amylase and self-reported stress from before to after exposure. Meanwhile, research by Ewert and Chang (2018) indicated that spending time in natural environments could effectively reduce both physical and psychological stress levels, with individuals in natural settings reporting notably lower stress levels compared to those in more urban outdoor settings or indoor exercise facilities. Similarly, recent interdisciplinary research from Cornell University revealed that just 10 minutes spent in a natural environment could enhance the happiness levels of college students and mitigate the impacts of both physical and mental stress (Meredith et al., 2019).

Indirect exposure to natural environments through displays, projectors, or virtual reality can offer emotional well-being benefits, particularly for individuals unable to access the outdoors. Wood and colleagues (2020) investigated the influence of visual exercise environments on the response to psychological stress and discovered a notable impact of viewing conditions on cortisol reactivity, with significantly lower reactivity in the built environment compared to the natural setting. In a separate study focusing on the impact of exposure to green environments through virtual reality (VR) technology, a group of students with varying levels of exam anxiety underwent a simulated exam both before and after exposure to either a virtual green environment or an urban environment. The findings provided support for the notion that even simulated exposure to nature could alleviate anxiety and improve students' perceptions of their academic performance (O'Meara, et al., 2020).

Most studies utilizing visual stimuli, including photographs, 3D images, virtual reality, and videos of natural landscapes, consistently affirm that observing natural scenery induces a more relaxed physiological response compared to the control condition (Jo et al., 2019). For instance, Ulrich et al., (1991) conducted a study in which participants were exposed to a stressful movie followed by color and sound recordings of six distinct natural and urban settings to assess stress levels. The data they obtained, derived from both physiological and verbal measurements, demonstrated that individuals exposed to natural environments exhibited a quicker and more comprehensive recovery from the stress induced by the movie, as opposed to those in urban environments.

Soundscape and Restoration

The correlation between an enriching environment and stress recuperation has received limited attention from researchers. Alvarsson et al. (2010) conducted an experiment involving 40 participants exposed to nature sounds and noisy surroundings after engaging in a mentally taxing arithmetic task. Their aim was to examine whether auditory exposure to natural or urban environments aids in recovery after psychological stress. Their findings validated the notion that listening to nature sounds facilitates recovery from sympathetic activation subsequent to psychological stress. Similarly, Jahncke et al. (2011) delved into the restoration of attention post-exhaustion in office settings. Their study revealed that viewing a nature film or listening to the sounds of a river had a more positive impact on motivation for work compared to listening to office sounds.

Based on Payne's (2013) findings, rural soundscapes are shown to possess a greater capacity for healing compared to those from parks or urban areas. In a separate study, Annerstedt et al. (2013) investigated the physiological recovery linked to the viewing of a virtual reality image with and without natural sounds. Their research indicated that exposure to the image with natural sounds resulted in increased parasympathetic activation, implying more effective stress recovery. Krzywicka and Byrka (2017) examined the healing potential of both positively evaluated natural and urban sounds. Their study revealed that participants perceived natural sounds more favorably and deemed them more therapeutic compared to urban recordings. Additionally, recent research by Buxton, Pearson, Allou et al. (2021) supports the idea that exposure to natural noises in national parks enhances health outcomes, reducing stress and discomfort. Collectively, these studies suggest that the restorative capabilities of natural soundscapes can aid in stress recovery.

To assess the connection between computed estimations of noise and the soundscape, uncovering its potential for enhancing enjoyment, Evensen et al. (2016) investigated three methodologies for evaluating the soundscape in a quiet zone within an urban park in Oslo. Their research aimed to alleviate the tension and anxiety experienced by patients in hospital settings while simultaneously cultivating a sense of security. A comprehensive review of the literature on sound perception and its impact on healthcare is presented by Iyendo (2016). In their study, Aletta et al. (2018) sought to determine whether pleasant, calming, and less bothersome soundscapes had a beneficial impact on health, such as promoting restoration and reducing stress-inducing mechanisms. This discussion intersects with the discourse on urban sound and health by Radicchi et al. (2021).

Soundscape Preferences

Li et al. (2018) utilized immersive virtual environment technologies to explore individuals' inclinations towards soundscapes in protected areas such as parks, investigating their emotional responses to these sounds and the leisure activities that they believe are most affected by these sounds. The primary objective of Liu et al. (2019) was to examine the associations between visitors' motivations for visiting, along with other social, demographic, behavioral, and visual landscape factors, and their experiences of the soundscape in terms of perceived occurrences, volume, preferences for specific sounds, and overall soundscape preferences within urban green spaces.

In a study by Wang et al. (2019), eight films featuring urban green spaces in Xuzhou, China, were coupled with five different natural sounds (such as birdsongs of single and multiple species, wind sounds, a frog croak, and running water sounds) to assess the impact of auditory-visual combinations on aesthetic choices. Seeking to comprehend how visitors' perceptions of the soundscape, preferences, and behaviors are influenced by the quality of the surrounding sounds, Ma et al. (2021) conducted a comprehensive investigation. Baquero Larriva et al. (2023) adopted the PRISMA methodology to systematically evaluate the available scientific literature, focusing on the distinctions between older individuals and the general population in terms of sensitivity to noise, annoyance, acoustic comfort, and preferences for urban soundscapes. Wang et al. (2022) examined the characteristics of soundscapes (including loudness, frequency, preference, and auditory satisfaction) based on 394 valid questionnaires completed by residents of the Qianjiangyuan National Park Pilot Area. Notable contributions also come from the work of Miller et al. (2014).

Yu et al. (2010) conducted a systematic analysis of the factors influencing sound preference evaluations, considering various social, demographic, physical, behavioral, and psychological aspects across 19 case study sites through an extensive survey conducted in Europe and China, along with relevant laboratory studies. The specific neural processes underlying these transitions remain inadequately understood. Moerel et al. (2012) employed functional magnetic resonance imaging (fMRI) and natural sound stimulation to investigate the correlation between these two levels of sound representation in the human auditory cortex. Sound samples utilized included recordings of distinct sound source categories such as water, wind, birdsongs, and urban noises like street music, mechanical sounds, and traffic noise).

In a study by Romanowska (2018), 390 individuals were surveyed across five public locations in Warsaw to determine the possible relationship between people's sound preferences and the function of the respective location. Moerel et al. (2018) explored the depth-dependent stability of acoustic feature preference in the human auditory cortex using ultra-high field fMRI. Puspagarini and colleagues (2019) employed the soundscape method to evaluate the acoustic quality of an urban campus park in Yogyakarta.

The study by Wang et al. (2020) aimed to examine the acoustic requirements of the elderly and the impact of six influencing factors categorized into three types: activity type, objective environment (e.g., number of individuals in a room, sound pressure level), and demographic factors (age, gender, and occupation type). Ma et al. (2021)sought to comprehend how visitors' perceptions, preferences, and behaviors concerning the soundscape are shaped by the quality of the surrounding sound.

While extensive research has confirmed the restorative potential of natural soundscapes and their benefits for psychological well-being (Alvarsson et al., 2010; Annerstedt et al., 2013; Krzywicka & Byrka, 2017; Ulrich et al., 1991), limited attention has been given to how psychological distress itself may influence soundscape preferences. The COVID-19 pandemic created a prolonged period of uncertainty and emotional strain, heightening people’s sensitivity to their everyday sensory environments. Drawing from Stress Recovery Theory (Ulrich et al., 1991), individuals experiencing greater psychological burden may develop selective auditory preferences that serve distinct coping and regulatory functions. Natural sounds can promote passive restoration and physiological recovery by lowering arousal (Alvarsson et al., 2010; Jahncke et al., 2011), whereas music may offer an active means of emotional adjustment and mood regulation within stressful contexts. Consequently, pandemic burden is expected to shape not only the perception but also the preference for specific soundscapes, as individuals seek auditory environments that align with their emotional needs and adaptive coping strategies.

Building on the literature and theoretical framework discussed above, the following four hypotheses are proposed:

H1. Higher perceived Burden of COVID-19 (BUC) will be positively associated with greater depression (DEP) and stress (STR) levels.

H2. Individuals experiencing higher pandemic burden will report a stronger preference for music, reflecting an active self-regulatory or coping response.

H3. Higher depression and stress scores will be associated with a stronger preference for natural sounds (Voice of Nature), reflecting a tendency toward passive restoration and stress recovery.

H4. City Voice/traffic sounds will show no positive association with BUC, depression, or stress, due to their low restorative potential and greater likelihood of being perceived as stress-inducing.

RESEARCH METHODOLOGY

Participants

Data were gathered from both undergraduate and graduate students enrolled in the two primary universities boasting the largest student body in Kerman. Participation was contingent upon students being officially registered at these institutions. Invitations to partake in the survey were extended to the students via email. A total of 323 university students responded to the survey, representing various academic disciplines. The demographic details of the participants are outlined in Table 1. The average age of the participants was 29.04 years (SD= 7.80).

Table 1. Respondents’ demographic characteristics.

Demographic factors	Categories	*N*	Percentage
Gender	Male	72	22.8
	Female	244	77.2
Age	18-30	177	59.6
	Above 30	146	40.4
Marriage status	Single	182	56.5%
	Married	140	43.5%

Measurement Scale

Depression, Anxiety, and Stress were measured using the DASS-21, a validated 21-item self-report instrument with three 7-item subscales (Depression, Anxiety, Stress). Items are rated on a 4-point scale from 0 = did not apply to me at all to 3 = applied to me very much or most of the time, referencing the past week. Following standard practice, subscale totals were computed by summing the relevant 7 items; where comparisons to DASS-42 norms are made, DASS-21 subscale scores were multiplied by 2. Internal consistency (Cronbach's α) was calculated separately for each subscale.

Pandemic burden was assessed with ten author-developed items (BUC1–BUC10) capturing social constraints, daily-life restrictions, fears, isolation, coping strategies, future expectations, shifting priorities, relationship changes, perceived advantages, and concerns about the future. Each item used a 7-point Likert response format (1 = totally disagree to 7 = totally agree). A total BUC score was computed by averaging across items; internal consistency was assessed with Cronbach's α. These measures were employed to evaluate participants' psychological well-being and pandemic-related experiences.

After each audiovisual trial, participants rated how much they would prefer to walk in the depicted setting with the accompanying soundtrack on a 5-point Likert scale (*1 = dislike very much* to *5 = like very much*). Higher scores indicated a greater preference for walking in that sound environment. These study-specific, single-item ratings corresponded directly to the three experimental conditions (City Voice, Music, and Voice of Nature).

Procedure

A 60-second animation of a 500-m-long and 2.5-m-wide green pedestrian way was created in Autodesk 3ds Max. All visual parameters remained constant for the full 60 s (geometry, tree number/height/spacing, materials, color palette, and lighting); only the audio track differed between conditions. Three soundscape conditions were presented: City Voice (road-traffic/cars), Music, and Voice of Nature (birdsong). The order of the three conditions was randomized per participant.

To minimize loudness confounds, all audio files were loudness-normalized to a common integrated loudness using the ITU-R BS.1770-5 algorithm (LKFS/LUFS units) with true-peak limiting prior to export. Participants were required to use headphones. Before the main task, they completed a brief headphone-screening check (anti-phase level test per Woods et al., 2017 and/or Huggins-pitch test per Milne et al., 2021). These steps help ensure that subsequent differences in ratings reflect content rather than uncontrolled playback level or device variability.

Data collection occurred in February–March 2021 via an online questionnaire distributed to students by email. After electronic informed consent, participants completed demographics, the DASS-21, and the BUC items. They then viewed the three 60-s animations (randomized order), providing a 5-point preference rating immediately after each. At the end, participants confirmed they had no history of mental illness or neurological conditions (self-report). Analyses were conducted in IBM SPSS Statistics v27.

Fig 1. The Image of the Pedestrian Way

RESULTS

Internal Consistency

All multi-item constructs showed acceptable internal consistency. Cronbach's alpha ranged from .72 to .89, indicating adequate to excellent reliability for the Burden of COVID-19 (BUC), Depression (DEP), and Stress (STR) scales (Table 2). Reporting follows APA JARS–Quant.

Zero-order Associations among Sound Preferences and Psychological Variables

Pearson correlations examined linear associations among soundscape preferences (City Voice, Music, Voice of Nature) and psychological variables (BUC, DEP, STR). As shown in Table 3, BUC correlated positively with Music ($r = .288$, $p < .001$) and with Depression ($r = .213$, $p < .001$) and Stress ($r = .186$, $p = .001$). Associations of BUC with City Voice ($r = .101$, $p = .070$) and Voice of Nature ($r = .035$, $p = .540$) were not significant.

Depression showed positive correlations with Music ($r = .174$, $p = .002$), Voice of Nature ($r = .492$, $p < .001$), BUC ($r = .213$, $p < .001$), and Stress ($r = .649$, $p < .001$). The correlation between Depression and City Voice was not significant ($r = .017$, $p = .760$).

Stress correlated positively with Voice of Nature ($r = .377$, $p < .001$), BUC ($r = .186$, $p = .001$), and Depression ($r = .649$, $p < .001$). Associations of Stress with City Voice ($r = −.062$, $p = .264$) and Music ($r = −.061$, $p = .280$) were not significant.

Interpreting effect sizes, most significant associations were small to moderate in magnitude (e.g., $r ≈ .17–.38$; $r ≈ .49–.65$ toward moderate-to-large) for individual-differences research. To account for multiple tests, we controlled the false discovery rate (Benjamini–Hochberg, $q = .05$) across the family of zero-order correlations; all associations with $p ≤ .002$ (and all with $p < .001$) remained significant after FDR control, whereas marginal effects (e.g., $p ≥ .070$) did not. Reporting follows APA JARS–Quant guidance on exact p values and effect-size reporting.

Textual summary (consistent with Table 3). Individuals reporting a higher Burden of COVID-19 also reported higher Depression and Stress, and a stronger preference for Music; BUC was not related to preferences for City Voice or Voice of Nature. Depression was associated with higher preferences for Music and Voice of Nature (but not City Voice), and Stress was associated with higher preference for Voice of Nature (but not City Voice or Music).

Table 2. Reliability of Study Constructs.

Factor	Number of items	Cronbach's alpha
Burden of COVID-19 (BUC)	10	0.72
Depression (DEP)	7	0.87
Stress (STR)	7	0.89

Note. Alphas are the coefficient α for the present sample.

Table 3. Zero-order Pearson Correlations among Sound Preferences and Psychological Variables.

Row variable →	City Voice	Music	Voice of Nature	BUC	DEP	STR
BUC	.101 (*p* = .070; *n* = 322)	.288 (*p* < .001; *n* = 316)	.035 (*p* = .540; *n* = 310)	—	.213 (*p* < .001; *n* = 309)	.186 (*p* = .001; *n* = 322)
DEP	.017 (*p* = .760; *n* = 309)	.174 (*p* = .002; *n* = 303)	.492 (*p* < .001; *n* = 297)	.213 (*p* < .001; *n* = 309)	—	.649 (*p* < .001; *n* = 309)
STR	−.062 (*p* = .264; *n* = 322)	−.061 (*p* = .280; *n* = 316)	.377 (*p* < .001; *n* = 310)	.186 (*p* = .001; *n* = 322)	.649 (*p* < .001; *n* = 309)	—

Notes. Entries are Pearson r with exact two-tailed p and pairwise n. Bolded coefficients remain significant after Benjamini–Hochberg FDR control at $q = .05$ across the family of zero-order correlations. Effect-size interpretation for individual-differences contexts: ≈.10 small, ≈.20 typical, ≈.30 relatively large.

DISCUSSION

This study tested four hypotheses linking the Burden of COVID-19 (BUC), depression (DEP), and stress (STR) with soundscape preferences (City Voice, Music, Voice of Nature). **H1** predicted that higher BUC would be associated with higher DEP and STR, which was supported. **H2** proposed that individuals under greater pandemic burden would show a stronger preference for music, which was also supported. **H3** predicted that higher depression and stress would relate to a stronger preference for nature sounds, which was partially supported—both DEP and STR correlated positively with Voice of Nature, whereas BUC did not. **H4** anticipated no positive relationship between City Voice and psychological variables, which was confirmed. Together, these results suggest that distinct forms of psychological distress correspond to different auditory preferences: music aligns with active self-regulation under contextual stress, whereas nature sounds correspond to passive restoration from ongoing emotional strain.

This study examined links between the Burden of COVID-19 (BUC), depression (DEP) and stress (STR), and soundscape preferences (City Voice, Music, Voice of Nature). In line with pandemic evidence of heightened psychological distress (Dong & Bouey, 2020; Montemurro, 2020; Panchal et al., 2023), higher BUC correlated with higher DEP and STR. Contrary to our initial expectation, BUC was not associated with a preference for nature sounds; instead, it was positively associated with a preference for music. While BUC was positively associated with music preference, it is noteworthy that the DASS-21 Stress (STR) subscale did not show a significant association with Music ($r = -.061$, $p = .280$). This pattern suggests that the desire to seek out music may be more closely tied to the generalized, pervasive psychological load of the crisis (BUC)—which captures social constraints, fears, and future concerns—rather than the immediate or acute symptom of stress measured by the DASS-21. This aligns with music serving as a long-term, compensatory coping strategy during chronic public-health crises. DEP related positively to Music and Voice of Nature, while STR related positively to Voice of Nature; City Voice showed no reliable associations. These patterns are compatible with people's use of music for mood/arousal regulation (Schäfer et al., 2013; Thoma et al., 2013) and with restorative environment theories predicting affective benefits of natural stimuli (Kaplan, 1995; Ulrich et al., 1991).

Previous research by Lesan and Gjerde (Lesan & Gjerde, 2021a, 2021b) demonstrated how spatial design features and the distribution of business activities along streets influence people's movement, comfort, and patterns of social interaction. Building on that foundation, the current study extends the behavioral perspective from spatial and visual aspects of urban experience to its auditory dimension—showing how sound environments contribute to psychological regulation and restoration during periods of heightened stress.

Our findings refine restorative and self-regulation accounts in three ways:

1. BUC and music preference – A stronger preference for music under higher pandemic burden aligns with theory and evidence that people engage music to regulate affect and recover from stress (Aalbers et al., 2017; de Witte et al., 2020). This suggests music-seeking may be a compensatory, self-administered coping strategy during public-health crises.
2. Depression/stress and restorative auditory contexts – Positive associations between Voice of Nature and both DEP (moderate) and STR (small-to-moderate) support extending Stress Recovery Theory and ART to auditory stimuli (e.g., birdsong, water), not just visual greenery (Jeon et al., 2021; Kaplan, 1995; Ulrich et al., 1991).
3. Null links for City Voice vs. noise exposure – Our "City Voice" metric captures preference, not exposure. Epidemiology shows traffic/aircraft noise exposures can elevate risks of depression/anxiety (Hahad et al., 2025; Hegewald et al., 2020), but liking city sounds does not equate to harmful exposure levels—explaining the null correlations.

The pattern resonates with work documenting how pandemic burdens and contextual stressors shape mental health and environmental preferences: Khozaei et al. (2024) show BUC, anxiety and stress predict depression among Afghan migrants; Khozaei et al. (2022) report heightened post-COVID demand for biophilic attributes; Khozaei et al. (2022) highlight determinants of migrants' mental disorders during COVID-19; and earlier environmental-psychology work links fulfilled environmental preferences to satisfaction and attachment (Khozaei ta al., 2011; Khozaei et al., 2012). These strands jointly suggest that matching sensory preferences (including sound) within place design can bolster wellbeing—particularly under strain.(Khozaei et al., 2022; Khozaei et al., 2011; Khozaei et al., 2024; Khozaei et al., 2012).

Given the consistent pandemic-era rise in mental-health need (Dong & Bouey, 2020; Panchal et al., 2023), equity-minded soundscape design can extend restorative experiences to populations with limited access to large green spaces—for example, through small pocket-parks that are acoustically shielded, or temporary interventions during emergencies (quiet hours; curated music in care facilities). Evidence tying noise exposure to mental-health harms underscores the public-health value of such measures (Hahad et al., 2025; Hegewald et al., 2020). Work on vulnerable populations by Dr. Khozaei reinforces the need to prioritize communities under compounding stress (Khozaei et al., 2022; Khozaei et al., 2024).

Cross-sectional correlations do not establish causality; preferences and symptoms may influence each other. Our City Voice index measures preference rather than actual exposure (e.g., LAeq, Lden), which can attenuate associations relative to noise-health epidemiology. Future work should (i) employ loudness-normalized stimuli and exposure metrics, (ii) test audio-visual combinations (greenery + sound masking), and (iii) study programmed music interventions in outdoor settings. Applying ISO/TS 12913-2 protocols will improve comparability.

This study has several limitations. The sample comprised university students in Kerman, Iran, which limits generalizability to other age, occupational, or cultural groups whose sound preferences and coping patterns may differ. Soundscape preference was measured with single items to minimize fatigue and maintain focus during repeated trials; however, this approach may not capture multiple dimensions such as comfort or appropriateness. The design was cross-sectional and correlational, so the observed links among pandemic burden, distress, and sound preference should not be interpreted causally. The high correlation between depression and stress ($r \approx .65$) suggests shared variance that future work could model as a broader distress construct. Finally, the virtual-simulation method offered control but simplified real-world complexity; thus, the design implications presented here are best regarded as potential considerations rather than prescriptive recommendations.

CONCLUSION

This study contributes to the soundscape and restorative environments literature by showing that pandemic burden co-occurs with higher stress/depression and greater preference for music, while depression/stress are associated with preference for nature sounds; urban/city sound preference was not reliably related to distress. The results extend restorative frameworks to emphasize auditory design and show how self-regulatory music use may rise under crisis conditions (Aalbers et al., 2017; de Witte et al., 2020; Kaplan, 1995; Ulrich et al., 1991). For practice, Emerald's audience of planners, designers and facilities managers can translate these insights into evidence-based guidelines: buffer traffic, foreground pleasant natural acoustics, and consider curated, opt-in music zones during emergencies—consistent with ISO 12913. The work complements biophilic preference evidence and pandemic mental-health pathways and underscores the social value of sound-attentive public spaces.

Future research should include participants from more diverse cultural and demographic contexts, use longitudinal or experimental designs to clarify cause–effect relationships, and incorporate both physiological and sound exposure measures to better understand how auditory environments influence well-being. Studies combining sound with visual and spatial factors could further guide the creation of inclusive, resilient urban spaces that support collective recovery during and beyond public-health crises.

AUTHOR DECLARATION ON AI ASSISTANCE

The authors acknowledge the use of *ChatGPT (GPT-5, OpenAI)* for English language editing and refinement of the manuscript. The tool was used solely to improve grammar, readability, and phrasing. All study design, data analysis, interpretation, and conclusions were conceived and developed entirely by the authors.

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