

REVIEW ARTICLES

Influence of COVID-19 Lockdown on Noise Level Reduction: A Scoping Review With Stakeholders' Consultation

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ABSTRACT

In light of the COVID-19 pandemic, empirical evidence suggests that the global community has commenced a recuperation process and witnessed a notable positive influence. Despite several published research on the topic, a complete analysis examining the effects of lockdown measures implemented during the COVID-19 pandemic on environmental noise has yet to be conducted. Thus, this scoping review with stakeholders' consultation was conducted to systematically identify literature related to noise level reduction. An electronic search was conducted up to August 8, 2020, on four databases (Science Direct, SCOPUS, CINAHL, and PubMed). Eight articles met our criteria for further review where G20 countries conducted most studies. Three were reviewed, two were experimental, two were case reports, and the other was protocol. Although the current literature is minimal, it is evident that global noise levels are decreasing significantly. However, our review revealed that none of the included studies addressed the effect of noise level reduction on human health, and we view the decrease not necessarily as an outcome of the COVID-19 pandemic outbreak but rather because of the transition from outdoor to indoor environments. As this subject matter has received a lack of attention and is often overlooked, more innovative research to look for state-of-the-art stagnant initiatives is needed to control the issue of noise pollution and to provide a basis for government policies.

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associated with tranquilly, a significant proportion of its residents, specifically 70%, experience the negative impacts of noise pollution (5). Hence, it is unavoidable for people in developing countries to experience significant impacts from the prevalence of high road traffic noise.

INTRODUCTION

Noise pollution is any unpleasant or distracting sound affecting the health and well-being of humans and other animals (1), particularly in urban areas. It is more serious now and will worsen due to the continuous growth of highways, railways, and air transportation (2). Effects of noise pollution on human health vary from occupational to environmental exposures. As an example, extended exposure to noise in the workplace can lead to hearing impairment, elevated systolic and diastolic blood pressure, and decreased productivity (3). Conversely, extended exposure to environmental noise can lead to various health issues such as sleep disturbances, difficulties in communication, stroke, anxiety, and depression (4). According to statistics, 3/4 of residents in large cities in the United Kingdom, such as Liverpool and London, are extensively affected by noise. In Stockholm, Sweden, a location typically

Assessments of recent noise levels distinguished on roads in Ho Chi Minh City, Vietnam, have repeatedly surpassed the permissible limit. According to survey results, 100% of people were affected by the sound exceeding the permitted regulations, affecting their lives and health (6), while in Malaysia, result showed that traffic noise in residential areas varied from 65 to 84 dBA during both weekdays and weekends. Results suggest that noise level is significantly increasing compared to the previous year (7). Thus, many countries have adopted policies and initiatives for many years to reduce noise emissions and retain quiet areas. In Malaysia, under The Planning Guidelines for Environmental Noise Limits and Control 2019, during the day, the average equivalent continuous sound level in suburban and urban residential areas should not exceed 65 dBA during the daytime (8). India

implemented a mitigation plan where under Section 290 of the Indian Penal Code, people shall be subjected to a fine of up to two hundred rupees if any individual experiences injuries due to noise pollution, as noise is considered a public nuisance (9). Meanwhile, the European Union (EU) enacted the Environmental Noise Directive (END), which mandates Member States to develop and report noise maps and noise mitigation plans every five years, as well as consult the concerned public (10).

The outbreak of Coronavirus diseases-2019 (COVID-19) cases around the world in the first quarter of 2020 has caused a global pandemic and has had devastating consequences after on 31st December 2019, the first outbreak was reported in Wuhan, China (11). As of 23 February 2021, 111,419,939 cases have been confirmed in 219 countries by WHO, with 2,470,772 deaths (12). Implementing a lockdown to restrict human activities has created an economic crisis due to the significant shutdown of the industrial, transport, and tourism sectors (13) even though it helped to contain the virus. Road vehicles such as cars, trains, buses, and aircraft were halted to reduce large-scale gatherings. Malaysia closed all religious buildings, such as churches, mosques, and business premises starting from 18 March, except for relevant government and private premises, such as hospitals, petrol stations, grocery stores, and convenience stores that sell daily goods (14). On March 17, France enforced a total lockdown, banning public gatherings and outings to decrease population mobility (15). Colombia implemented a regional quarantine on 24 March, requiring all 70 years of age and older to remain indoors until May, while, on 26 March, South Africa started a 21-day lock-up, and only essential businesses remain open, with soldiers and police patrolling the streets (16).

Before the end of 2020, Malaysia was struck by three waves of COVID-19. The first wave started on January 25, 2020, and ended on February 16, 2020; the second wave occurred on February 27, 2020, and ended on June 30, 2020; and the third wave began on September 8, 2020 (17). Concurrently, a second wave of infections appeared in the European Union (EU) starting at the end of July 2020 after the percentage of patients infected with the virus began to increase again with varying degrees of severity in different regions (18). This was explained by the fact that, following the lockdown in several EU countries, some action plans, such as the travel restriction, were loosened across the EU during the summer. Nonetheless, due to changes in lockdowns, stay-at-home orders, and closure of various types of services and businesses, mobility trends vary widely during all waves (19).

At the same time, however, research on a global scale has already showed that this pandemic has made it

easier for the environment to recover, as (20) show a highly significant positive correlation ($r=0.66$) between the number of days in which environmental pollutants reached permissible limits and the total number of COVID-19 cases. The comparative burden of disease studies suggests that traffic noise has ranked second in public health effects and disability-adjusted life-years (DALYs). Following the gradual implementation of lockdown initiatives in several countries, preliminary studies from research centers and government agencies around the world indicate that noise pollution has decreased dramatically due to the reduction of ground vibration (21). Prior to the emergence of the COVID-19 pandemic and the subsequent implementation of lockdown measures, the levels of indoor noise in residential areas were influenced by a range of factors, such as daily schedules, transportation patterns, and community events. An example of a field study was conducted in Besançon, France (40), which assessed the levels of indoor noise in residential homes and examined the potential factors that could affect their variation. The study revealed a notable rise in indoor noise levels in correlation with both outdoor noise levels and the length of time or level of activity of individuals present in the household. In France, an average decrement of 7.6 dBA has been reported on the Paris Road network, with a decrement in noise pollution ranging from 60% to 90% since the lockdown on French territory was implemented on 17 March 2020 (22). In parallel, the data from Barcelona indicate a general reduction in noise emissions, reaching as high as 9 dB a week after the lockdown, with a further drop over the subsequent week (23). However, to our knowledge, there is still limited evidence that researchers have approached the influence of quarantine lockdown to reduce the level of road traffic noise, especially concerning human health effects. Thus, this paper could provide more explicit evidence of the impact on the climate of our globalized economy and people's day-to-day activities. The purpose of this review, which is governed by the (24) framework, is to provide an overview of how the quarantine lockdown influences the reduction of global noise levels.

MATERIALS AND METHODS

Search Strategy

A systematic search was conducted to find information about the impact of the COVID-19 pandemic on outdoor and indoor noise levels worldwide. The investigation was conducted on four electronic databases, namely Science Direct, SCOPUS, CINAHL, and PubMed. The following keywords were utilized for the search ("noise" OR "sound" OR "noisy") AND (pollution OR environment) AND ("covid19" OR "coronavirus" OR "2019-ncov" OR "sars-cov-2" OR "cov-19" OR "novel coronavirus"). Boolean operators, truncations, wildcards, and MeSH terms related to

these keywords were used whenever possible. Date restriction was implemented during the search from November 2019 to the current date. The search was done on 28th August 2020.

Study Selection

Duplicates were removed before screening. Retrieved articles were screened for inclusion and exclusion based on pre-defined criteria. Inclusion criteria are the studies conducted during the COVID-19 pandemic, focusing on noise emission health effects, and conducted either in outdoor or indoor environments. Meanwhile, the exclusion criteria are animal study, the study based on earlier coronaviruses (such as MERS-CoV and SARS-CoV), non-peer review journal article, non-English, no full text available, and in grey literature format (e.g., thesis, book). The screening was conducted independently by the first and second author, and pre-consensus on accepted articles were compared to calculate agreement rating. Any disagreed the two authors resolve accepted articles through discussion, and if required, the third author will be called an arbiter.

Data extraction and analysis

The included articles are extracted into a table comprising information on citation, study objective, study design, country, setting and characteristics of the study, and findings. Instruments and equipment used in the study are also extracted. The extraction was performed by the first author and verified by the second author. The findings are then synthesized and reported narratively.

Quality analysis of the included studies

The included articles were analyzed for their quality against a standardized quality assessment checklist. The Nottingham-Ottawa Scale was selected to assess the quality of nonrandomized studies with its design, content, and ease of use directed to the task of integrating the quality assessments (25). A 'star system' has been developed in which a study is assessed from three perspectives: selection of study groups; comparability of groups; and ascertainment of either exposure or interest outcome for case-control or cohort studies, respectively. The maximum attainable score for longitudinal/cohort and case-control studies was nine stars and for cross-sectional studies, seven stars. High-quality research was considered to have a score of at least six.

Consultation

Our scoping review considered the consultation process of discussing preliminary findings with five experts, all members of the Committee on Public Health and Environment Pollution, which helped us identify additional emerging challenges, validated the outcomes through peer review, and contributed as authors for this manuscript. The consultation was

conducted online via Zoom Meeting as part of the study. Before the discussions, all participants had given informed consent, and a description of the preliminary results of the survey was given to each participant to guide the talks. At the same time, the researcher acted as a moderator to facilitate the discussions. The participants were free to discuss their views in any language convenient for them if all participants understood them. They were also given the list of questions and submitted back to us with the answer to address any future confusion.

RESULTS

Variations in the Noise Level

A corpus of 53 articles was retrieved from the electronic search, and 6 papers were added from manual searching. After removing the duplicates, 50 articles remained for screening. Finally, a total of eight articles were considered relevant and selected for further review as they met the criteria (Fig.1). Of the total eight articles, three were reviews (26-30), two were experimental (13, 29), two were case report (30-31), and the remaining one was protocol (32).

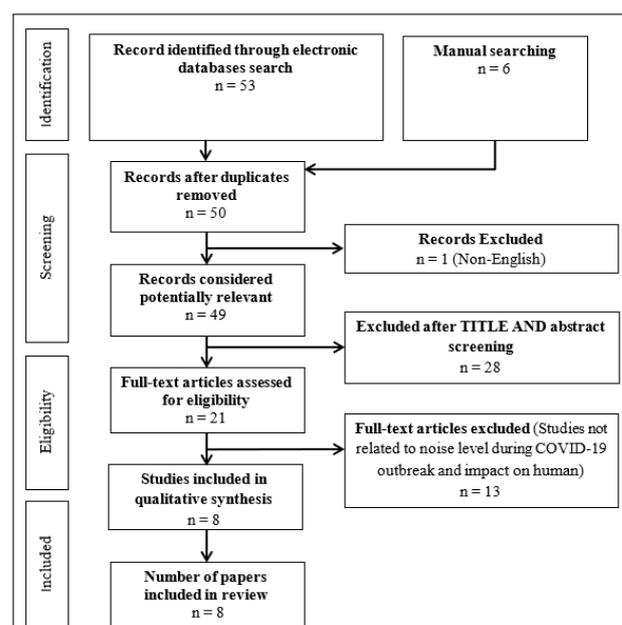


Fig. 1 : Analysis Sem PLS Result.

Stakeholders' Consultation

All of our consultation stakeholders concede that little literature on the subject matter is carried out. The subject of noise pollution during lockdown is also often ignored. In contrast, other types of pollution, such as water and air pollution, can be identified by themselves as the consequences of the lockdown, so finding the relevant literature related to the topic discussed is a challenge. Nonetheless, based on the tabulated references to this document, some of the stakeholders indicated that several additional concerns related to the subject were not cited due to the date restriction.

Table I : Summary of studies

Author citations	Study objective	Study design	Study setting	Findings
Arora et al. [2]	To identify the COVID-19 effect on the global environment.	Review	Global	<p>The noise level decreased drastically in different parts of the globe including India (up to 35% to 68% from 8 am to 4.00 pm).</p> <p>The noise level at metro stations in India was reduced to 50% after the lockdown, which earlier recorded noise level was 100 dB.</p> <p>Noise level at most of the residential areas in New Delhi reduced from 55 dB to 30-35 dB during the lockdown period (up to 30 to 40%).</p> <p>Decrement of transport processes in the marine ecosystem reduced the pollution level drastically.</p>
Asensio et al. [3]	To propose a set of indicators that will enable to address the challenge from several different approaches outline an extended set of descriptors that better enables the application of more novel approaches to evaluate the effect of new soundscape on people's subjective perception.	Protocol	Global	<p>Traffic noise has been drastically reduced due to restrictions on urban mobility.</p> <p>The extended set of indicators allows a more detailed analysis of the changes in noise environments related to confinement and to a broader extent, help in understanding the impact on sound settings of any policy achieved at the urban scale.</p> <p>The sound environments introduced by the lockdowns modified them not only in levels but also by the present sources.</p>
Mandal and Pal [11]	To explore the impact of forced lockdown on environmental components like PM ₁₀ , Land Surface Temperature (LST), river water quality, and noise using image and field-derived data in pre and during lockdown periods.	Experimental	<p>India</p> <p>Landsat 8 OLI image and spatial resolution of the United States Geological Survey (USGS).</p> <p>Digital noise level analyzer (type LT SL 4010).</p> <p>Two hundred forty-five sites in pre lockdown phase and 37 sites during the same lockdown.</p>	<p>The incident of lockdown has turned this noise level quite average like residential area or even less where the noise level is dropped to 65dBA, and above 85dBA in stone crusher-dominated areas in pre lockdown period.</p>
Paital [14]	<p>To understand how COVID-19-induced social lockdown has helped nature to nurture.</p> <p>To discuss whether the introduction of COVID-19 was a natural plan by Mother Nature to self-revive.</p>	Review	<p>Global</p> <p>Authentic news sources (Reuters, BBC news, Times, Hindustan India, India Today, WHO, etc., and scientific literature).</p>	<p>Due to the shutdown of buses, trains, and flights, wild animals, especially birds, enjoy a noise-free environment.</p> <p>In major Indian cities, the footprint (as measured by daily average changeover of impressions (%) in walk-ins from home to a bank, groceries, petrol pumps, and diagnostic centres) to the respective sectors is reduced during the lockdown.</p> <p>The footprint also significantly decreased by >70% in the UK compared to before the lockdown.</p> <p>Lower vibrations from "cultural noise" than before the pandemic was reported.</p>

Saqib and Rampal [15]	To set up a staff well-being hub (a designated 'positive space') to help them detox and recuperate during the COVID-19 pandemic.	Experimental	United Kingdom Continuous quality improvement methodology. Staff survey conducted via social media (Twitter, WhatsApp groups, and Trust global email). The character of the hub was modeled in real-time, with input, ideas, and support from the attendees, and comprised relaxed furniture, soft furnishings, and inspirational messages as requested on the survey.	91% of responders would like a quiet space, away from clinical noise, to relax and access mindfulness and other calming activities. Staff members found the hub calming and relaxing as the space allows them to express their feelings in various manners, such as using a mood board or finding another person to speak to while attending the hub. 100% of staff who have attended love the space, and 95% want it to stay beyond the pandemic.
Shakil et al. [18]	Critically analyze four underlying research clusters and propose research questions to guide future research on the relationship between COVID-19 and the environment.	Review	Global Selected articles were studied thoroughly and revealed four underlying research clusters. Scopus database. ("Coronavirus disease 2019" OR "COVID-19" OR "Novel Coronavirus" OR "Sars-Cov-2") AND ("environment" OR "climate" OR "weather" OR "pollution" OR "environment* pollution").	Countries with severe COVID-19 transmission, such as China, the USA, Italy, and Spain, experienced sharp reductions in noise pollution due to full or partial lockdowns and strict movement control orders (MCO). The lockdown reduced the movement of public transport and completely stopped industrial activities, resulting in a substantial reduction in worldwide noise pollution.
Somani et al. [19]	To investigate and examine the effects/implications of COVID-19 on the environment (mainly in the Indian context). To collect and collate significant data that has been disseminated by the media, regulatory authorities, and academic circles, which report the changes attributed to COVID-19 on the environment in the cities/regions of India. To record the forward course of action in the present and probable scenarios.	Case Report	Global (broadly in India)	A remarkable drop in the noise level was during the lockdown period, as global data shows that traffic movement is down by 54, 36, and 19% in the United Kingdom, United States, and China, respectively. Decreased economic activity during lockdown has reduced the detection threshold resulting in increased earthquake detection. In Canadian cities like Montreal, Ottawa, and Calgary, noise level dropped by more than 40, 33, and 60%, respectively. Suburban trains of Mumbai are wholly halted due to the lockdown and noise measurement stations located across Kolkata show a 50-75% reduction. Due to reduced vehicular transport, certain areas of Delhi showed a reduced noise level by 40-50% (50-60 dB).
Zambrano-Monserrates et al. [20]	To show the positive and negative indirect effects of COVID-19 on the environment, particularly in the most affected countries such as China, USA, Italy, and Spain.	Case Report	Global	The decrement in public and private transportation and commercial activities have caused noise level to drop considerably in most cities worldwide.

Still, as mentioned earlier, they presume that during lockdowns, there is relatively limited study on noise pollution as it is unlikely to do any noise measurement to support the analysis. However, some countries are not in lockdown, and the articles produced from these countries can be beneficial for this study. After all, many further described that issues related to this study should be involved in grey literature since some information might end up located in the news and government reports and might offer the foundation for government policies.

In line with our thoughts, all stakeholders agreed that during COVID-19 outbreaks, environmental noise such as road, air, and water transport were the primary issues related to noise levels that had to be pointed out. There are three methods to control the noise: at the source, transmission path, and receiver (33). The best way to mitigate the noise is at the start while building up noise barriers or interfering with the sound wave at the transmission path could be the second-best option. If noise at both the original and transmission path cannot be controlled to an adequate level, protecting the receiver, such as using earplugs and earmuffs, could become the last resort to mitigate noise pollution. In terms of technology-based noise emission intervention due to the advent of the Industrial Revolution 4.0 (IR 4.0) and the Internet of Things (IoT), they claim that the improvement that can be staged can hardly be articulated. One of them, however, clarified that Malaysian industries are actively engaged in 'buy quiet' technologies, which is an initiative to select and purchase the lowest noise-emitting equipment and machinery to ensure that the instruments used would produce less noise and less acoustic effect on employees, but the price of said technologies can be considered expensive. Nevertheless, the stakeholders also mentioned that the National Institute of Occupational Safety and Health (NIOSH) and the Department of Occupational Safety and Health (DOSH) have already introduced and enforced laws and regulations to regulate noise pollution, where the features of technologies or rules and regulations are certainly would reduce the noise levels produced. In the case of middle-upper-income countries, generally, although all countries have set permissible noise limits, due to a lack of enforcement, noise levels have remained relatively high over the last decade. It would therefore be essential to implement local/national emission standards, as well as national vibration standards, to resolve the problem of noise pollution, as only five countries appear to have set vibration standards, which are Malaysia, Vietnam, Indonesia, Sri Lanka, and India (34).

DISCUSSION

Our scoping review provided an overview of noise pollution during the COVID-19 lockdown, and

according to the above results, it is evident that the study on noise pollution, specifically how the implementation of quarantine lockdown influences the reduce noise levels across the globe, is significantly limited. According to our synthesis of eight studies, including a review, an experiment, a case report, and a protocol, there has been a significant reduction in global noise levels. In India, a drastic reduction in noise level is evident during the lockdown period, which is up to 68% (26). Similarly, due to complete or partial lockdowns and strict movement control orders (MCO), other countries with extreme COVID-19 transmission, such as China, the USA, Italy, and Spain, experienced sharp decreases in noise pollution, while in Canadian cities, reports indicate that noise level fell by more than 60% (28,30). This occurrence can be attributed to decreased traffic movements, especially road traffic, as it is the leading cause of environmental noise (35). Since COVID-19 has spread, countries worldwide are restricting people's mobility to reduce the spread of the virus. Correspondingly, some countries prohibit the service duration of public transport, canceling some services, and shutting down specific stations (27,36).

Nevertheless, based on our review, the literature on our topic is limited and mainly generated by G20 nations. Due to movement restrictions, it is unlikely that any noise measurements will be conducted during the quarantine confinement, as agreed upon by the stakeholders. Therefore, it is essential to increase the number of professionals to uncover the state of the art of stagnant initiatives to advance research in this field. It would be beneficial to research developing a low-cost, real-time Sound Level Meter that can capture vast data sets and be deployed in a specific location. It can process gathered data from a continuous sampling of instantaneous sound pressure level for the entire duration of a day and night to obtain the $L_{(Aeq\ day,15h)}$ and $L_{(Aeq\ night, \ nine\ h)}$. Correspondingly, it can be accessed and monitored from home without going to the selected location. Therefore, raising more self-awareness about noise and promoting interdisciplinary research is important.

Another gap and potential research direction that can be addressed is related to health risks associated with noise exposure. Despite the well-known effect of environmental noise on physical and mental, none of the included studies discuss the impact of noise level reduction on human health, particularly individuals that experience hypertension, cardiovascular disease, sleep disruption, as well as loss of productivity during office hours. A study on the potential exposure of individuals suffering from homelessness to COVID-19 (37). Their study found that insufficient housing quality is associated with stress and mental health impacts from noise and other environmental factors. However, the study poorly reports the significant association

of decreased noise levels with human health effects during the COVID-19 lockdown. It focuses primarily on the risk exposure of individuals suffering from homelessness to coronavirus infection. Thus, future studies of this subject matter should be carried out in a broader range that encompasses both indoor and outdoor noise pollution to have a broader perspective on the impact of lockdown.

Intriguingly, we view the decrease in noise levels worldwide as not attributable directly to the outbreak of COVID-19 but rather due to the change in the mobility of individuals. This pandemic has changed human life, where all over the world, the amount of time that people spend outdoors has been decreasing (38). People spend most of their time indoors due to government instructions to 'stay at home.' Despite our assumptions, the estimates are following other previous studies. One recent study identified that staff in hospitals experiencing a new set of challenges during this pandemic; long working hours, an increase in patient mortality, and noise in the clinical environment (29). In addition, the noise level at home will be higher during COVID-19 stay-at-policy, as up to 60% of individuals became less active and did more of their indoor physical activity (39). Notably, the COVID-19 pandemic has reshaped the distribution of human activities, with a significant portion of the population transitioning to remote work and online learning, contributing to a new set of indoor noise sources. Studies (41) conducted during the pandemic identified increased indoor noise associated with activities like virtual meetings, online classes, and household chores. This shift from outdoor to indoor noise sources presents a unique soundscape for individuals, with implications for acoustic environments. While our review primarily focused on outdoor noise, it is essential to acknowledge this transition and its impact on human well-being, especially during a time when individuals have spent more time indoors

The lockdown situation has influenced the changed in levels and existing sources in the sound settings (32). Considering this gap, this review suggests that more comprehensive and detailed policies targeting the right source of noise should be developed in the future to positively impact noise pollution issues worldwide. Therefore, noise is not necessarily decreased due to the outbreak of the COVID-19 pandemic. However, it is possible to state that it shifts from the environment to indoors. While we have specified the search strategy, certain limitations are imposed on this scoping review. Studies may be excluded if they have been published in a non-indexed journal, are not available in Malay or English, or are published exceeding our date restriction. Lastly, since this review focused on the outdoor noise level, it is unknown whether there is any change in the level of indoor noise and how this

dramatic lockdown affects human health as people spend significantly more time indoors.

CONCLUSION

Our review reveals that despite a noticeable reduction in noise levels worldwide, there are only a few data and peer-reviewed publications. In addition, rather than indicating that the noise level decreases because of the COVID-19 pandemic outbreak, it is preferable to state that it transfers from the outdoors to the interior. Therefore, there is a need to investigate the indoor acoustic condition of the household, as it has a significant negative impact on human well-being, general performance, and mental health due to its association with depressive symptoms and suicidal thoughts. As people frequently remain at home during this post-pandemic period for online learning, working from home, or self-quarantine, they are more likely to experience noise pollution due to constant exposure to high noise levels. Stakeholders concur that, relative to other forms of corruption, noise pollution should be more frequently addressed. Inevitably, it is difficult to identify relevant literature and provide related information that is important for increasing public awareness of noise pollution and providing concrete guidance for government to amend laws and regulations and ensure a safe and habitable environment. Consequently, presenting the influence of the COVID-19 lockdown on noise levels globally is the intention of this scoping review for new findings in future studies, especially in the post-pandemic era.

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