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RESEARCH ARTICLE

Noise complaints, the COVID-19 pandemic, and compact developments: evidence from five American cities

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Abstract

The COVID-19 continues to take its toll on human life. Even though to a less threatening extent, and insignificant to some, noise turns out to be one of its consequences without consensus. While individuals experience multiple restrictions and restrain from exuberant activities by spending most of their time at home, reducing public transportation and personal vehicles, overall, they end up reduce anthropogenic noise pressure. On another level, people continue reporting noise concerns at various degrees during the COVID-19 pandemic. To draw a bigger picture as to whether or not these complaints have increased during the COVID-19 compared to the same period last year, this research examines them in five major American cities: New York, Chicago, San Francisco, Phoenix, and Dallas. Furthermore, the study also assessed the complaint patterns, whether reported in compact or sprawled areas. The findings highlight that either the noise complaints increased or decreased during the COVID-19 crisis. Accordingly, four of the five selected cities, except San Francisco, showed a decrease in reported noise. As it turns out, compact developments correlate significantly and positively with noise complaints in all study areas, except in Phoenix. These findings call for regulating and prioritizing noise-related policies. Planners and urban designers can thus advise to sustain environmental planning and public health issues, especially in planning compact developments.

Keywords Noise complaint · The COVID-19 · Compactness · Sprawl · 311 data

Introduction

Reported in Wuhan, China, in December 2019, the first coronavirus (COVID-19) case shortly thereafter spread to the rest of the world. These extraordinary conditions continue affecting people's lives, ranging from public health and working environments to transportation and the built environment. While different countries have devised various coping mechanisms to deal with the COVID-19 consequences, this research focuses on the US reactions since its first breakout in January 2020.

The USA adopted different policies since the COVID-19 breakout including international travel bans and school closures, institutionalizing hybrid working and studying schedules, enforcing limited hours of operations in firms and enterprises, regulating social gatherings, or even complete lockdowns and limited use of public and private transportations. These actions have put into effect "new normal" lifestyles for people with "not that new" consequences, including physical mobility limitations, access to healthy food and health concerns, excessive mental exhaustion, commuting with public transportation, discontinuing school and related educational activities, unemployment, and spending excessive time at home during the pandemic (Tong et al. 2021; Yildirim and Arefi 2021). Reduced human pressure has in turn lifted some burden off of nature—especially on air quality and noise. Air quality has been assessed in various regions and reported a decline in PM, NO, and other emissions during the COVID-19 (Berman and Ebisu 2020; Han et al. 2021).

As regards noise, two types of studies seem important: while noise levels have reduced notably world-wide, the fact that self-reported COVID-19 shows increase or decrease in

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noise complaints remains somewhat unexpected. Technical and purely physical environmental characteristics cause the difference between noise levels and noise reports, where noise levels may not rely on individual' experiences and perceptions within their acoustic milieus. Particularly with the "new normal" regulations still lingering, people in many places continue working from home and stay at home for longer hours, or for recreational, educational, and socializing purposes. Obviously, by doing so, they end up drive and use public transportation less, and construct fewer new buildings, etc., during the COVID-19 period.

This study explores the interface between noise complaints (due to spending longer hours at home) and the COVID-19 pandemic in the built environment. To do this, it addresses three key research questions: Compared to the pre-COVID period, have the noise complaints increased or decreased during the COVID-19 period? Related to this question, can we detect specific directions about the nature of these complaints in this period? By the same token, do these complaints occur in compact or sprawled urban areas? To address these questions comprehensively, the study conducts various analyses in five major representative American cities: New York, Chicago, Phoenix, Dallas, and San Francisco.

Overview of the literature

COVID and noise

Like its other environmental aspects, researchers have explored noise during the COVID-19 breakout. These studies distinguish two categories: noise level measurements and individual reports. As it turns out, noise level measurement studies with more diverse coverage in different locations outweigh the latter reports. In a fairly early study, Sakagami (2020) examined whether noise levels differ before and during the state of emergency periods in Japan, where authors emphasized a 1–2 dB(A) reduction in noise levels during the COVID-19 emergency period.

Similarly, Aletta et al. (2020) collected noise samples from 11 sites before and during the COVID lockdown and confirmed reduced noise levels approximately 5 dB(A). Measuring noise levels before and after the lockdown in Dublin, Ireland, in the first half of 2020, Basu et al. (2020) also reported quieter times compared to the pre-lockdown period. Rumpler et al. (2020) assessed the noise levels for a year in Stockholm, Sweden, and observed around a 4 dB(A) decrease during the COVID-19 period. Mostafa et al. (2021) conducted a wide-ranging environment-related study by including noise level changes in Egypt and found an almost 75% decrease during the COVID-19 period. Fewer studies, though, have examined the noise level and COVID-19 in North America. Using the Apple Watch and headphones with over 5000 participants in four states (California, Florida, New York, and Texas), Smith et al. (2020), for example, measured whether noise level reduced during COVID-19 or not, and found some 3 dB(A) decrease during the pandemic period.

While individual reports seem relatively rare in the literature, Lee and Jeong (2021) examined the residents' attitudes on noise concerns while at home in London, analyzed the social media data, and conducted a survey in the pre-and during the COVID-19 period. With findings similar to the survey results, they reported that people complained more than twice as much about noise during the lockdown than during the COVID-19 period. Tong et al. (2021) used noise complaints to see the extent to which the built-environment attributes affected them in the exact location and compared before and during the COVID-19 period. Based on the findings, while noise complaints remarkably increased, house-related factors caused more complaints compared to other factors. In the only related study in North America, Yildirim and Arefi (2021) analyzed noise complaints and found an almost 15% reduction in those complaints during the COVID-19 period compared to the same period a year before. The study also claimed that after a 5-mile distance, noise complaints increased from city centers outwards. Perhaps caused by unique aspects of the complaints and local dynamics; therefore, no consensus exists as to whether noise complaints increase or decrease during the COVID-19 period.

Pathways to noise complaints and micro-level attentions

Several attributes seem relevant to noise complaints. In a pioneering study, Duncan et al. (2017) included sociodemographic attributes to observe possible low-income neighborhoods' exposure to more public health concerns in New York. Tong and Kang (2021) conducted another study on the linkage between noise complaints and sociodemographic features in England and showed that job-related and demographic attributes affected them. Besides sociodemographic origin studies, Liu et al. (2019) assessed several complaints about residential units in Brisbane, Australia, and evaluated noise complaints in four categories: animals, builders, and others. Tong and Kang (2020) examined how building and transportation attributes affected noise complaints in England and found that highly populated and dense building areas report much more complaints. Bartalucci et al. (2021) conducted a survey based on daily life noise during the COVID-19 in Italy. The study included several key questions and comparisons pre- and during the COVID-19 lockdown periods. The study findings indicate that traffic noise perception increased for over 35-year-old inhabitants and overall noise levels increased during the

lockdown. Similarly, Aumond et al. (2022) conducted a survey in Lorient, France, to examine the residents' perception of the acoustic environment before and after the COVID-19. With a total of 318 participants, the findings during the COVID-19 period showed a decrease in the overall noise level particularly adjacent to roads located within the study area. Moreover, the participants' output showed an increase in the natural sounds and a significant decrease in mechanical sounds in the study area. In a rare study in North America, Hong et al. (2020) examined the relationship between noise complaints and building construction in Canada, and demonstrated a direct relationship between noise complaints and increased construction activities. In a recent study, Tong and Kang (2021) examined the association between noise complaints and urban morphology features, e.g., roads, land uses, and buildings in New York, and found an uptick in complaints in denser areas with wider roads. In South America, Maggi et al. (2021) conducted a survey with 1371 participants in Argentina and examined the sound environment against the COVID-19 backdrop, and found that mechanical noise, particularly in larger cities, dominated before the pandemic while natural sounds and tranquility feelings showed an increase during the lockdown.

Other studies have examined the relationship between health and well-being and the COVID-19. Amerio et al. (2020) conducted a study on mental health, well-being, and noise concerns during the COVID-19 period. The survey findings administered on more 8000 participants showed that working from home reduced work performance. Furthermore, designing homes with green space and other amenities is highly effective in tackling mental health issues. Torresin et al. (2022) surveyed 464 people who worked from home in London during the lockdown. The first part of the study noted that working from home has significant impacts on relaxation. The findings also showed that sounds as well as homes' and individuals' characteristics affect soundscape to various degrees, and neighborhood noise affects people's comfort and well-being during the lockdown.

While there are several studies on noise and COVID-19 pandemic, no study has examined the association between noise complaints and compactness in that period. Since the noise complaints during the COVID-19 have not been empirically studied whether noise complaints occur more in compact areas or not during the pandemic, this study aims to address this nexus.

Methods

Study areas

This study initially aimed to include the most populated US cities; however, due to unavailable noise complaint data as service requests in Los Angeles, Houston, Philadelphia, San Antonio, San Diego, etc., this idea did not pan out. Eventually, using heavily-populated cities with noise complaint data availability helped select five cities as case studies: New York, Chicago, Phoenix, Dallas, and San Francisco. These cities also evenly represent different states and regions.

Datasets

The study incorporates two key datasets: noise complaints and compactness scores for five representative cities. As part of the urban service systems, the noise complaint data include various resident requests and complaints, including flooding, traffic and stop signs, and public health and sanitizing concerns. The data consist of all these service requests available up-to-date with details, i.e., types of requests, key dates, and locations. The study filters noise-related complaints from service requests and includes all types of noise complaints classified under different names, labels, and categorizations in each city. This data also identifies the study coverage timeline for comparing before and during the COVID-19 periods. To resolve the standardized approach of the data timeline, the collected data starts from March 2020 dating the official announcement of the COVID-19 Act restrictions to the end of 2020 that represented "during the COVID-19 period," and the same period a year before, labeled as "before the COVID-19." Eventually, the data included two categories of noise complaints collected for each study area in two consecutive years. The noise complaint data was also standardized for geographical area census tract. Based on this standardization, the number of noise complaints was divided into the population for each census tract.

Compactness refers to a special development configuration with spatial alignment, efficient land-use mix, preferably high density, effective accessibility, and ample public spaces (Ewing and Hamidi 2015). Demonstrating a locational compactness pattern helped create a scoring system on four key attributes. The National Institutes of Health (NIH) provided the compactness score—which consists of development density, mixed-use, mix of population and employment centers, and street network, and a total of twenty-one variables, at various geographical scales and the data are publicly available (ibid.). To elaborate on the calculation method, density development shows the combined value of the percent of the individuals residing within suburban, moderate, or dense areas, including land, and employment density. Mixed-land use represents the combined value of the jobs of total inhabitants and available job mix along with walk scores (Ewing and Hamidi 2014a, b). The population and employment mix includes the inhabitants and businesses located in close proximity based on population and employment magnitudes in various block groups. Finally, the street network factor combines street length, mean block areas,

the number of intersections, and intersections of four-way or more (Ewing and Hamidi 2014a, b).

The statistical significance of the compactness index measures the subordinate components of these factors: population and employment density, job to population ratio, the magnitude of job mix, walk score, the ratio of small blocks, mean block area, the density of intersections, and ratio of four-way or more intersections before equally weighted and transformed to an average score of 100 (Ewing and Hamidi 2014a, b). While a compact location refers to a score over 100, a sprawled one obtains a score below 100. Noise complaint data typically determine the timeline coverage of the study, whereas the geographic scale characterizes the compactness score available at the county or census tract levels. Since our study adopted a comprehensive outlook, the smallest scale (the census tract level) was selected for the unit of analysis.

Statistical analysis

The statistical analyses of the study area along with incorporating the compactness score reflected the number of noise complaints in each city and at the census tract level. Before discussing this association, the noise complaint data for each city helped compare before and during the COVID-19 trends and whether they showed change. A *t*-test analysis for the noise complaints of each city seemed warranted. The same analysis followed by the compactness score compared the census tracts where complaints were collected. The study also aimed to compare whether noise complaints emerged in compact or sprawled areas during the COVID-19 period.

The correlation analysis measures the associations between noise complaints and compactness scores and relies on the features of those variables. The Pearson correlation mainly performs two continuous variables. The distribution of the data determines the correlation type and Spearman's rho and Kendall's tau help understand the correlations between the noise complaints and compactness scores by meeting sample size (Bonett and Wright 2000).

Several noise studies, i.e., Salomons and Berghauser Pont (2012) on facade noise and transportation as well as Hao and Kang (2014) on urban form configurations and aircraft noise, have used correlation analysis. Thus, in this study, several significant moderate-level correlations exist between compactness scores and noise complaints. Furthermore, since the study only examines this relationship and not the inter-relational circumstances, further analyses fall outside the scope of the study.

To correlate noise complaints and the compactness score, the variables not normally distributed after running Shapiro-Wilk Test, Spearman's rho and Kendall's tau correlations tests help obtain that goal. The SPSS software Version 26 operationalized all these procedural estimates. Furthermore, the data were normalized based on a two-way normalization process (Templeton 2011) to perform further analyses, i.e., *t*-test.

Results

The trends of noise complaints within cities

Figure 1 represents the noise complaints in each city by comparing before and during the COVID-19 periods. Based on data analysis, New York showcased approximately one million noise complaints, 597,825 of which were reported in 2019 and 347,679 during the COVID-19 period. The reported noise complaints reflected 4320 census tracts in 2019 and only 2166 during the COVID-19 period. Therefore, comparing the noise complaints mean within the census tracts, 145.9 complaints belong in and 160.5 during the COVID-19 period in 2019, showing a considerable overall reduction of about 55% during the COVID-19 period, while the mean values in census tracts

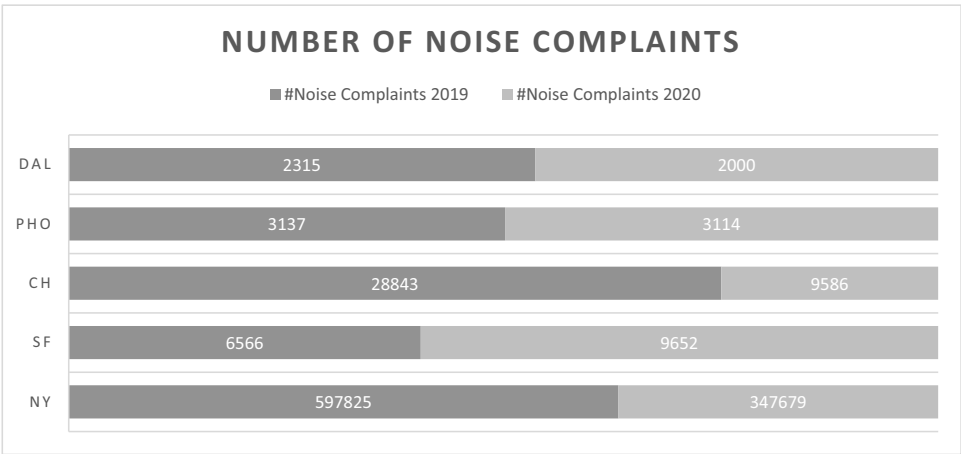

Fig. 1 Number of noise complaints about each city for before and during the COVID-19 periods

increased most 10%. Performing a *t*-test shows statistical significance between before and during the COVID-19 noise complaints ($t(4449.568) = -3.028$, $p = 0.002$).

Observing almost one million noise complaints in New York with a dramatic reduction in the total number of noise complaints shows a similar trend in other cities too. Chicago reported 28,883 noise complaints before the COVID-19 in 215 locations and 9586 during the COVID-19 period in 199 census tracts, respectively, though the *t*-test shows no statistical difference between the two periods (t (452.338) = .918, $p = 0.359$). The mean values of noise complaints also show a similar trend in the actual number of noise complaints with 134.1 and 48.2, respectively. This roughly shows a 65% reduction for both the number of noise complaints and mean values.

The "Golden Gate" city revealed a different pattern in observing more noise complaints during the COVID-19 period. While people filed 6566 noise complaints before the COVID-19 period, they reported 9652 cases during the COVID-19 period within slightly similar 194 and 197 census tracts, respectively. The *t*-test also confirms a statistical difference between before and during the COVID-19 noise complaints (t (389) = 4.829, $p = 0.000$). The mean values of noise complaints also remain along the same lines by 33.8 before and 48.9 during the COVID-19 period, and approximately shows 45% increase in both complaint numbers and mean values within the census tracts during the COVID-19 period.

Phoenix is perhaps the most balanced city in terms of noise complaint patterns moving from San Francisco to the south. The city received 3137 and 3114 noise complaints before and during the COVID-19 within the same 397 census tracts. Representing no statistical difference between before and during COVID-19 noise complaints ($t(794) = .214$, $p = 0.830$), the *t*-test also confirms this similarity. The mean values of noise complaints before the COVID-19 breakout seem slightly higher than during that period at 7.90 and 7.84, respectively.

Dallas represents the fewest noise complaints among the case studies though it shows a prolonged pattern by including more noise complaints before the COVID-19 period. While people reported 2315 complaints before the COVID-19 period, a 15% drop of around 2000 cases were reported during the COVID-19 period from 278 and 261 census tracts, respectively. Furthermore, computing a *t*-test shows no statistical significance between before and during COVID-19 noise complaints ($t(536) = -.536$, $p = 0.592$). The mean value of noise complaints within census tracts also shows an increase, though a lower percentage of 8%, by comparing before and during the COVID-19 period.

Spatial distribution of noise complaints in different cities

Aside from using statistical assessments in other sections, i.e., *t*-tests and correlation analysis, the study highlighted the noise complaints trends by a spatial overlook. To do this, using the ArcGIS tool 10.7.1, several maps came in handy, with the essential goal of illustrating both before and during the COVID-19 trends in each city by also including the quantified number of noise complaints with black/white and spatial patterns with colorful illustrations.

Observing the noise complaints in New York, the Staten Island, Brooklyn, and Manhattan boroughs significantly experienced fewer noise reports while Bronx and Queens show fewer variations compared to before the COVID-19 period (Fig. 2). The Staten Island (left circles in the Fig. 2) noticeably had fewer complaints particularly on the south and west directions. Noise complaints also reduced in Brooklyn greatly, while this trend was slightly lower for Manhattan (right circles in the Fig. 2). It also seems that the outskirt of Bronx and Queens boroughs included slightly more noise complaints during the COVID-19 period.

Noise complaint trends in Chicago reveal a different pattern with two observations. One spatial pattern shows that while noise complaints occurred fairly evenly within the city before the COVID-19 period, they concentrated in the center and the northern part of the city during the COVID-19 period (dark tones of circles in Fig. 3). Based on the other observation, as one of the busiest airports in the world, the Chicago O'Hare Airport census tract records the highest noise complaints both before and during the COVID-19. However, since the flights stopped world-wide (almost 67% only in this area), that census tract shows a dramatic decrease on noise complaints during the COVID-19 period too even though this census tract still included the highest noise complaints in the city (Fig. 3).

San Francisco represents the polar opposite of Chicago, where noise complaints move out of the CBD (Central Business District). While the city center and northbound experienced higher noise complaints before the COVID-19, they spread out and moved towards the south and west by intensifying in the CBD during the COVID-19 (darker tones of circles in Fig. 4). Looking quantitatively, south and west census tracts had more than four times noise complaints during the COVID-19 period compared to before period (darker circles in Fig. 4).

Phoenix includes evenly distributed noise complaints—perhaps one of the interesting one—around the city by intensifying, particularly in north and south directions (Fig. 5).

The last case study, Dallas, illustrates a pattern similar to Chicago where noise complaints intensified around the city center and northern direction before the COVID-19 period as darker tones represented in Fig. 6 and moved away

Fig. 2 Spatial examination of noise complaints in New York

from the city center (particularly towards south) during the COVID-19 period with overall reduction trends in the city.

The trends of noise complaints in relation to compactness

The compactness score, whether the complaints concentrated in compact or dispersed in sprawled areas, shows mixed findings (Fig. 7). New York shows a slight increase in those complaints with the census tracts associated with them, while the mean compactness score of 147.21 before the COVID-19 shows an increase of 147.37. Similarly, the mean compactness score of 134.90 for the Chicago noise complaints during the pre-COVID-19 period for the census tracts and their increase to 137.67 during the COVID-19 period shows stark change in observations. The last pattern showed an increase in compactness score during the COVID-19 period in Dallas, where the mean compactness scores of 108.14 and 108.91 represented the before and during the COVID-19 values, respectively.

However, the compactness score decreased during the COVID-19 period for the other two cities. In other words, the noise complaints were reported more in sprawled census tracts in San Francisco and Phoenix. The compactness score of 144.34 before the COVID-19 period dropped to 143.85 during the COVID-19 period. In the same vein, compactness scores for before COVID-19 and during COVID-19 periods were 98.86 and 98.77, respectively.

The number of noise complaints and compactness: Are they correlated?

Table 1 illustrates the relationship between noise complaints and compactness score as the key study objective. To do this, both Spearman's rho and Kendall's tau correlations were performed and showed similar results. Noise complaints in New York show a positive relationship (though it is weak) to the compactness score both before and during the COVID-19 period, though that relationship slightly dropped during the COVID-19 breakout by obtaining .347 and .339 scores, respectively. This is in a similar line with some other studies that examined the urban density, disparities, and noise complaints in New York (Ramphal et al. 2022; Schiff 2021; Tong and Kang 2021a; Tong and Kang 2021b). San Francisco and Dallas showed similar patterns. While the former presents the strongest association with the compactness scores (.485

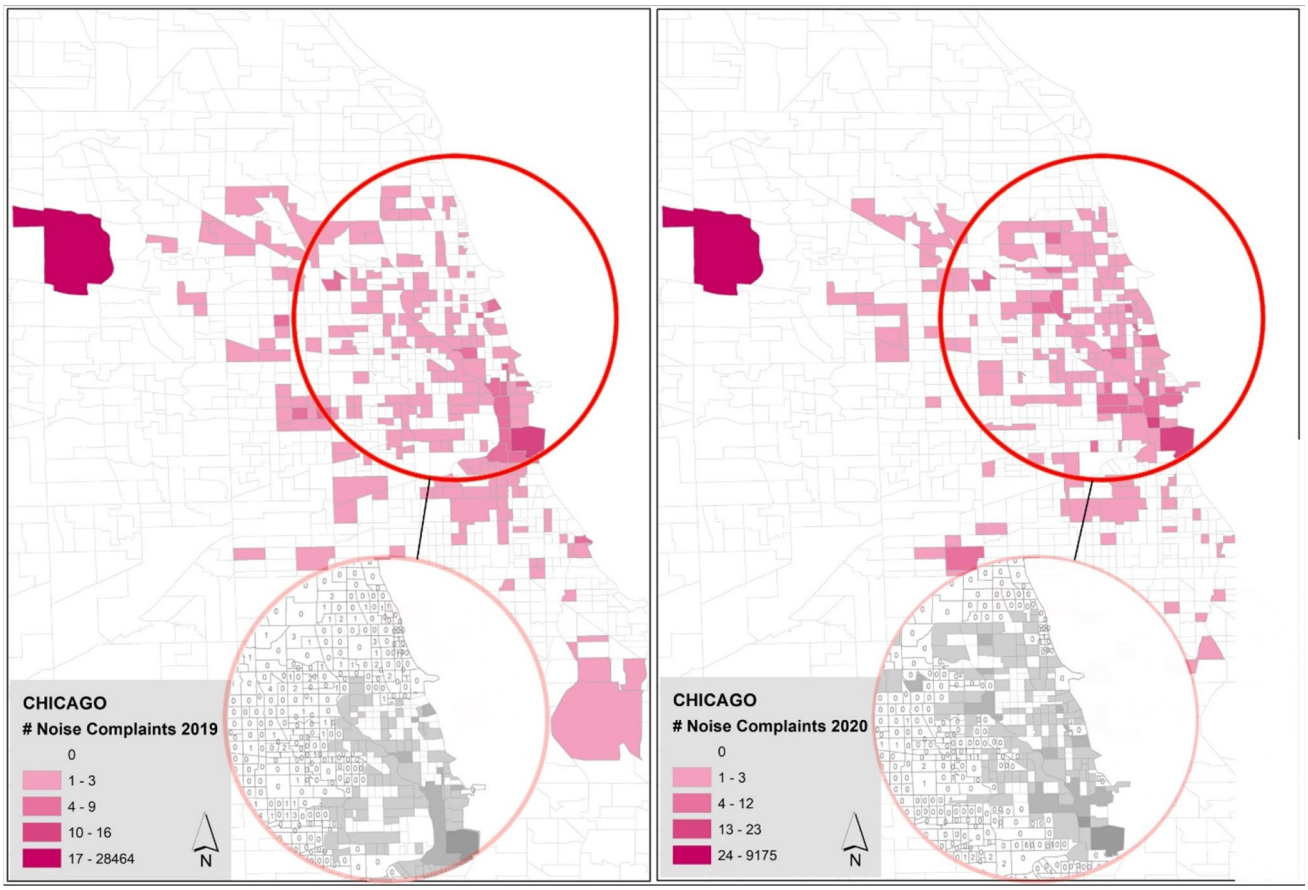

Fig. 3 Spatial examination of noise complaints in Chicago

and .357) both before and during the COVID-19 period, noise complaints in the latter relate significantly to compactness score coefficients of .240 and .191, respectively. Chicago, however, detects a different pattern, though positively and significantly related, where it scores .328 before the COVID-19 period but up ticking during the COVID-19 with the value of .347. On the other hand, noise complaints in Phoenix represent a negative relation with the compactness score, though not significant. As such, except for Phoenix, noise complaints across the selected cities correlate to compactness scores. In other words, noise complaint reports increase as the compactness score increases. However, the associations slightly go down during the COVID-19 period by consistently reflecting the majority of the five study areas.

Discussion

Exploring the spatial logic of noise complaints in the city against the broader backdrop of the COVID-19 pandemic, this study incorporated more than one million samples across different American cities. Since noise-related studies create technical challenges with their feasibility concerns, noise complaint datasets eliminate them to some extent and grant more regional and comprehensive approaches due to their big data nature directly reported by residents—in this case, city service request departments.

With four out of five cities in this study, overall, noise complaints decreased during the COVID-19. Yildirim and Arefi (2021) reported similar findings, although with a notably smaller scope. Perhaps, even though the COVID-19 pandemic continues threatening public health, it has raised global awareness at the same time. That is, along with catching up with daily chores, including childcare, home repairs, employment (home-based or not), access to vaccines, and medication have become high priorities for all humans. A decrease in aviation noise complaints due to rescheduling or flight cancellations seems to be an exception to these observations mentioned above as also verified by other studies (Arenas 2020). Beyond these, noise complaints in San Francisco have shown totally different trends, with an almost 50% increase during the COVID-19 period. This is consistent with other studies across the Atlantic Ocean in Madrid, Dublin, and Greater London (Asensio et al. 2020; Basu et al. 2020; Tong et al. 2021).

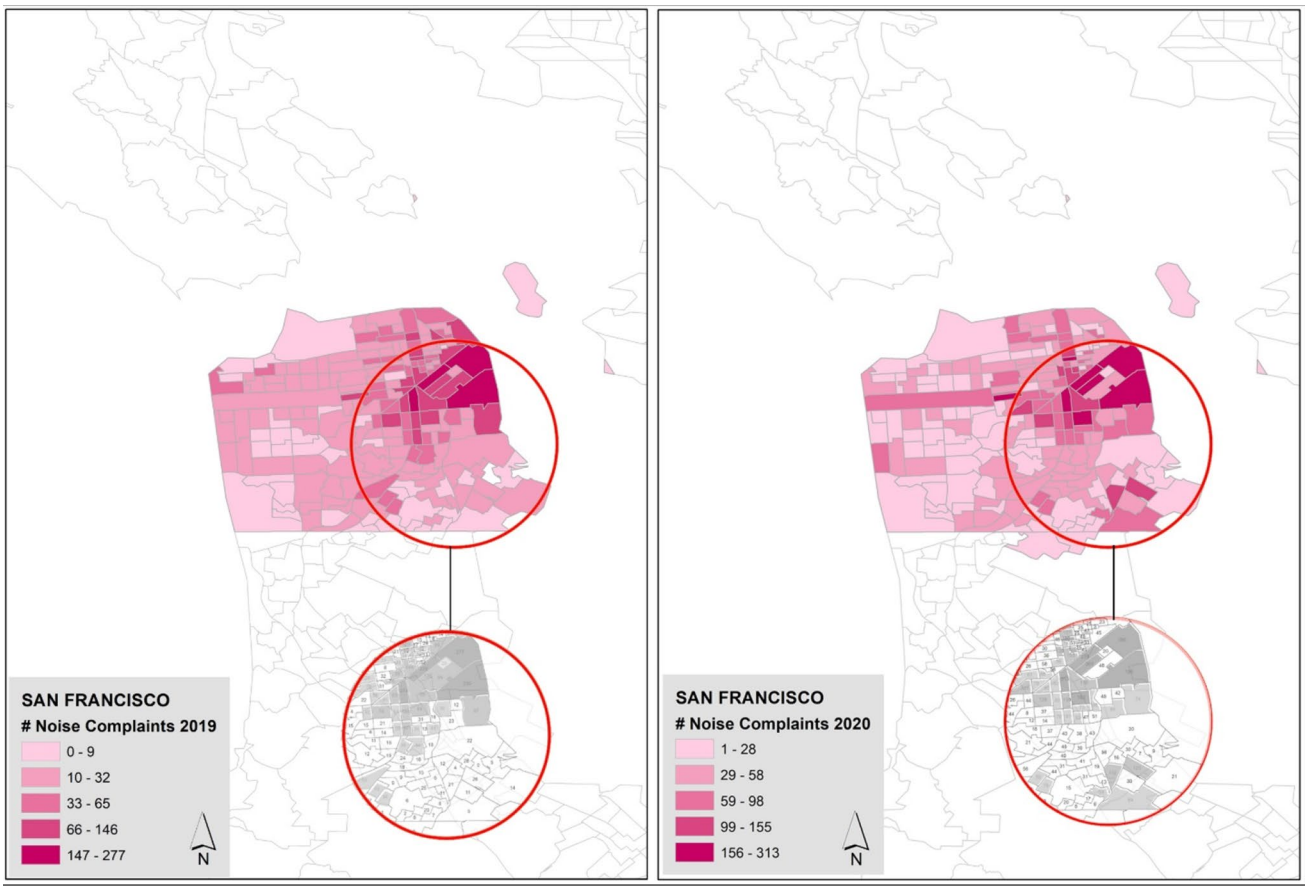

Fig. 4 Spatial examination of noise complaints in San Francisco

As a critical feature of this study, adding the compactness aspect to studies surrounding noise complaints has significantly changed the odds. Therefore, various studies acknowledge the social and environmental benefits of compactness (Ewing and Cervero 2010; Ewing et al. 2016; Ewing and Hamidi 2017; Glaster and Cutsinger 2007). As such, this study contributes to the literature by confirming the positive and significant relationship between noise complaints and spatial compactness. While compactness brings prosperity to cities, noise remains a critical environmental drawback, which needs attention for more remarkable features of compact developments. At this point, noise-related policies in compact developments might have local implications where locations tend to produce noisy environments pre- and during the COVID-19 period.

Since compact developments include dense and high-rise buildings, business centers, and service activities, along with transportation features, i.e., roads and vehicle within various widths and lengths of streets, such areas tend to include a noisy environment (Beenackers et al. 2018; Bibri et al. 2020; De Roo 2000; Kyvelou et al. 2021). This affects the residents' psychological well-being and environmental quality. Considering the main motto of compact developments as enhancing social and psychological well-being, noise-related policies are imperative to take into account in these dense developments.

Density inevitably increases noise complaints. Our study also confirms this trend even though before the COVID-19 period shows a slightly higher association compared to during the pandemic period. Thus, both compact and sprawled locations should incorporate noise within pandemic-related solutions and the planning policy idea is twofold in regard to this study. While one specifically focuses on planners, the other one addresses compact and sprawled areas—aka the urban form.

From the planners' perspectives, it might add two categories: First, the pandemic resulted in a snapshot for social and environmental situations to obtain some takeaways (Mouratidis 2021). A promising way of understanding noise concerns by monitoring, collecting data and information, and applying novel implementations and policies, planners could potentially help to better prepare for extreme circumstances, i.e., the COVID-19 (Basu et al. 2020). Such data and framework also enhances the capacity and resilience of future pandemics and extreme conditions. Second, planners should operationalize indoor- and outdoor-related noise solutions

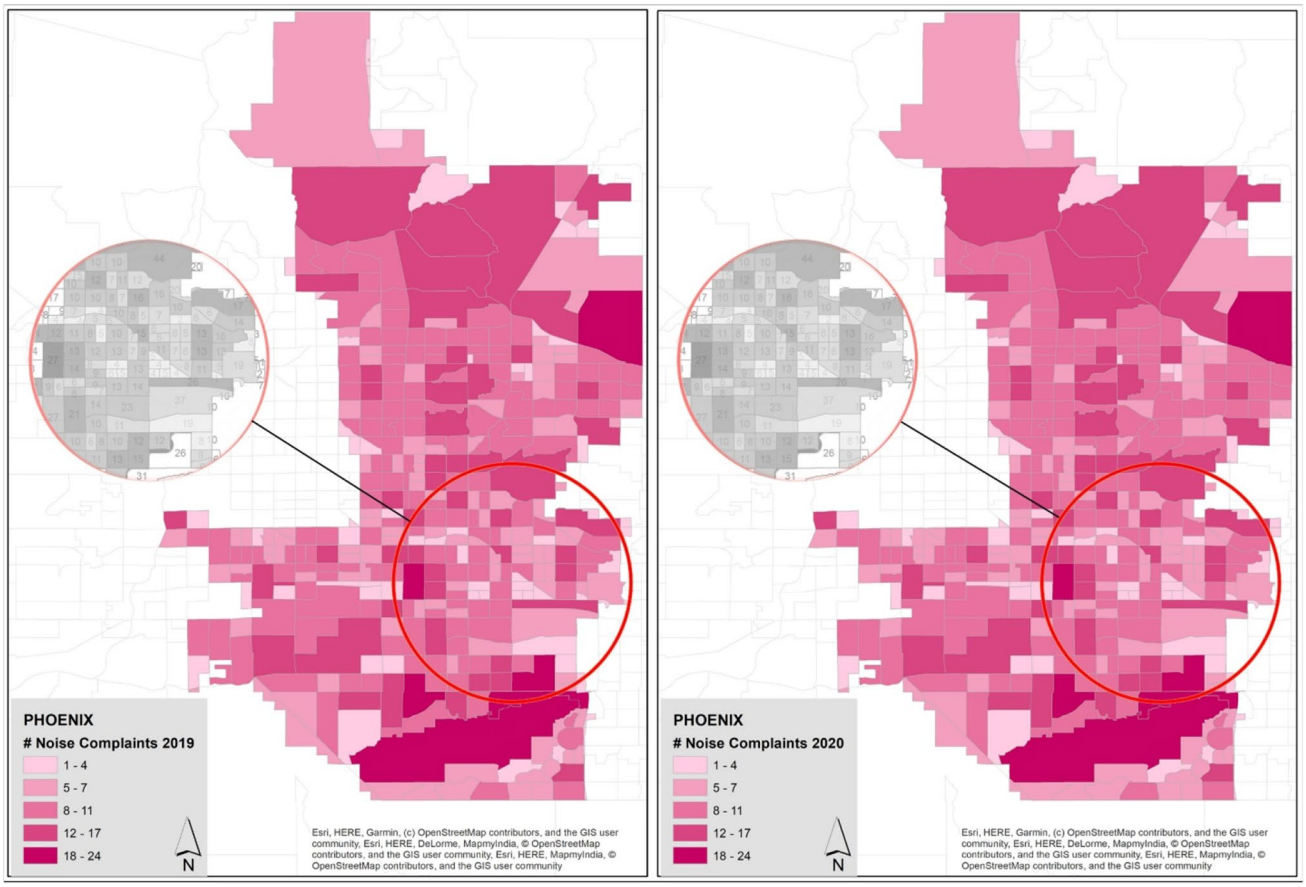

Fig. 5 Spatial examination of noise complaints in Phoenix

by adapting the severe aspects of the extreme circumstances (Basu et al. 2020), i.e., the pandemic as tailoring actions has a key role in reducing the negative consequences on individuals' quality of life. Since individuals use indoor environments frequently during the pandemic due to lockdowns, appropriate acoustic solutions seem imperative to consider at both policy and practice levels. For outdoor solutions, people cannot use public spaces during the pandemic due to restrictions, etc. Hence, planners should consider restorative ambiances for a range of tranquility, silent, and more natural soundscape sources by planning and designing novel solutions. Social and environmental management prompts a key reminder on indoor and outdoor sound solution for harmonizing a balance between these features based on compact vs. sprawled urban forms.

From an urban form aspect, while compact areas promote social, economic, and environmental integration, they also result in more noise and cause more complaints that continue before and during the pandemic (Ramphal et al. 2022). During the pandemic, people move out of the urban areas, particularly with the remote working job opportunities (Althoff et al. 2022). This situation triggers various dynamics including housing and land prices (Althoff et al. 2022). However, as a takeaway for working remote during the pandemic has now become a new trend in post-pandemic era and companies as well as individuals consider adjusting their lifestyles accordingly (Carozzi et al. 2020). This might sound like the pandemic forces people to move out of the city. As both short- and long-term effects, noise will penetrate urban fringes in terms of density and activity, i.e., entertainment, transportation, shopping, or personal amenities, would cause more indoor or outdoor-related noise. On the one hand, new noise policies for potentially new areas seem imperative. Such policies might address various noise-related issues, i.e., quiet zones in compact developments (Ihlebæk et al. 2021) or cause service and disservice, i.e., housing, air quality, public health, and transportation as well as socio-demographic aspects that mitigate the adverse impacts of new trends as holistic approaches (Barak et al. 2021; Sun et al. 2022). On the other hand, while there have been several types of urban forms over previous decades based on changing trends and needs such as industry and sustainability in the case of garden city, new urbanism, and transit-oriented developments, the COVID-19 pandemic urges considerations for the areas of public health,

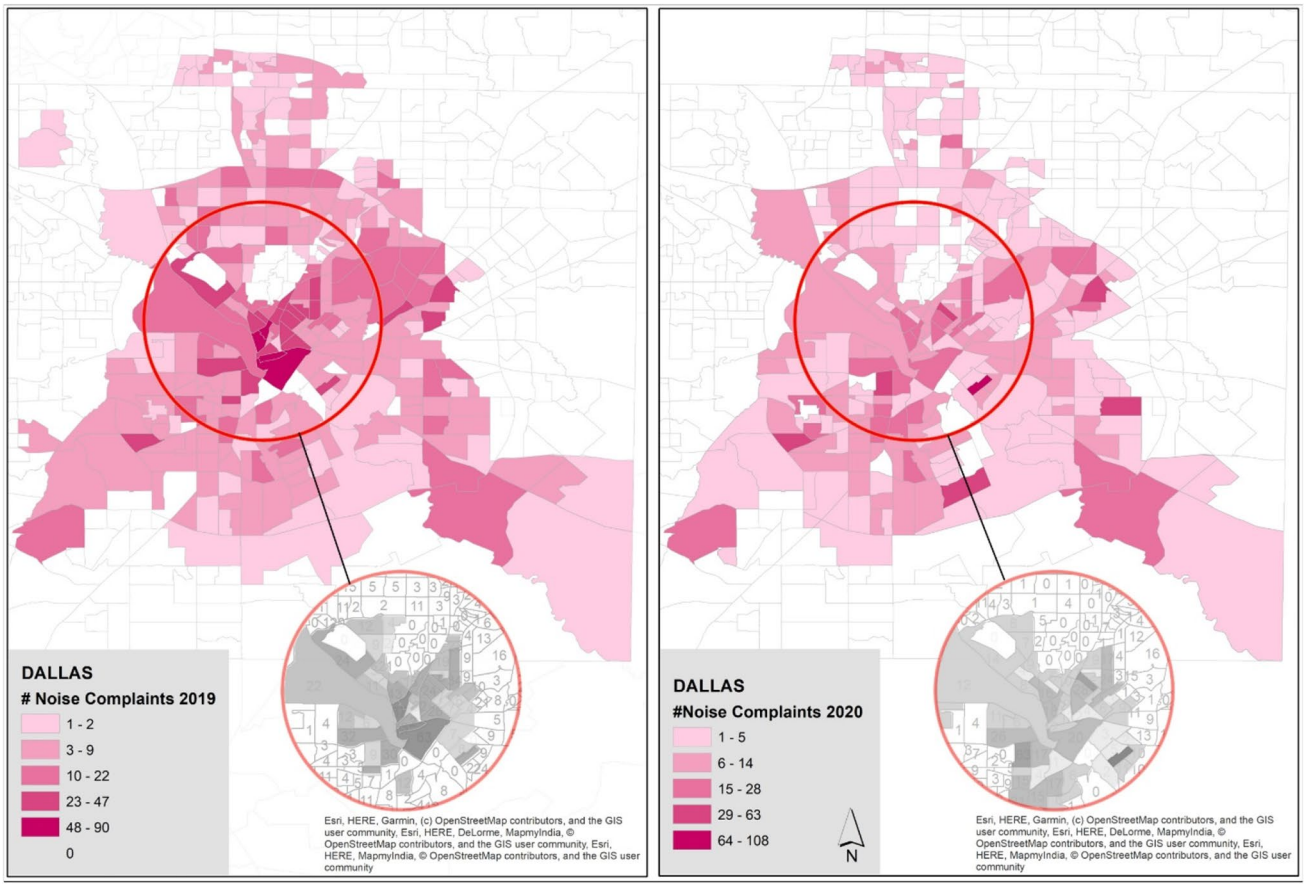

Fig. 6 Spatial examination of noise complaints in Dallas

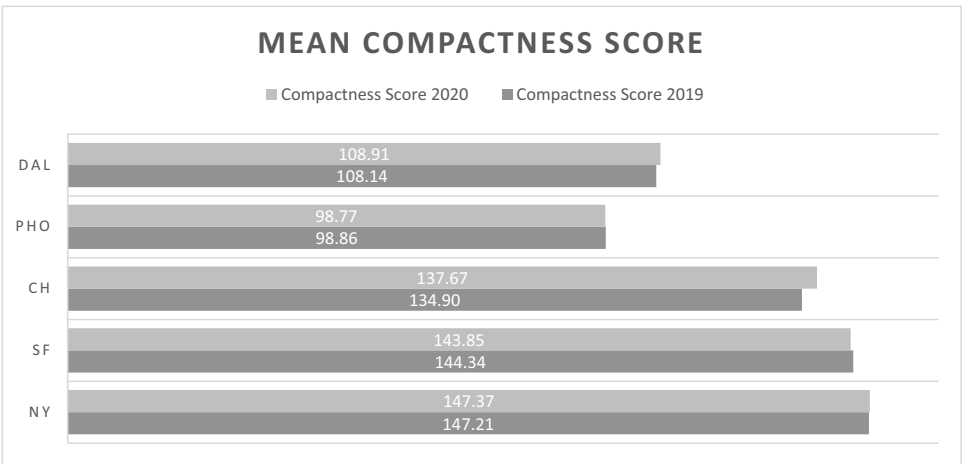

Fig. 7 Mean values of compactness index within census tracts of noise complaints

hygiene, and environment. So, noise solutions should be incorporated within these emerging urban form concepts regardless of the scale and density criteria associated with them. Eventually, large- or small-scale communities should adapt noise solutions to cope with the "pandemic-related urban forms." Thus, this study mainly aimed to inform urban planners, environmental planners, and city officials to reformulate potential new urban forms as well as crafting policies addressing the pandemic consequences surrounding noise. Noise is inevitable in any and all circumstances even before or after the pandemic; however, it might be preventable or manageable with the incorporated resolutions.

Table 1 Spearman's rho and Kendall's tau correlation coefficients between the number of noise complaints and compactness index

City	Noise complaints	Compactness index	Spearman's rho correlation coefficients	Kendall's tau correlation coefficients
New York	Before COVID-19	Index	.347**	.235**
	During COVID-19	Index	.339**	.229**
Chicago	Before COVID-19	Index	.328**	.265**
	During COVID-19	Index	.347**	.281**
San Francisco	Before COVID-19	Index	.485**	.343**
	During COVID-19	Index	.357**	.247**
Phoenix	Before COVID-19	Index	−.033	−.022
	During COVID-19	Index	−.027	−.019
Dallas	Before COVID-19	Index	.240**	.167**
	During COVID-19	Index	.191**	.134**

**Correlation is significant at the 0.01 level

Conclusions

Examining five major cities that represented a broad range across the USA, this study sought to understand the noise complaint patterns initially compared to the same period before the COVID-19 period and also exploring the nexus between noise complaints and compactness.

Recapping the research questions of the study, noise complaints tend to decrease during the COVID-19 period in the USA up to 55%, except for San Francisco, which included an almost 47% increase in noise complaints in the same period. This shows no one-size-fits-all pattern on the current noise complaint trends. The spatial examination also demonstrated a different aspect of these complaints about different study areas following different patterns before and during the COVID-19 periods.

Finally, whether noise complaints occur in sprawl or compact areas, the nexus between noise complaints and compactness reveals a more robust confirmation with a positive and significant statistical relationship, except for Phoenix that already experiences urban sprawl concerns.

This study also reports certain limitations, including the lack of in situ or empirical noise samplings, relying on the cities' service requests data. Similarly, the compactness score belongs to the National Institutes of Health and the smallest available geographic unit observed at census tract levels. Further studies may "zoom in" on such efforts. The study also did not include the built environment factors even though the compactness index consists of several sub-level sociodemographic, land use, and economic attributes. Perhaps, including more residents and indoor-related factors better help explain such understandings. Another limitation excludes the socio-demographic attributes of noise complaint services users as most study locations did not provide such data. The 311 service request data might be related to socio-demographic and socioeconomic characteristics of individuals. For instance, some studies show minorities being more reluctant to use the 311 service due to language or cultural reasons (Yildirim and Arefi 2021b). Similarly, older individuals report less complaints compared to other age groups (Cesaroni et al. 2010). Low-income populations tend to use lesser or only certain, i.e., infrastructure concerns including the 311 services (Kontokosta and Hong 2021). Some other body of literature shows that individuals with higher education levels use 311 service request more frequently (Kontokosta et al. 2017; Wang et al. 2017). Even though this study is subject to such limitation, it offers a snapshot at the interface between the urban form and noise complaints. So, further studies may include these variables to understand the effects of this association in depth. These efforts may also explore the impacts between different stakeholders, including the residents and local authorities in regard to noise-related policies.

Nonetheless, the study not only attempted to bring forward the noise and compactness nexus for the first time, but also specified this association for the global pandemic agenda. Doing this calls into attention whether noise hovers more in compact areas or penetrates through sprawled developments. By alerting policymakers and local city officials as well as touching base with urban planners, public health experts, and environmental planners, comprehensive noise-related policies, regulations, and guidelines can help create more resilient urban environments.

Author contribution Y. Yildirim: methodology, data, analysis, and writing. M. Arefi: writing, editing, supervising

Data availability The data is open to public in the city data portal.

Declarations

Ethical approval This study did not conduct any experiment subject to human or animal.

Consent to participate This study did not conduct any experiment subject to human or animal.

Consent for publication This study did not conduct any experiment subject to human or animal.

Competing interests The authors declare no competing interests.

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