

Review Article

## Spatial correlation between environmental noise and air pollution

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### ARTICLE INFO

Received: 1 July 2020 | Accepted: 15 August 2020 | Published Online: 30 September 2020

EOI: 10.11208/essence.20.11.SP2.133

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### ABSTRACT

The review paper is on basis of an exploratory research focused towards understanding the scenario of Noise and Air pollution in the Urban Indian context. Over the past few years it has come to light that a few ailments such as respiratory and cardiovascular diseases which were majorly attributed to air pollution until recently, are also influenced by noise pollution and as such begs the question as to what actually is the impact of the same. This further leads to the root of the problem in urban environment where the traffic is a major source of both, Noise and Air pollution and as such raises the query whether there is any correlation between the two in the urban context.

### KEYWORDS

Environmental Pollution | Noise pollution | Air pollution | Spatial Correlation

### CITATION

Dubey, A.; Patel, R. L. and Brahmabhatt, J. (2020): Spatial correlation between environmental noise and air pollution: A review. ESSENCE Int. J. Env. Rehab. Conserv. XI (SP2): 107 — 113.

<https://eoi.citefactor.org/10.11208/essence.20.11.SP2.133>

## Introduction

It has been established through many studies that noise pollution has verifiable association with non-auditory health impacts such as cardiovascular impairments, as well as respiratory diseases such as bronchitis and bronchial asthma. Further to this, it is also important to note that air pollutants, or air pollution, especially that stemming from traffic has been conclusively tied to a degradation of cardiovascular and respiratory health, during which process the effects of noise have hardly ever been taken into account. In light of this, it is only logical to attempt to explore, if there is any confounding and/or synergistic relationship between noise and air pollution, as traffic is a major source for both (Kheirbek *et al.*, 2014).

Studies in the above mentioned direction though commonly undertaken for developed countries are not so common for the developing ones. As the scenarios in developed countries are usually never representative of those in the developing ones, it is advisable to conduct some such research to identify if the conditions are similar or different over such starkly different social and technological environments. The present study, thus aims to develop from the above premise in an attempt to establish the need to explore the current scenario of spatial variation and correlation in environmental noise and air pollution for Ahmedabad.

A study as this can be immensely helpful for laying the foundations to push future epidemiological studies, as well as developing policy based and technical solutions to the problem of environmental

pollution. Studies like these can provide a better perspective towards developing solutions that tackle the combined issue, based on their simultaneous affect. This study is aimed at creating a strong enough case that clearly indicates the need for a spatial correlation study between environment noise and air pollution for Ahmedabad city.

## Why Ahmedabad?

Ahmedabad, located on the banks of River Sabarmati between 7228'E – 7242'E and 2258'N – 2310'N, in the northern hemisphere is a city that registered a population of just over 6 million during the 2011 census of India, within its Urban Development Authority limits, which is currently expected to be somewhere around 7.5million. Furthermore, it is the economic capital of the state of Gujarat which is one of the states with the largest economies out of the 29 states of India. Ahmedabad, from an urban development perspective is currently in the transition from a Tier - I city to a metro city. This is a phase usually marked with a drastic augmentation to public transportation, development of various service based industries, and overall expansion of the city towards including the rural areas surrounding it. This also can be a fruitful time to incorporate new policies for development, to guide further development, or to bring about a change in the overall environment of the city. A transitioning city is also the perfect case study from the perspective that it gives a picture that is relatively more inclusive as compared to a city that clearly belongs to one category and fails to provide any insight regarding the other. Thus, a study for

Ahmedabad can be considered to be representative of both, Tier - I as well as Metro cities.

Furthermore, in 2017, the old city within the old fort walls on the east side of the river Sabarmati was declared the first UNESCO World Heritage Site in Indian owing to its Pol Housings, and this also gives Ahmedabad a strong incentive to create a more aware and pure environment, which can only be achieved by thoroughly understanding the challenges it faces.

To establish the outline of the study, an in-depth review of existing researches on the topic has been undertaken and summarized here.

The reason for undertaking an extensive literature review is to ensure that the work is not a duplication of an existing work. Furthermore, it also helps establish the proper methodology, establish the metric to be monitored, establish a sampling procedure and the extent of sampling among other parameters. The literature reviewed has been bifurcated as critical and secondary literature review. The critical review is of studies that are directly along the same lines as this study aspires to, whereas the secondary review explores the importance of the exploration of noise as a pollutant in the urban context.

### **Critical Literature Review**

To summarize for this article, the outcomes of various studies have been documented so as to establish whether or not there is any foundation to the base idea of any relationship between noise and air pollution in urban environment.

Weber and Litschke, 2008, in their study of the Essen urban environment, Germany, observed that noise was homogeneously distributed spatially, whereas the concentration of particulate matter in air did not seem to confirm to the same, and was rather inhomogeneous. Spatially, noise and coarse particulate matter did not seem to have any correlation, whereas the correlation between noise and  $PM_{10}$  was positively moderate during weak turbulent atmospheric mixing. However, they believed that the correlation between noise and ultrafine particles, smaller than 100nm, of air pollution could be more evident.

Davies *et al.*, 2009, observed that both air and noise pollution associated with motor vehicle traffic have been associated with cardiovascular diseases. The similarities in the sources of the pollution and the health outcomes means that there is significant potential for noise to confound studies of air pollution or vice versa when focused on cardiovascular diseases or other, or even more complex interactions to take place. In their study they found mildly positive correlation between  $L_{eq5mins}$ , and  $NO_2$ , where the Pearson's correlation coefficient was 0.53; and between  $L_{eq5mins}$  and  $NO_x$ , was 0.64. This study having been conducted along highways and major roads, found that the number of lanes on the closest road, the number of cars or trucks during the noise sampling and the presence of a major intersection were major factors influencing the degree of correlation.

Foraster *et al.*, 2011, established that the correlation between  $NO_2$  and noise ( $L_{24h}$ ) was

0.62, however the same differed across the urban environment with lower correlations at sites with higher traffic density and in the modern downtown areas. The variability, as much as 35.6% of NO<sub>2</sub> and 73.2% of noise was explained by building density nearby, traffic density and distance from the location to the sidewalk. This being a model study, the correlation between the residuals of the two models suggested the presence of other unmeasured common variable/s. They also concluded a substantial correlation between traffic related noise and NO<sub>2</sub>, and considering that the correlation is acutely impacted by the local features and characteristics, calls for an in-depth and careful consideration of both the factors to accurately assess their impact on cardiovascular health.

Curran, *et al.*, 2013, concluded from their study that the impacts of traffic induced air pollution and road traffic noise are not confounding, but rather independent of each other as far as their impact on cardiovascular health is concerned. It is important to note that in this study, only the noise originating from the tyre-pavement interaction was considered and other traffic noises such as running engine noise, horn, and other vehicular sounds were not taken into account. Though most of the modern vehicles have significantly muffled engine noises it is rather advisable that in the Indian context the overall vehicular noise be considered as there is no uniformity in the over-all condition of the vehicles lying the roads in any context.

Yang, 2014, concluded that for the study focused on the noise and air pollution

correlation at two major freeways in Los Angeles, a largely positive correlation was found between ultrafine particle (UFP) concentration and noise levels in the downwind direction and upto a distance of 3m from the freeway. Correlation between PM<sub>2.5</sub> concentrations and UFP concentration was found to be positive but no conclusive correlation between PM<sub>2.5</sub> and noise could be established.

Kheirbek *et al.*, 2014, in his study focused on the New York urban area observed that *all* monitoring sites exceed EPA and WHO guidelines for noise levels set to avoid activity interference and annoyance (EPA: L<sub>dn</sub>=55dBA, WHO L<sub>eq.day</sub>=55dBA), while over half of the sites' 1-week L<sub>eq</sub> exceeded EPA noise guidelines for hearing loss. Strong correlations were observed between alternative noise metrics that characterize average noise exposures, but low correlations among average exposure metrics and indices of intermittent noise. Average noise levels were well correlated with combustion-related pollutants, most notable NO, NO<sub>2</sub>, and BC and average noise levels correlated with traffic density in close proximity to monitoring sites. Characterization of the spatial patterns of multiple exposures will be useful in developing risk models for health effects research and ultimately strategies that mitigate exposures to traffic-related chemical and non-chemical stressors.

Fecht *et al.*, 2016, reported that across all London postcodes, they observed overall moderate correlations between modelled noise and air pollution that were stable over time (Spearman's rho range: |0.34-0.55|).

Correlations, however, varied considerably depending on the spatial unit: largest ranges were seen in neighbourhoods and 1km grid squares (both Spearman's rho range: |0.01-0.87|) and was less for boroughs (Spearman's rho range: |0.21-0.78|).

Munzel *et al.*, 2017, also concluded that the effects of air and noise pollution on cardiovascular health are independent and cannot be said to have any confounding relationship. However, the independent nature of both factors also points in the direction where simultaneous air and noise studies from a health point of view should be undertaken more frequently and spread over a large enough time span along with the independent study of noise and with an exposed as well as control population to actually be able to observe and understand the precise effects of noise and air on the health of human beings.

### Secondary Literature Review

These are sources whereby the studies have focused on the impacts of noise and air pollution individually and are a basis for the case as to whether or not a more detailed understanding of noise and air pollution in the urban environment is necessary.

de Kluizenaar, Gansevoort, Miedema, and de Jong, 2007, concluded that exposure to road traffic noise may be associated with hypertension in subjects in the age bracket of 45 to 55 years and that the association seems to be stronger for higher noise levels.

Niemann and Maschke, 2009, concluded that noise induced annoyance and sleep disturbance shows statistically increased risk of many ailments in all groups. This is

important as it is one of the very few epidemiological studies exploring the non-auditory impacts of noise pollution. The increase in risk was observed for most ailments excluding diabetes, malignant tumour, skin disease and stroke.

Gehring *et al.*, 2014, concluded that noise had a measurably negative impact on term birth weight in the target populations in British Columbia, Canada. For joint effects of noise and air pollutants, the effects of noise exposure remained largely unchanged and associations decreased for air pollutants. However, though not conclusive, they expressed the belief that traffic may affect birth weight through exposure to both air and noise pollution.

Tobias *et al.*, 2015, concluded that despite having the same source, noise levels and air pollutants in Madrid have similar and independent effects on health. If avoidable mortality attributable to noise is compared to avoidable PM<sub>2.5</sub>-related mortality, it will be observed that both figures are very similar in the case of cardiovascular cause mortality and that the effect of noise on respiratory mortality was practically double that attributable to PM<sub>2.5</sub>, though these differences did not prove statistically significant.

### Conclusions

As documented above, it is apparent that while many studies find some notable correlation between NO<sub>x</sub> and noise pollution, and in a few cases ultrafine particles and noise, a few also conclude that the two act independently in spite of the common factors. Furthermore, none of the studies that

find any correlation between noise and air pollutants are not conclusive.

Though many studies fail to find any correlation, the core idea that both of these pollutants seem to have some similar health impacts reinforces the need for exploring whether or not they have a confounding relationship on human health or otherwise. Most studies majorly point to a dire need for the understanding of the net effects of noise and air pollution on cardiovascular disease and respiratory diseases among others, to be better equipped for formulating policies that protect against the same.

Lastly, the fact that no such study could be found for the state of Gujarat, or India, and as there is a drastic change in context when compared to the other similar studies documented here and referred to, it is only logical that a study as this would immensely push forth the impetus towards understanding the overall public health impact of noise in the urban context, and provide a foundation to build upon.

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