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EDITORIAL
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Editorial: Cities in Lockdown: Implications of COVID-19 for Air Quality and Urban Environmental Health

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Editorial on the Research Topic

Cities in Lockdown: Implications of COVID-19 for Air Quality and Urban Environmental Health

Viewed through the lens of "controlled interventions," the reduction in traffic emissions associated with lockdowns intended to reduce the transmission of COVID-19 has offered scientists a rare opportunity to establish an evidence base to justify future emissions abatement policies. However, such research is not without its challenges. Comparing reported reductions between studies is complicated by choice of temporal and spatial averaging scales, and measurements are further contextualized by local social, economic, and geographical conditions. Global statistics also hide a huge variability in emissions reduction patterns and differing local meteorological conditions, which can act to enhance or suppress the impact of reduced traffic flows.

As a result of these complications, the regional and local magnitude and even direction of the documented inter- and intra- urban air quality benefits reported from lockdown conditions are varied. For example if we just examine changes in nitrogen dioxide concentrations, Borge et al. report a 60% reduction at all sites studied during the most restrictive lockdown periods in Madrid. However, in Malta, local reductions in ambient NO_2 concentrations of up to 54% were calculated at a roadside site but smaller, and less linear, reductions were observed at urban background sites and from satellite data suggesting a more modest regional reduction (over longer time periods) of just 24% (Fenech et al.). This spatially averaged figure is more closely aligned with the global estimated average reduction of ∼30% (Muhammad et al., 2020; Mishra et al., 2021). However, other studies using surface-based monitors suggest that decreases in NO_2 in rural areas of Europe were on average only of the order of 10% (Menut et al., 2020), while Adélaïde et al. observe large regional variability in calculated reductions in France.

As with all short-term intervention-based research, identifying the alternative 'business as usual scenario' remains a significant challenge. Scientists must detect cause and effect based changes in the system over and above its inherent statistical noise. To do so they must grapple with a vast array of different methods (with differing underlying assumptions, errors and biases), all designed to model the spatial heterogeneity and non-stationarity of the human-atmosphere system, to calculate "what would have been". Here, the importance of using appropriate meteorological data (Fenech et al.) and identifying the short-term influences of meteorological conditions and longer-term trends in air quality on measurements are shown to be necessary to avoid significant over-estimates of impacts (Borge et al.; Hernández-Paniagua et al.).

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Choice of pollutant also matters when quantifying the magnitude of the cause and effect response of reduced pollutant emissions. Some studies note that, due to complex atmospheric chemistry, cities observe an increase in ground-level ozone concentrations during lockdown periods (Borge et al.) (Patel et al., 2020; Sokhi et al., 2021). However, regional European and global scale studies suggest only minor increases in ozone concentration over longer time periods (Menut et al., 2020; Keller et al., 2021). Local increases in $PM_{2.5}$ have also been observed, due perhaps to localized increases in biomass burning for domestic heating, or changes in long range atmospheric transport or emission patterns not directly related to economic activities (such as wildfire smoke, dust or sea salt) (Sokhi et al., 2021).

Such results, however, should not necessarily be interpreted as revealing a simple negative correlation between reduced traffic emissions and ambient concentrations, or the failure of traffic volume reduction to mitigate pollution. Rather they highlight the need to consider multiple sources of pollutants, behavioral responses in the population, persistence of pollutants in the atmosphere and long-range transport processes, complex secondary reactions and the lag between cause and effect when evaluating impacts of short-term, localized interventions or changes in conditions.

Although it is difficult to quantify the health effects and economic costs of air pollution, recent studies have suggested that 4–9 million people die each year due to exposure to outdoor pollution (Vohra et al., 2021; World Health Organization, 2021). The risk to human health resulting from exposure to air pollution also varies significantly around the world (Anenberg et al., 2019) with low income and minority populations typically bearing the brunt of the burden in urban areas (Castillo et al., 2021a). Many cities lack the dense monitoring networks necessary to accurately determine pollution trends, making it challenging to accurately quantify pollution levels and determine the global disease burden (Martin et al., 2019). Given the uncertainties associated with quantifying changes in exposure, it is not surprising that there are even greater uncertainties associated with calculating the health benefits associated with reduced exposure to transport emissions (Adélaïde et al.).

Modeling studies in this Research Topic estimate that 588 deaths in Mexico City (population 21 million) (Hernández-Paniagua et al.) and 3,500 in France (Adélaïde et al.) were averted or delayed due to improved air quality associated with lockdown conditions. However, they also note the complexity of the evaluation process as other behavioral changes, such as time spent indoors exposed to indoor air pollution, may affect the validity of the results (Adélaïde et al.). Elsewhere in this Research Topic we are reminded that the health benefits of improved air quality also include reduced morbidity and mortality of individuals with COVID-19 (Amnuaylojaroen and Parasin).

Whilst quantifying the multi-scale impact of reduced transport emissions on health is clearly a complex process, fraught with errors and limitations, there is little doubt that the evidence supports the notion that reductions in vehicle traffic can improve air quality and human health (albeit in complex, non-linear and unpredictable ways) (Vardoulakis et al., 2018). Such improvements are often immediate, tangible, and if sustained could significantly reduce the burden on our health care systems with the added co-benefit of reducing carbon emissions (Amnuaylojaroen and Parasin).

Exposure to poor air quality is currently recognized as the "single biggest environmental threat to human health" (World Health Organization, 2021, xiv). Targeting urban areas to introduce policies which mitigate both climate change and improve air quality has long been promoted as a cost-effective way to improve urban sustainability (Rosenzweig et al., 2010; Vardoulakis and Kinney, 2019; Castillo et al., 2021b). As we move into the post-lockdown period, we are seeing a rebound in road traffic and energy consumption. However, we could also choose to make changes which prioritize behaviors to reduce the consumption of, and pollution from, fossil fuels with the added further co-benefit of reducing crowdedness and the risk of future infectious disease transmission (Vardoulakis et al., 2020; Mishra et al., 2021).

Overall, there is now sufficient evidence to support the need for reduced traffic emissions in cities, and indeed the benefits of wider action to reduce air pollution globally (World Health Organization, 2021). Although it is important to further strengthen this evidence base, the need for certainty should not delay decisive action to improve air quality in our cities. At the end of 2021 the WHO released more stringent air quality guidelines providing a global pathway to improving air quality in cities (World Health Organization, 2021). Governments around the world chose to act in a timely and decisive manner to mitigate COVID-19. This could serve as an example of the scale of action and urgency required to improve air quality and protect our health.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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