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COVID-19, Ambient Air Pollution, and Environmental Health Inequities in Latin American Cities

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Commentary

SARS-CoV-2 infections continue to grow in Latin America, where 80% of the population lives in urban areas that are also home to some of the largest societal inequities in the world. Some national governments across the region have enacted stay-at-home orders, closing schools, and shutting down much of the economy.

High levels of air pollution in many Latin American cities in the past may have primed many residents for more severe infection and mortality from COVID-19 by contributing to the development of chronic diseases. Many of the chronic diseases associated with long-term, cumulative exposure to air pollution appear to be correlated with a higher vulnerability to severe COVID-19 outcomes, including hospitalization, need for critical care, and death [1, 2]. A recent study in the USA reported that a long-term increase of only 1 μg/m^3 $PM_{2.5}$ was associated with an 8% increase in COVID-19 death rate [3]. In addition to cumulative exposures, it is plausible that short-term air pollution exposures interact with SARS-CoV-2 infection itself [4], possibly via their effects on inflammation-related processes. However, the effect of immediate changes in air pollution on COVID-19-related mortality is yet to be tested.

Even as air pollution may impact COVID-19 outcomes, stay-at-home orders related to COVID-19 have impacted ambient air pollution levels in some Latin American cities [5–7]. We aimed to characterize COVID-19-related reductions in ambient $PM_{2.5}$ in four major cities in Latin America and to estimate the magnitude of reductions in adult mortality if long-term exposure to $PM_{2.5}$ was lower proportional to levels observed during the COVID-19 shutdowns. We compared ambient fine particulate matter ($PM_{2.5}$) concentrations during the first week of COVID-19-related school closures in each city with average concentrations for the same period in 2017–2019, using direct measurements from publicly available government air monitor networks in four major Latin American cities. We averaged hourly data from each monitor into a monitor-specific daily mean and considered monitor-days with < 16 valid hourly means to be missing. Daily means from all monitors within the urban core area were averaged into a citywide daily mean. For each of these four cities, we projected the reduction in all-cause mortality among adults aged ≥ 30 years if annual ambient $PM_{2.5}$ concentrations were lower proportional to current COVID-19-

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related reductions (Table 1). We used a well-validated modeled estimate of annual $PM_{2.5}$ in 2016 [8] as the baseline concentration for each city, to leverage the complete geographic coverage within each city for estimates of city-level exposures. We gathered mortality and population estimates from national governments according to previously described methods [9]. We then applied standard health risk assessment methods from the World Health Organization [10], assuming long-term $PM_{2.5}$ exposure, a log-linear exposure-response relationship, and an excess risk of all-cause mortality per 10 $\mu g/m^3$ increased $PM_{2.5}$ exposure of 6% (95% CI 4%, 8%) [11].

In Lima, weekly mean $PM_{2.5}$ concentrations were 41% lower during the first week of COVID-19-related school closures in 2020 than in the same period during the prior 3 years (17 vs. 29 $\mu g/m^3$) (Fig. 1). Similarly, weekly $PM_{2.5}$ concentrations were 31% lower in São Paulo (9 vs. 13 $\mu g/m^3$) and 21% lower in Santiago (15 vs. 19 $\mu g/m^3$). In Mexico City, the difference between 2020 and 2017–2019 was minimal (5% lower, 21 vs 22 $\mu g/m^3$). We estimate that in a counterfactual scenario of reduced annual $PM_{2.5}$ proportional to COVID-19-related reductions, all-cause mortality among adults aged ≥30 years in Lima would be 7% lower (95% confidence interval [CI] 4% to 9%) with 2522 fewer premature deaths annually (95% CI 1666 to 3304). In São Paulo, these reductions would result in 3% lower all-cause mortality (95% CI 2% to 4%) with 3573 fewer premature deaths per year (95% CI 2341 to 4712). Santiago would experience 3% lower all-cause mortality (95% CI 2% to 4%) with 930 fewer premature deaths annually (95% CI 610 to 1228). In Mexico City, where observed COVID-19-related ambient $PM_{2.5}$ reductions were minimal, all-cause mortality would be 0.6% lower (95% CI 0.4% to 0.8%) with 730 fewer premature deaths per year (95% CI 476 to 966).

Recent reductions in ambient air pollution in Latin American cities are undoubtedly beneficial and may have significant short-term effects on non-COVID-19 mortality, though the impact of stay-at-home orders on mortality is complex. However, long-term cumulative exposure to ambient air pollution remains a substantial contributor to morbidity and mortality in these urban areas. Within cities in Latin America, chronic conditions and mortality are often distributed along inequitable societal lines [9], with the poor bearing the brunt of the disease burden. Similarly, risk of exposure to SARS-CoV-2 may be higher in lower-income populations through higher rates of residential overcrowding and overrepresentation in occupations with high levels of interaction with the public. Air pollution exposures are also frequently socially patterned and may contribute to higher rates of severe and fatal COVID-19 in lower-income populations, both by influencing the prevalence of chronic conditions and by interacting with SARS-CoV-2 infection directly. If these patterns were confirmed, cities with high air pollution may need to prepare for more intense outbreaks of COVID-19 in poorer neighborhoods and areas with worse air pollution.

A silver lining in the COVID-19 pandemic has been the reductions in air pollution that have followed lockdowns. Within Latin America, policies which reduce air pollution have faced resistance due to perceived economic cost, yet in recent months, we have seen how immediate public health threats can take a firm priority over national economies in ways that seemed impossible just a year ago. Reductions in air pollution during COVID-19 lockdowns are the indirect results of policies not intended to reduce air pollution, and targeted pollution mitigation policies could reduce ambient air pollution at a fraction of the economic cost.

The current reductions in air pollution during COVID-19 lockdown in Latin American cities are

Table 1 Inputs to the analysis of the impact of long-term $PM_{2.5}$ reductions on all-cause mortality among adults aged 30+ years in four Latin American cities

City	Baseline annual $PM_{2.5}$ $\mu g/m^3$	% reduction in $PM_{2.5}$ during initial COVID-19 lockdown	Counterfactual long-term $PM_{2.5}$ $\mu g/m^3$	Population at risk, aged 30+ years	Mortality rate per 100 k, aged 30+ years
Lima	30	41	17.7	4,876,101	725
São Paulo	16	31	11.0	11,336,039	1064
Santiago	22	21	17.4	3,808,372	891
Mexico City	19	5	18.1	11,362,609	1071

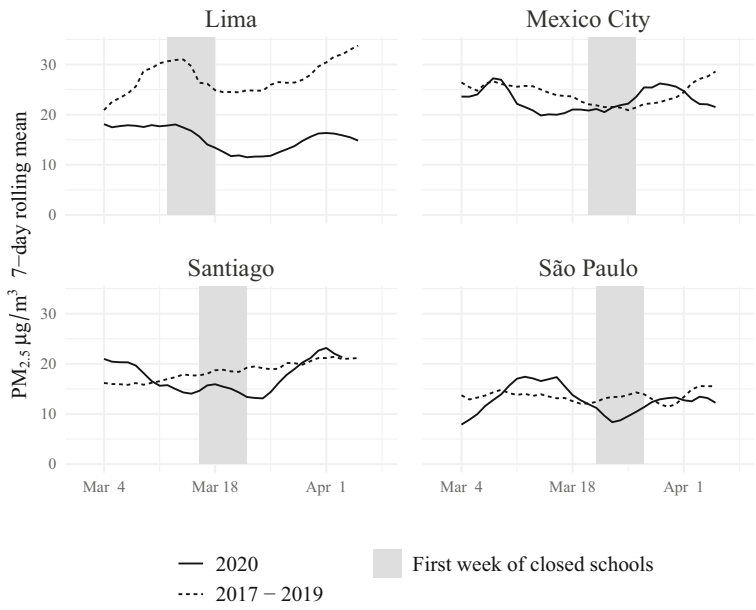

Fig. 1 Weekly $PM_{2.5}$ concentrations comparing the first week of COVID-19 school closures with the same period in 2017 to 2019 within four Latin American cities

driven by changes across a broad range of emission sources, yet dramatic reductions in vehicular traffic have likely been a major contributor to the air pollution reductions seen during lockdown [7, 12]. Previous interventions to reduce urban air pollution in the region have emphasized policies which reduce vehicular traffic [13–15], yet these interventions have not always been fully evaluated. Reductions in vehicular use during the COVID-19 lockdowns [12] likely far outweigh the reductions achieved by previous interventions [14], yet the transit sector remains a critical sector for cost-effective air pollution reductions in the region [16].

As a response to the pandemic, dozens of cities in the region, including Lima [17], Mexico City [18], and Santiago [19] have enacted policies which promote bicycling and walking, often converting car lanes to protected bike or pedestrian lanes [20]. Transitioning to an urban infrastructure which supports biking and walking has enormous potential as an actionable, immediate, and cost-effective intervention to both reduce COVID-19 transmission and air pollution in the short term and support long-term goals of building cities with healthy air that are resistant to future pandemics.

At first glance, it may appear that achieving these reductions absent dramatic lockdowns is unfeasible. Yet, reductions in pollutants comparable or even larger than those observed have occurred in high-income countries as a result of concerted policy efforts and evidence-based regulation. For example, in the USA, annual $PM_{2.5}$ decreased by 43% between 2000 and 2018 [21], despite already being at significantly lower levels in 2000 (about 13.5 $\mu g/m^3$) than the cities we examine. Although there is growing awareness of the threats of air pollution across the cities of Latin America, levels of many pollutants remain high, and countries have been slow to incorporate WHO guidelines into national-level regulations. Monitoring networks also remain limited [22]. Thus, there is much room for improvement.

Our analysis suggests that even relatively small reductions in ambient air pollution may provide substantial public health benefits. Current levels of ambient air pollution cause 145,000 deaths in Latin America and the Caribbean every year [23], and many more individuals develop chronic respiratory and cardiovascular conditions which severely limit quality of life. As national governments look to reorganize public health systems to become more resilient to pandemics and to restart economies after social distancing measures, there is a critical opportunity to take a fresh look at policies and structural changes which reduce air pollution, prevent chronic diseases, and promote health equity in Latin America and beyond.

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Compliance with Ethical Standards

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