Air pollution exposure is shifting from outdoor to indoor – here's why

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You may have seen the before-and-after-lockdown photos of major cities that appear to show dramatic changes in air quality. In one, the India Gate war memorial in New Delhi is barely visible amid the smog.

Then, during lockdown, it's clearly visible in its red Bharatpur stone grandness.

Getting vehicles off the road may do wonders for smog, but there's more to air pollution than that. The shift away from vehicles powered by fossil fuels and the improvement of outdoor air quality in urban areas, combined with changes to buildings and lifestyles, means that indoor air pollution will become much more important in the future. And there aren't many easy answers about how much of a risk this will create—or how to address it.

Vehicles have been a dominant source of air pollutants for decades. But the century-long dominance of petroleum-based fuels is drawing to an end with the increasingly rapid rollout of electric vehicles. A consequence of this will be a fall in concentrations of highly reactive gases called nitrogen oxides, which actually neutralize another pollutant from industrial sources, ozone. So fewer petrol and diesel-fuelled cars, coupled with lower emissions from those that remain, could actually result in higher ozone concentrations in urban areas.

Unlike way up in the stratosphere where ozone plays an important role in protecting us from harmful ultraviolet radiation, at the surface, it can act as a respiratory pollutant. This property makes life difficult for those with respiratory illnesses such as asthma and bronchitis.

But we are not just exposed to ozone outdoors, it can also move into buildings through windows, doors and cracks in buildings. So it follows that if ozone concentrations increase outdoors, they will also increase indoors. Indeed, computer models predicted that during lockdown, indoor ozone concentrations would increase by 50%.

Once indoors, ozone reacts with the many chemicals that are emitted from common indoor activities, such as cleaning, to form new air

pollutants, some of which are harmful to our health.

However, indoor ozone is not the only problem. There are many sources of air pollution indoors. When we cook, particularly with natural gas, and when frying meat at high temperatures, we produce nitrogen oxides and particulate matter. Cleaning can produce fragrance compounds (called volatile organic compounds) as well as particulate matter. Burning candles can also produce nitrogen oxides and particulate matter, and also volatile organic compounds if scented.

Some of these compounds are emitted directly and some of them can further react—such as with ozone—to form new air pollutants. Consequently, indoor air quality depends largely on indoor activities and how well-ventilated a building is.

Over the last 50 years or so, buildings have become more airtight with increased energy efficiency measures—a trend that is likely to continue. Over the same period, people in many countries have been spending an increasing amount of time indoors—in homes, commuting or at work. Children in the UK were recently estimated to be spending only just over an hour outdoors each day. As a result, most of our exposure to air pollution happens indoors, even if the pollutants are formed outdoors.

Yet while ventilation will dilute emissions from indoor sources, it will also allow more ozone indoors that could initiate chemical reactions. It is clearly a complex picture.

> Before-and-after photos show dramatic decline in air pollution around the world during coronavirus lockdown https://t.co/BmG20jHRwE pic.twitter.com/GakjNvAJlR
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> — CBS News (@CBSNews) April 23, 2020

Air pollution exposure is complex and dynamic

Altering sources of air pollution may reduce the concentration of some pollutants, but could increase those of other pollutants such as ozone. We are exposed to air pollution outdoors and indoors and to mixtures of different air pollutants in each. Even on the same street in identical houses, exposure is likely to differ in the individual houses because of the different behavior within.

The main health effects associated with air pollutants are either from long-term exposure, such as cardiovascular and respiratory diseases and lung cancer, or arise from short-term exposure, such as damaging the lungs or exacerbating asthma. Although we understand the health effects of some air pollutants such as nitrogen dioxide and particulate matter reasonably well, for many airborne pollutants, there is little or no information on how they affect our health.

This absence of information is particularly acute for indoors, where research lags that of outdoor air quality significantly. For instance, indoor air particulate matter is formed or emitted during cooking, and it would be useful to know whether the toxicity of these particles is greater or less than common sources outdoors, such as motor vehicles.

All this means improving outdoor air quality will not necessarily reduce our overall exposure to air pollution. An important future step is to get a better understanding of our total exposure to air pollution, particularly that indoors, and its effects on our health.

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