Taking the True Measure of Air Pollution

We have to look where the people are

by Kirk R. Smith

Concern about air pollution has traditionally focused on the effects on outdoor environments. We have become accustomed to thinking of air pollution in the context of such visual symbols as the industrial smokestack and the dark layer smothering modern cities. In view of knowledge gained in recent years, this focus on outdoor air pollution and its sources has diverted attention from our principal goal of reducing the exposure of people to the health-damaging pollutants they actually breathe. These exposures can be caused by relatively small localized sources that are, literally, right under our noses: cigarettes, spray cans, and dry-cleaned clothes, for example. More often than not, these exposures occur indoors.

Although a number of adverse effects on human welfare are associated with outdoor air pollution, including property damage and loss of visibility, its impact on human health has been the focus of most concern. Primary standards for criteria pollutants under the Clean Air Act in the United States, as well as similar standards in other nations, have been established to avoid health damage. Evidence includes the acute episodes in London and in Donora, Pennsylvania; epidemiological studies of long- and short-term effects on different populations; and laboratory experiments with human volunteers. The current pattern of monitoring and regulation, however, may not directly address the locations and types of pollutants with the most damaging health impact.

Present standards apply to outdoor levels of pollution where measurements are most easily made. Most people, however, do not spend much time outdoors, particularly in temperate, developed countries. In the United States, for example, only about 10 percent of the population's time is spent outdoors. To measure the pollutant concentrations to which most people are exposed most of the time, it is also necessary to monitor indoor environments. A number of studies show that indoor and outdoor concentrations of most pollutants are often significantly different and that they do not correlate well with concentrations at the nearest outdoor monitoring site.

The first ever air-pollution monitoring network was located on the tops of London fire stations during the last century. Concentrations are still most often measured on the roofs of public buildings and at other locations chosen by a range of criteria such as convenience, security, geographic spread, and general congruence with population distribution. This placement assumes that outdoor levels reasonably indicate health-relevant exposures. Such measurements, however, do not truly represent individual or population exposures to many pollutants of interest. In some cases, total exposure is less than that indicated by outdoor measurements, because there are few indoor sources: for example, sulfur oxides. In other cases, total exposure is actually more, because there are significant indoor sources: for example, nitrogen dioxide from gas stoves.

The attention being given to indoor air pollution in recent years indicates a fundamental shift in environmental health science: recognition of the need

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for total exposure assessment (TEA). The idea behind TEA is that if we are to understand how a particular pollutant affects humans and what the most effective control measure would be, it is necessary to account for all routes of exposure. Put more bluntly, to determine human exposure it is necessary to measure the exposures of humans directly. Studies of the microenvironments within which people spend time are needed. These can be done by measuring pollutant concentrations separately in each microenvironment, then taking the sum weighted by the amount of person-hours spent in each. Another approach is personal exposure monitoring, in which the air in the breathing zone of individuals is sampled during normal daily activities. A range of portable devices and techniques for both kinds of monitoring has been developed.

TEA across all times and locations is now a recognized way to conduct health-effects studies of air pollution. For many pollutants, small changes in indoor conditions affect total exposures more than do large differences in outdoor concentrations, even considering that indoor levels are partly due to penetrations of pollution from outside. Further, considering the most significant sources on the basis of exposure reveals that a quite different set of sources is important. Many of these sources, such as tobacco smoking, gas stoves, and chemicals in consumer products, occur indoors. On the other hand, localized outdoor sources may produce greater exposure than outdoor monitoring instruments would indicate because the instruments are remote. Lead exposure of people living near highways is an example.

The significance of looking where the people are can be illustrated by studies of recently targeted pollutants such as those volatile organic chemicals that are part of the category called “air toxics.” The Total Exposure Assessment Methodology (TEAM) studies discussed on pages 23-24 provide ample evidence that outdoor measurements of these chemicals are often inadequate for determining total human exposures. This is also true for some of the more traditional pollutants, such as particulates and nitrogen dioxide.

In a feasibility study of the effectiveness of new nitrogen dioxide emission controls on vehicles in Chicago, for example, researchers found that even large decreases in average outdoor concentrations would have minor impact on total daily exposures. Peak concentrations along highways would be little affected by such controls. Also, daily average outdoor exposures were much less than the indoor exposures from gas stoves. Although vehicle emission controls could help Chicago meet ambient outdoor-air pollution standards, in this case they would not appreciably decrease actual human exposures to nitrogen dioxide. This is true even though there are many more tons per day of nitrogen dioxide emitted from cars than from stoves.

A pound of pollution released outdoors or in places where people do not spend much time is substantially less damaging to health than the same amount released near people. Stringent pollution controls, for example, are applied to coal-fired power plants in the United States, yet they collectively still release about 500,000 tons of particulates each year. Tobacco smoking, which fortunately is declining, now releases only about
20,000 tons each year. From a direct particulate emissions standpoint, therefore, power plants are 25 times more polluting than cigarettes. When the comparison is based on human exposure, however, the total exposure from environmental tobacco smoke (ETS), sometimes called passive smoking, is 50 times higher. This means that, from a particulate exposure standpoint, a 2-percent decrease in ETS would be equivalent to eliminating all the coal-fired power plants in the country.

Perhaps even more striking is that, per pound released, ETS is more than a thousand times (25 multiplied by 50) more dangerous than the smoke from power plants. This is not because of any difference in their composition, which here is assumed to be identical, but simply because of the differences in the time and place of release. The power plant smoke is mostly released from stacks high in the air and out of town, or at least in parts of town where few people live. ETS, on the other hand, is largely released indoors and often during human presence. Put another way, per pound released, a thousand times more ETS is actually inhaled by people than is the smoke from power plants. This difference is their relative "exposure effectiveness," based on a comparison of how much of what is emitted actually goes down people's throats.

This one comparison alone, if generally accepted, would have tremendous implications for air-pollution control strategy in the nation. It implies, for example, that we ought to be willing to pay a thousand times as much to control emissions that cause ETS as we are to control power-plant smoke. But this is only one example of how our present system of air pollution regulation and control tends to ignore the sometimes large differences in exposure effectiveness that can exist for the same pollutant in different situations.

Some argue, however, that indoor and outdoor exposures are fundamentally different and should not be so compared. Power plant smoke is imposed on people without their consent, the argument goes, and thus warrants greater public concern than indoor sources that people in some way bring on themselves. This argument, however, has at least two major flaws.

First, it is only partly true that people knowingly decide to bring indoor exposures on themselves. How many members of the public are able to interpret the list of ingredients on a can of household cleaner or pesticide to decide how much exposure is warranted for them or their families? How are housekeepers able to judge what chemicals will be released from a carpet or piece of furniture they buy? What can members of a single household do to determine what they are being exposed to in the water piped into their home?

The second flaw in this argument is the hidden assumption that the emissions from outdoor sources such as chemical plants are somehow different from those originating indoors. If we are serious about controlling benzene exposures for health reasons, should we not view each benzene molecule as our enemy and work to stop as many as possible from reaching people? What sense does it make to propose spending hundreds of millions controlling stationary outdoor sources, which cause relatively little human exposure, while ignoring indoor sources that cause much? Will the parents of a child afflicted by benzene-triggered leukemia be less upset if they are assured that the benzene probably came from indoor sources?

Another argument sometimes leveled at efforts to bring indoor and other total exposure considerations into regulatory frameworks is that somehow this will result in an infringement of individual rights—for example, big government will place electronic monitoring devices in every home. This is ridiculous; total exposures can be determined by statistical sampling techniques analogous to the way the Nielsen ratings of television viewing habits are done.

A variant on this Big Brother argument is that regulating indoor pollution will require the government to impose its will on the individual householder, meaning that pollution fines, limits, and other controls would be imposed on the "castle" that is each householder's home. In fact, the government already has ways to control much inside the castles that are our homes. Fuel quality is regulated by the government, as is the performance of stoves and other combustion devices. Building and fire codes already affect ventilation rates. Household chemical products are subject to regulation, some substances being banned, for example. Termites and other inspections are mandated in most states. Taxes, public education, and controls on advertisements have had clear impacts on tobacco consumption. There would seem to be little need to invent any other policy tools to control indoor air pollution, but rather to adjust the existing ones to reflect total exposure.

In summary, to be sure that we are protecting the most people possible from ill health induced by air pollution, we need to examine conditions where the people are. This will entail finding ways to take into consideration the indoors in addition to our already well-developed monitoring systems for the outdoors.