

NO₂—The Inside Story By-Product May Be a Problem

Due to its well-documented adverse health effects, including throat irritation, cough, and difficulty breathing, nitrogen dioxide (NO₂) has long been a prime focus of scientific investigations into indoor air pollution. Nitrous acid (HONO), a by-product of NO₂, is less well-studied in terms of human health effects of low exposures. But it has chemical characteristics that suggest that it, too, is a potential respiratory irritant and that its presence in the indoor environment is worthy of study. In this month's issue, Kiyoun Lee of the University of California at Davis School of Medicine and his coauthors investigate indoor HONO levels as well as the relationship between indoor concentrations of HONO, NO₂, and ozone [EHP 110:145–149]. Their efforts clearly indicate that HONO is indeed potentially an important factor in indoor air pollution.

Gas combustion—simply cooking on a gas range—is known to be a major source of NO₂ in the residential environment. HONO, too, is formed by gas combustion, and is also a by-product of NO₂ reactions with water on indoor surfaces. So its concentration in the indoor environment is affected by several variables, including NO₂ concentrations, ventilation, surface materials, available surface areas, temperature, and humidity. Ozone concentrations indoors appear to be determined largely by outdoor levels.

In April and May 1996, the team measured indoor and outdoor HONO, NO₂, and ozone at 119 Southern California homes. Fifty-seven of the houses were located in a valley area, and 62 were in a mountainous region. The varied nature of the outdoor environment of the houses, as well as certain characteristics of the homes themselves, such as the presence of an air conditioner, gas range, or humidifier, were thought to be significant factors contributing to the levels of the three pollutants and the relationships among them.

Analysis of the air samples taken over a six-day period both inside and outside the houses showed that average indoor HONO concentrations were higher than outdoor concentrations, which was unsurprising, given that HONO quickly breaks down outdoors in the presence of sunlight. Indoor NO₂ concentrations were also found to be significantly higher than outdoor concentrations, while indoor ozone concentrations were significantly lower than those outdoors. Indoor HONO concentrations correlated positively with indoor NO₂ concentrations, averaging about 17% of NO₂ levels, but correlated inversely with indoor ozone concentrations.

The associations explored by the researchers shed light on some of the factors contributing to what they describe as “substantial” indoor HONO concentrations. Each house's location was found to be associated with certain relationships among the three contaminants. Indoor and outdoor NO₂ levels (and therefore HONO levels) were lower in the mountain sites, which had higher ozone levels, leading the authors to speculate that “it is possible that the association between community and the three

air pollutants may be different when ambient ozone levels are different.” The opposite was true of valley sites, which had higher NO₂ and HONO levels and lower ozone levels.

Homes with an air conditioner and a gas range had higher indoor NO₂ concentrations, and homes with higher NO₂ also had higher HONO levels, but the investigators could not establish a direct relationship between these housing factors and high HONO levels. Similarly, homes with humidifiers had lower HONO levels, which was an anomaly in that the increased moisture on surface areas would have been expected to result in a concomitant increase in HONO.

The study represents one of the first times that indoor HONO concentrations have been measured at all. Although the authors did not find clear evidence to account for the substantial levels of indoor HONO they discovered, their efforts do indicate that the levels of HONO found make it potentially an important factor in indoor air

pollution, and that further research into the complex interrelationships among the pollutants and the indoor and outdoor environments is warranted. —Ernie Hood



Turning up the heat. A study of gas combustion suggests that indoor concentrations of nitrous acid may add significantly to indoor air pollution.

Stroke of Inspiration Researchers Implicate Air Pollution

Strokes, one of the world's leading killers, are caused by more than just sedentary lifestyles and poor diets, says an international team of researchers [EHP 110:187–191]. Air pollutants also play a part. In one of the few detailed studies of stroke death and air pollutants conducted to date, a team from four Korean institutions and the Harvard School of Public Health led by Yun-Chul Hong found that deaths from stroke increased consistently with rising concentrations of either particulates 10 microns in diameter and smaller (PM₁₀), carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), or ozone. The two most susceptible groups were found to be women and people 65 and over.

The team based its findings on data from Korea's largest metropolitan area, Seoul, a city of both relatively high particulate concentrations and high numbers of fatal strokes. Hourly air pollution readings from 20 stations over the years 1995–1998 revealed a wide range of pollutant concentrations during the study period. Government records documented a high rate of stroke deaths during the same period, totaling 22,341. As the team analyzed the data, it factored in potential confounders such as temperature, relative humidity, barometric pressure, and day of the week. Team members did not evaluate several other potential influences, such as lifestyle, income level, living conditions, or health care history, because these weren't expected to vary daily as air pollutant concentrations would.

The team found that rises in PM₁₀ and ozone concentrations had a strong, nearly immediate link with stroke deaths: for every interquartile range increase of these two pollutants, death rates rose 1.5% and 2.9% respectively on the same day. Analysis of NO₂, SO₂, and CO showed increases of a similar scale, but with

a two-day lag. When researchers performed a two-pollutant analysis with PM₁₀ and each of the other pollutants, they found a correlation in each case, but sometimes in opposite directions. The risk from PM₁₀ was significantly elevated with higher concentrations of ozone, but it was reduced with higher concentrations of NO₂, SO₂, and CO. The team didn't evaluate the effects of the four gaseous pollutants interacting with each other.

Some of the varying findings might be explained by the shortage of data for all scenarios; the number of days when both PM₁₀ and each other pollutant were near their peaks were rare. The team also acknowledges that it is difficult to separate out the effects of individual pollutants because various pollutant concentrations tend to be interrelative. In addition, the data from the 20 stations don't necessarily reflect the actual exposures of the people who suffered strokes.

Nonetheless, the generally consistent link between stroke deaths and single pollutants at concentrations that often were well below many countries' regulatory standards suggests that stroke incidence might be reduced through air quality improvement. However, additional studies will be needed to determine whether the results of this study apply in different cultures and settings.

It also would be useful to understand the mechanism by which air pollutants boost deaths from stroke. The research team speculates that free radicals may increase after pollutant exposures, causing inflammation, increased plasma viscosity, and subsequent stroke in susceptible people. **—Bob Weinhold**

Nontoxic Neonates

Babies Avoid Chemical's Effects

In the late 1950s, porphyria cutanea tarda killed more than 1,000 Turkish babies when they developed a secondary soft tissue infection known as *pembe yara*. The babies had been exposed to the toxic chemical hexachlorobenzene (HCB) through breast milk. Researchers realized during that outbreak that breast-fed babies are particularly vulnerable to the effects of this fat-bound contaminant. Scientists have also known that HCB is transferred from mother to fetus through the placenta. Yet until recently, they knew little about the impact of prenatal exposure. In this issue, researchers find that infants exposed prenatally to high concentrations of HCB appear to escape the adverse effects associated with the pollutant [*EHP* 110:205–209]. However, metabolism might be affected in babies exposed *in utero* to both maternal cigarette smoke and HCB.

The porphyrias, of which porphyria cutanea tarda is only one, are disorders characterized by excessive excretion of porphyrins, pigments formed during the production of hemoglobin and excreted naturally in urine and feces. Elevated porphyrin excretion can also indicate subclinical metabolic abnormalities. University of Barcelona researcher Dolores Ozalla and colleagues studied porphyrin excretion among Spanish neonates born at a Móra d'Ebre hospital between 1997 and 1999. They chose the hospital for its proximity to Flix, a rural village of 5,000 where residents have the highest atmospheric (35 µg/m³) and serum (36.7 ng/mL) concentrations of HCB ever reported. Villagers are exposed to HCB through emissions from a nearby electrochemical factory.

The researchers studied the effects of prenatal exposure to HCB by measuring porphyrin concentrations in the infants' urine. They took urine samples from 68 neonates, 38 of whose mothers were from Flix (the exposed population) and 30 of whose mothers were from neighboring villages (the nonexposed population). To assess the infants' exposure to HCB, the

researchers analyzed concentrations of the chemical in both maternal serum and cord blood.

Children of mothers from Flix had the highest HCB concentrations in their cord blood. These infants, however, did not excrete unusual amounts of urinary porphyrins. All were within normal range, although the researchers did note higher excretion of one type of porphyrin, CPIII, among exposed infants than among the exposed group. When Ozalla adjusted for maternal cigarette smoking during pregnancy, which for reasons unknown occurred more among mothers exposed to HCB, the difference between the two infant groups disappeared. This indicates that maternal smoking alone seemed to account for the difference in porphyrin excretion. Total porphyrin excretion was approximately 34% higher in infants whose mothers smoked, with the biggest difference occurring in excretion of CPIII, which was 116% higher.

An unexpected finding was that infants in the highest tertile of HCB exposure excreted the lowest levels of two types of porphyrins, CPI and CPIII. Ozalla discounts the negative association, claiming the number of subjects is too small to draw conclusions. Her data overall suggest that, although HCB levels in Flix are among the highest in the world, they're too low to affect porphyrin metabolism in infants exposed prenatally. The only cause Ozalla found for higher excretion in infants was mothers' cigarette smoking during pregnancy. She emphasizes that her study did not measure tobacco exposure, and suggests future studies examine this link more closely. **—Cynthia Washam**



Good news for babies. Contrary to expectations, prenatal exposure to high concentrations of the toxic chemical hexachlorobenzene may not adversely affect the health of babies, although postnatal exposure has been linked with serious problems.