

## Expanded View of PAHs: Identifying Especially Harmful Constituents of Bituminous Coal Smoke

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The adjacent counties of Xuanwei and Fuyuan in southwestern China have long had some of the world’s highest lung cancer rates, particularly among nonsmoking women.<sup>1,2</sup> For more than three decades, researchers in China and around the world have sought to understand why. Epidemiological and experimental studies to date suggest that the use of local bituminous coal for household cooking and heating is responsible for the region’s elevated cancer risk and mortality rates.<sup>3,4</sup> A study recently published in *Environmental Health Perspectives* identified specific constituents of smoke from the implicated coal that might be especially harmful—with potential significance far beyond rural China.<sup>5</sup>

Bituminous coal is found everywhere in the world, says first author Roel Vermeulen, a professor of environmental epidemiology and exposome science at Utrecht University in the Netherlands. So why is the coal in this particular area so strongly associated with cancer risk? Vermeulen and colleagues, including senior author Qing Lan of the U.S. National Cancer Institute, set out to find an answer.

The study included 1,015 never-smoking women and 485 controls. The authors analyzed lung cancer incidence in relation to coal-related pollutant exposures, as estimated by a comprehensive exposure assessment model. When they examined clusters of exposures, they found the strongest association with a group of 25 polycyclic aromatic hydrocarbons (PAHs), including several methylated subspecies. Within the PAH cluster, the strongest association was estimated for a single subspecies called 5-methylchrysene.

Although methylated PAHs are known to be both mutagenic and carcinogenic,<sup>6,7</sup> the authors point out that these chemicals “have never been directly evaluated in an epidemiological study of any cancer.”<sup>5</sup> Instead, the 16 “priority” PAHs regulated by the U.S. Environmental Protection Agency (EPA) are typically used as an indicator of overall risk.<sup>8,9</sup> These priority PAHs were selected in 1976 based on the knowledge and the analytical capabilities of the day.<sup>9</sup>

“What’s really interesting about our findings is [identifying] these clusters of large groups of PAHs, a lot of which aren’t typically measured but are likely to be present in other coal-burning



Vermeulen describes the Chinese study sites as “something of a geologic perfect storm” when it comes to coal use. This is the only known area in the world where people burn coal from the Permian-Triassic boundary, he explains. Because the local coal’s silica content is so high, its carbon and volatile content is relatively low, so people must burn more of it to produce adequate heat.<sup>14</sup> Image: © Jules Bucher/Science Source.

and other solid fuel-burning contexts,” says coauthor George Downward, a researcher at the Institute for Risk Assessment Sciences at Utrecht. “The real takeaway here is that maybe this expands beyond the EPA’s sixteen-PAH perspective that a lot of exposure assessment has, to start looking more at other species and at other factors.”

The current study’s multipollutant exposure assessment was developed by Downward through multiple previous papers.<sup>10,11,12</sup> It drew upon personal and indoor air quality measurements recorded for 163 women and their households across 30 villages in 2008 and 2009, self-reported histories of stove and fuel use, and an analysis of local coal mine types and locations. Lung cancer diagnoses were tracked among study participants between 2006 and 2013.

Senlin Lu, a professor at Shanghai University in China who has also worked in the region, called the new research “innovative” and “very attractive.” Its results could be further tested through *in vitro* study of the oxidative potential (a measure of inhalation toxicity) of 5-methylchrysene and other methylated PAHs in the cluster, says Lu, who was not involved in the study. The preliminary estimates will also need to be confirmed in other human populations.

“Epidemiological data combined with laboratory data would provide a powerful explanation for Xuanwei’s high lung cancer incidence,” Lu says. “Considering coal consumption in China and in the world is tremendous, scientific assessment of health risks caused by coal combustion is necessary and urgent.”

University of Münster professor Christine Achten, an expert on PAHs who also was not involved in the study, agrees that it is time to revisit the EPA’s widely adopted approach to monitoring and regulating these chemicals.<sup>13</sup> “I think it is very important that people start to look beyond the sixteen,” she says. “[The work by Vermeulen and colleagues] is a study where they looked at other compounds, and it is very important to get more of this kind of information.”

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