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Warm, Cozy Woodstoves … and the PM They Produce: Home Interventions Show Mixed Results in Protecting Children with Asthma

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Millions of households in the United States and other developed countries, particularly those in rural areas, rely on wood-burning stoves for heat.[1–3] Wood smoke contains particulate matter (PM), which potentially can exacerbate respiratory symptoms in children with asthma.[3,4] A new study in *Environmental Health Perspectives* used a randomized control trial approach to test whether interventions at home improved health measures for children with asthma. The results showed that neither efficient stoves nor in-home air filtration had much effect on the children's quality of life, although some lung function measures did improve.[5]

Asthma is characterized by inflammation in the lungs, which constricts airways and impairs breathing.[6] In children, asthma potentially undermines lung growth and interferes with daily activities, including school attendance.[7] Strategies to maintain open airways include medication and limiting exposure to factors that cause airway inflammation, according to the Centers for Disease Control (CDC).[6] Air filtration, for example, reduces the concentrations of airborne triggers of inflammation, including allergens, dust, and PM.[8,9]

The U.S. Department of Energy estimates that 11.6 million households in the United States burn wood as either a primary or supplemental source of heat.[1] Study coauthor Curtis Noonan, an associate professor of epidemiology at the University of Montana, says PM from wood-burning stoves can be present in the air even if there is no perceptible smell of smoke. For children with asthma, PM exposure may increase their respiratory symptoms, adversely affecting their quality of life.[4]

In the current study, the researchers used data collected during two consecutive winters through the Asthma Randomized Trial of Indoor Wood Smoke (ARTIS), conducted in rural areas of Montana, Idaho, and Alaska.[4] The ARTIS cohort included 114 children with asthma, age 6–18 years, who lived in nonsmoking homes with woodstoves as the primary heat source. The woodstoves in these homes were made before 1995 and did not meet current certification guidelines by the U.S. Environmental Protection Agency (EPA) for reduced emissions.[10]

The households were randomly divided into three treatment groups. Between the first and second winters, the control group received a sham air filtration device, the "air filter group" received a functioning device, and the "woodstove changeout group" had their old stoves replaced with EPA-certified units.

During both winters, children completed the Pediatric Asthma Quality of Life Questionnaire, a tool for assessing symptoms, activity limitation, and emotional function in the prior week. With parental assistance, the children recorded their peak expiratory flow (PEF) and forced expiratory volume in the first second (FEV_1) twice daily for two weeks. These measures of asthma control permitted later calculation of what is called diurnal peak flow variability (dPFV), an indicator of airway hyper-reactivity. PM concentrations in the homes were measured, with a particular focus on fine particles ($PM_{2.5}$).

Households that received the new woodstoves showed no change in indoor PM concentrations, but the air filtration intervention substantially reduced indoor PM concentrations (67% less $PM_{2.5}$ in comparison with the control group). However, changes in quality-of-life scores did not differ significantly between groups. The dPFV measure showed a statistically significant improvement among children in the air-filter intervention, and a lesser improvement in the woodstove intervention group, in comparison with the control group.[11]

The design of this study was a particular strength, says Abby Fleisch, a pediatric specialist at the Maine Medical Center Research Institute who was not involved in the work. That's because its randomized control trial design eliminated many of the limitations of prior observational studies.

Some limitations were unavoidable, however, such as issues with self-measurements, possible changes in participants' health between winters, and ongoing outdoor PM exposure. In addition, the woodstove intervention group included fewer than half as many children as the placebo and air filter groups. That smaller intervention group's size is because the investigators discontinued the woodstove intervention early because there was no evidence of a reduction in $PM_{2.5}$. The authors note that the

A fieldworker and an ARTIS participant fill out a questionnaire to assess how the boy's asthma had affected his quality of life over the preceding week. Across the ARTIS cohort, study results showed that while using an air filter substantially reduced the amount of particulate matter in indoor air, with corresponding improvement in children's lung function, their quality of life did not necessarily change. Image: © Emily Weiler/University of Montana.

woodstove intervention findings should therefore be interpreted with caution.

"PM decreased fairly dramatically in homes that received the air filter intervention [but] without a marked improvement in respiratory symptoms in the children living in the homes," says Fleisch. "The youngest children, who spend the most time at home, may have had the potential to benefit most from the intervention. It would be interesting to consider results stratified by age, or to conduct future randomized control trials in a population of younger children," she says.

The ARTIS team did consider the time children spent at home,[4] but the researchers also noted that asthma often worsens during adolescence.[5] Noonan says, "Despite not seeing improvements in the quality-of-life measure, the peak flow variability improvements among the air-filtration group were consistent with some medical intervention studies. Given that PM exposures associated with biomass smoke are so high compared to many other settings, further intervention studies evaluating other vulnerable populations and health outcomes is warranted."

"In the bigger picture," Noonan adds, "the air filter intervention clearly works as we and others have shown, but it does not do much to address the problem of ambient air pollution in communities that have high proportions of homes that burn wood."

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