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When pediatrician Aaron Bernstein, MD, sees young patients with Lyme disease at Children's Hospital Boston, in Massachusetts, his advice to parents often goes beyond the obvious of protecting their children against infectious ticks with insect repellant, long pants, and long sleeves on trips to the woods.

"I explain to them that really, Lyme disease is a disease of ecology," says Bernstein. "We tend to think that we get infectious diseases from other people, but it turns out that the majority of infectious diseases are diseases that we share with other species."

And many of those species today are on the move. They are propelled not only by natural migratory patterns but also by human pursuits that drive climate change, especially the burning of fossil fuels, which can push birds, insects, and other disease vectors into new habitats.

Experts several years ago sounded the alarm on climate change's potential harm to human health in the years to come. But the impact on a particularly vulnerable group—children—has not received a great deal of attention. Only a handful of studies and reports have described the undue burden that climate change may place on children worldwide. But children's health advocates are coming forward with a message of caution and encouragement: for pediatricians and other clinicians who care for children, climate change may not be on their clinical radar screen just yet, but they can play a lead role in mitigating its effects to create a healthier environment for their young patients and children everywhere.

NOT JUST "LITTLE ADULTS"

Average temperatures in the Northern Hemisphere in the second half of the 20th century were likely to have been the highest in at least the past 1300 years, the Intergovernmental Panel on Climate Change (IPCC) reported in its fourth assessment report, *Climate Change 2007* (http://www.ipcc.ch/ipccreports/ar4-syr.htm).

But several years before that IPCC report was released, when climate change was the subject of greater scientific controversy, Supinda Bunyavanich, MD, now a clinical fellow at Harvard Medical School in Boston, noticed that studies examining the potential consequences of warming temperatures on human health looked primarily at adults or entire populations. She found none focused specifically on children. "Children aren't just little adults," she says. "They have a different physiology and different exposures."

So Bunyavanich and several colleagues, including Paul R. Epstein, MD, MPH, Associate Director of the Center for Health and the Global Environment at Harvard Medical School, reviewed the existing data on climate change and analyzed the impact it might have on children's health (Bunyavanich S et al. *Ambul Pediatr*. 2003;3[1]:44-52). Their review notes that, compared with adults, children breathe more rapidly and usually spend more time outdoors, exercising and playing. Children also have narrower airways. During vigorous outdoor activities they would be more likely to breathe through the mouth instead of the nose. All of these factors translate into higher exposures in children than adults to increased air pollution levels that generally result from warmer temperatures, putting children at greater risk of respiratory diseases.

Climate change also is linked with more extreme weather patterns, including heavy rains, floods, drought, and cyclones. Bunyavanich and her colleagues note that these patterns not only increase children's risk of drowning, they also disrupt sanitation systems, increasing the risk of waterborne diseases. Children are more susceptible than adults to these diseases, for several reasons.

Billy Economou/iStockphoto.com/NASA

Children's health advocates say that pediatricians and other clinicians who care for children can play a significant role in addressing the effects of climate change to create a healthier world for children around the globe.

In *Children and Drinking Water Standards* (http://www.epa.gov/safewater/kids/kidshealth/index.html), the US Environmental Protection Agency notes that pound for pound, children drink more water than adults, so a greater exposure to contaminated water increases the risk of disease. Some children are more vulnerable to infectious waterborne diseases, such as newborns, who do not have a fully developed immune system, as well as children whose immunity is impaired by malnutrition. Vomiting and diarrhea in those who are infected may cause dehydration more quickly in children than in adults (drought conditions also increase children's likelihood of becoming dehydrated).

Also, disease vectors' habitats shift to locales where temperature and precipitation patterns become more favorable for feeding and reproducing. Bunyavanich et al's review notes that malaria transmission has coincided with temperature increases in such areas as New York, Toronto, and the former Soviet Union that usually are not associated with the disease. Most at risk of dying from malaria are children aged 3 months to 5 years, because they have little specific immunity. Added threats come from vectors that transmit dengue fever, encephalitis, and Lyme disease.

Temperature shifts also could reduce crop production and make food animals more vulnerable to parasites. Without proper nutrition, children face long-term debilitating effects or death from malnutrition, stunting, and wasting. Heat stroke, more pronounced allergic reactions, and skin damage from UV radiation exposure pose additional risks, but their impact on children still is not well known.

"Further research to quantify the effect [of climate change] is necessary," says Bunyavanich. "It's difficult to know the extent of what we're dealing with. A lot of the potential effects of climate change are interwoven with things related to direct environmental change and ecological change, and those are tied to other research questions. This is affecting a whole network of research."

TEACHABLE MOMENT

In April the US Environmental Protection Agency announced that it would regulate carbon dioxide and other greenhouse gases as pollutants under the Clean Air Act. Pediatrician Katherine Shea, MD, MPH, welcomed the announcement as a game changer. "We have to move quickly because our window of opportunity to prevent serious, chronic changes [from warming temperatures] is closing pretty quickly," says Shea, of the Dennis and Joan Gillings School of Global Public Health at the University of North Carolina in Chapel Hill.

Shea also is the lead author of the American Academy of Pediatrics (AAP) technical report on climate change and children's health (Shea KM; American Academy of Pediatrics Committee on Environmental Health. *Pediatrics*. 2007;120[5]:e1359-e1367). An accompanying policy statement recommends steps that pediatricians can take to mitigate climate-related health risks (American Academy of Pediatrics Committee on Environmental Health; Shea KM. *Pediatrics*. 2007;120[5]:1149-1152). Despite her efforts to get the word out, Shea concedes that climate change may not be a high day-to-day priority for many pediatricians. "It's difficult in a busy practice," she says. "But there's a concept of the teachable moment."

For example, an asthmatic child who comes with a parent to the pediatrician's office after playing soccer on a hot day offers an opportunity for the clinician caring for children to teach about the Air Quality Index, which indicates unhealthy air pollution levels. A segue to walking and biking more to reduce vehicle emissions and turning electronic devices off to reduce power draws could follow.

"I think increasing numbers of offices are trying to do that, but it's a real challenge because the most important thing is to take care of sick kids," says Shea.

Modalities and Mechanisms for Susceptibility to Climate Change in Children

Modality	Mechanism	Increased Exposure
Metabolic	Greater respiratory rate	Air pollution, allergens
	Greater metabolic rate	Malnutrition, thermal extremes
	Greater water demand per unit body mass	Gastrointestinal tract diseases, dehydration
Behavioral	More outdoor time More vigorous activity	Infectious diseases, air pollution, UV radiation, thermal extremes, allergens
	Less ability to avoid unhealthy situations	Weather extremes, UV radiation, thermal extremes
	Less swimming capacity	Drowning
Physiology	Greater surface area to volume ratio	Infectious diseases, UV radiation
	Less detoxifying capacity	Air pollution, infectious diseases, thermal extremes
	Less skin development	UV radiation
	Less immunity	Infectious diseases, allergens, or mycotoxins
Time	Greater latency for genetic and long-term effects Greater lifetime exposure time	UV radiation, malnutrition, allergens
Development	Undergoing development	Malnutrition, stunting, psychosocial trauma Morbidity and quality of life

Source: Bunyavanich S et al. The impact of climate change on child health. *Ambul Pediatr*. 2003;3(1):44-52. Reproduced with permission.

Health Advice in Pediatric Offices Can Go Hand in Hand With Easing Climate Change

Everyone knows the drill: replace incandescent light bulbs with fluorescent bulbs, walk or bike to reduce vehicle emissions, and turn off the lights in rooms that are not being used. Opportunities to reduce greenhouse gas emissions that influence climate change are plentiful. But experts say that as the caretakers for children's health, pediatricians and other clinicians who care for children are in an opportune position to take action that mitigates the effects of climate change.

"Pediatricians look into the future . . . we're trying to build healthy bodies and, therefore, a healthy population," says Katherine Shea, MD, MPH, adjunct professor of maternal and child health at the Dennis and Joan Gillings School of Global Public Health at the University of North Carolina in Chapel Hill.

Shea has written several papers on climate change and children's health. Her work not only explains the disproportionate burden children face from climate change, but also steps that pediatricians and other clinicians can take to lessen the impact.

"Make it part of the rationale for doing things that are good for you," she says. Ensuring that all pediatric patients are fully immunized and that their parents know how important it is for children to have a healthy diet and get adequate sleep and regular exercise are key steps. All of these measures, says Shea, help children become more durable and less susceptible to infectious diseases and other consequences of climate change.

Advising families to walk or ride bicycles instead of driving to reduce vehicle emissions also encourages them to get more physical activity, which, in turn, could help to reduce high rates of overweight and obesity among children and adults. "Talking about the importance of diet and exercise and the co-benefit of decreasing greenhouse gases is the way to go," says Shea.

A similar theory applies to patients with asthma. Teaching families how to find local air quality information in the daily newspaper or online can help them reduce their exposure to pollutants. Shea also suggests that pediatricians encourage parents to push for state or local laws that limit or prohibit extended idling of school buses.

Creating a handout that explains the relationship between climate change and health is another helpful step that pediatricians and other clinicians can take for patients and their families. Linking a global phenomenon that may seem overwhelming to small steps that individuals can take may motivate patients to make substantial lifestyle changes, especially when the future of their children and grandchildren comes into play.

But Shea also suggests a number of steps that pediatric practices can take to mitigate climate change: follow the Green Guide for Health Care (http://www.gghc.org), a best practices toolkit for environmentally healthy health care operations; offer incentives for staff who walk, bike, carpool, or take public transportation to work; and encourage networking with colleagues more often by telephone or electronically rather than traveling. Shea also says that pediatricians can be effective local spokespersons on the links between climate change and health.

"As health care professionals, we need to be making it very clear that these are health threats that we don't want to have to live with, and that we can avoid," says Shea. "But we have to mitigate, we can't just prepare." —R.V.

The AAP's Committee on Environmental Health has been debating further measures to spread this message among pediatricians. Helen Binns, MD, MPH, the committee's chair, says the academy proposed the development of a certification program for "green" pediatric offices but was not able to obtain funding from the US Centers for Disease Control and Prevention to pursue the program. "We haven't been able to move forward with that," she says.

"The first wave of strategy is to have pediatricians look at their own offices and make changes in that regard," says Binns, professor of pediatrics and preventive medicine at Northwestern University's Feinberg School of Medicine in Chicago.

TECHNOLOGY, NOT TRAVEL

In April, pediatrician Jeffrey Goldhagen, MD, MPH, of the University of Florida College of Medicine in Jacksonville, was a co-organizer of an international videoconference intended to educate pediatricians and child health care professionals on ways to mitigate the impact of climate change on children's health. The conference linked speakers and viewers in 17 cities in 10 countries.

In addition to raising awareness about climate change and children's health, Goldhagen says another objective was "to use technology to bring global partners together." He noted that efforts in the United Kingdom in particular have been aimed at creating ways for physicians and health professionals to share ideas and to work together in ways that do not include carbon-producing long-distance travel. "Here in the US, we haven't moved along that continuum nearly to the same degree," says Goldhagen.

Back in Boston, Bernstein makes an effort to give his patients' parents a quick rundown on how such vector-borne illnesses as Lyme disease that make their children sick are linked with climate change and its influence on ecosystems.

"Things like climate change are affecting our health on a much bigger scale than people might realize," he says. "It's important to understand that climate change is perhaps the greatest public health issue of the century." □