

Virtual Mentor
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Medicine and the Environment: Doing No Harm

From the Editor

- The Yin/Yang of Health and the Environment** 425
Mitali Banerjee Ruths

Educating for Professionalism

Clinical Cases

- Educating Patients as Medicine Goes Green** 427
Commentary by Louise P. King and Janet Brown

- Physicians' Duty to Be Aware of and Report
Environmental Toxins** 434
Commentary by Gina M. Solomon and Steven R. Kirkhorn

Medical Education

- Climate Change and Human Health 101** 443
Kristie L. Ebi

Journal Discussion

- Hospitals and "Used Goods"** 448
Jason Gillman

Clinical Pearl

- The Biochemistry, Diagnosis, and Treatment of
Nitrate Toxicity** 451
Amir Miodovnik

Law, Policy, and Society

Health Law

- Proving Causation in Environmental Litigation** 456
Kristin E. Schleiter

Policy Forum	
Caring for the Health of the Community Means Caring for the Health of the Environment	461
Nancy J. Larson	

Medicine and Society	
Medicine’s Role in Mitigating the Effects of Climate Change	465
Andrew Jameton	

History, Art, and Narrative

History of Medicine	
The Lesson of John Snow and the Broad Street Pump	470
Mitali Banerjee Ruths	

Op-Ed and Correspondence

Op-Ed	
What Primary Physicians Should Know about Environmental Causes of Illness	473
William J. Rea	

Resources

Suggested Readings and Resources	477
About the Contributors	485

Upcoming Issues of *Virtual Mentor*

July: Medicine in the Era of Globalization
August: Problematizing the Principle of Autonomy
September: Ethical Questions in Genetic Testing
October: Religion, Patients, and Medical Ethics

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FROM THE EDITOR

The Yin/Yang of Health and the Environment

You see that pale, blue dot? That's us. Everything that has ever happened in all of human history has happened on that pixel. All the triumphs and all the tragedies. All the wars, all the famines, all the major advances. It's our only home. And that is what is at stake: our ability to live on planet Earth, to have a future as a civilization. I believe this is a moral issue. It is your time to seize this issue.

—Al Gore, *An Inconvenient Truth*

In 2006, director David Guggenheim made the Academy Award-winning documentary *An Inconvenient Truth* about former Vice President Al Gore's quest to raise public awareness on global warming and climate change, framed not as just a political issue, but a moral one, requiring immediate attention. Gore rekindled interest among citizens, business owners, politicians, and legislators to “go green”—to examine the choices we make with the environment in mind. As in the 1960s when Americans started grassroots campaigns to protect the environment; save the rainforest, save the whales, save the chimpanzees, save the polar ice caps, save the ozone layer, reduce, reuse, and recycle—it suddenly became trendy to love the planet again. People started bringing reusable tote bags to the grocery store, buying more energy-efficient light bulbs and appliances, considering more fuel-efficient or hybrid cars, and switching to power companies that use renewable resources like wind or solar energy. Businesses took cues from the consumers and started making greener products, greener buildings, and greener commercial models. The government also responded to growing public advocacy, implementing policies at local and national levels to improve our air quality, incentives to consume less-polluting and more-renewable forms of energy production, and initiatives to reduce society's carbon footprint. With Gore receiving the Nobel Peace Prize for his efforts, and all the public hoopla and media attention about the environment, we could only expect that health care would eventually be swept into the green revolution and experience an environmental awakening.

Unlike businesses, consumers, and even the government, however, health care must not whimsically follow tides of social opinion nor yield even to the force of scientifically proven facts without first considering its mandate to safeguard the health of the people and communities it serves. This timely June issue of *VM* looks at medicine and the environment: the interplay of physicians, hospitals, medical organizations, and health care professionals with our planet and its resources. We explore how our actions and policies relate to the patient-physician relationship, to our well-being as a species, and our obligation to, as Gore put it, “seize this issue” and catalyze change.

Examined closely, the topic is as vast and complex as the pale, blue dot we live on, and this issue highlights only a few of the many intricate facets of the discussion we hope to elicit. The authors who accepted the challenge to write about medicine and the environment approached the topic in terms of two broad categories, entwined in an ecological yin and yang—how the human health enterprise contributes to waste and destruction of the environment, and then how environmental toxins and exposures in turn affect human health.

Do we have special responsibilities as doctors to be advocates for environmental change? Does considering the environment mean a compromise in quality of care? Is the trend of hospitals going green by recycling and reducing toxic wastes just a fad or must it become a fundamental, conscious, lasting effort in how we practice medicine? As physicians, while we cannot steward the planet, we can be watchful over the smaller communities that we serve. We can identify environmental factors that affect the health of our patients and their families and help them seek justice within the legal system for harmful environmental exposures. Although readers may notice a well-intentioned overall bias toward “an inconvenient truth” in this issue, I hope each section incites us to explore an aspect of this relatively uncharted terrain of medical ethics: our duty as physicians “to do no harm” to the communities we serve, to our descendants, and, ultimately, to the planet Earth.

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CLINICAL CASE

Educating Patients as Medicine Goes Green

Commentary by Louise P. King, MD, JD, and Janet Brown

Ms. Chen had been going to Dr. Patel's outpatient gynecology practice for several years for her annual well-woman exam. The rural clinic was understaffed, and it was all the few participating physicians could do to manage the patient load.

A few months before Ms. Chen's yearly check-up, Dr. Patel's small group practice instituted a policy to stop using plastic specula for gynecological exams. The clinic-wide policy was an effort to reduce waste and avoid the increased shipping costs of plastic specula. Signs were posted in the clinic waiting area that informed patients of the practice's decision to "go green," and thanking them for their understanding and continued support.

Ms. Chen preferred the single-use plastic speculum, however, for hygiene reasons. She did not want to get a sexually transmitted disease from an improperly sterilized instrument and requested a single-use plastic speculum for her exam. Dr. Patel informed her that the clinic no longer stocked them and reassured Ms. Chen that measures had been taken to guarantee the metal specula were properly sterilized.

Commentary 1

by Louise P. King, MD, JD

Dr. Patel and her small group practice should be commended for "going green"—a movement that has become common in both large academic centers and public hospitals. Experts estimate that U.S. hospitals produce an average of 6,600 tons of waste per day. Over the past 10 years, waste production has increased as much as 15 percent with the escalating use of disposable, single-use products such as plastic specula [1]. Much of our medical waste is incinerated, with the resultant release of noxious gases that many argue are detrimental to the environment [2]. Movement toward recyclable materials should be encouraged not only as a cost-saving measure for hospitals and clinics but also as a necessary change to alleviate some of the burden of medical waste.

At the same time, Ms. Chen should not be faulted for expressing a fear, however unwarranted, that a change to a metal speculum would expose her to infectious disease. She is most likely unaware of the inherent safety of sterilization procedures. Perhaps Dr. Patel could educate her about this, which may or may not alleviate her fears. Ultimately, if Ms. Chen refuses an exam with a sterilized speculum, as the case asks, must Dr. Patel provide her choice of speculum? The answer is probably no.

As a question of principle, Dr. Patel should enforce the new green policy uniformly. Making exceptions in individual cases opens the door to an untenable situation. If enough patients demand specific nonreusable materials, this small practice might end up with a large stock room full of alternative materials. Even assuming one could charge the patient the cost of the speculum or other material, maintaining a room of alternative materials would be cost-prohibitive. More importantly, it would violate the group's new commitment to green practices, not only by including nongreen materials it had decided to exclude, but also by providing a market, albeit small, for them.

An argument might be made that Ms. Chen suffers from mysophobia (i.e., germaphobia) and that this condition could be recognized as a disability. Certainly no physician can refuse necessary medical care to a patient because of a disability, and the case implies that Ms. Chen cannot easily find another source of medical care. It is even possible that this rural clinic receives federal funding, which might oblige staff to consider making a reasonable accommodation for patients with special needs. This does not automatically mean, however, that ordering plastic specula is a reasonable accommodation for Ms. Chen's impairment.

Assuming a small, federally funded rural center might be required by law to consider accommodating Ms. Chen's mysophobia, the accommodation would not stop with the regulation for a plastic speculum. If Ms. Chen needs a biopsy of her cervix, for example, a Tischler biopsy forceps will be used. There is no plastic single-use equivalent. Much of the equipment in physicians' offices and operating rooms has no single-use equivalent. Ms. Chen might be surprised to learn this, since the process for obtaining consent to treat in either office or operating room does not include a specific description of the materials that will be used.

This raises a broader question. As offices and hospitals move forward to "green" their practices, what form of notification and consent is required? This clinic attempted to make patients aware of the change with a posted sign. But this sign did little to educate Ms. Chen about the relative safety of sterilized metal equipment, and there was no formal process to ensure she consented to this change in practice. It is unlikely that a formal consent process is legally necessary, based on the standard test of what a reasonable person in the patient's position would want to know; there is no inherent change in the risk of using a metal speculum as opposed to a plastic one. Both pieces of equipment are considered standard of care, and a strong argument can be made that a patient need not be informed of each piece of equipment that will be used for treatment. That said, educating patients on the need for multiple-use equipment and addressing their concerns regarding safety is an important part of the process of "going green." Perhaps in some instances, merely offering patients a handout that details the problem with medical waste and the process and safety of sterilization will suffice.

There may be situations, however, in which physicians should consider a formal consent process. One example is the trend toward sterilization of devices originally marketed for single-use in the operating room. A reprocessing industry has emerged that collects single-use products—such as laparoscopic trocars or skin staplers—sterilizes, and returns them to the hospital for reuse [3]. The process is inherently safe and does not pose any additional risk to the patient on whom the product is reused. These products, however, are being used in a way not originally intended. An argument can be made that patient consent must be sought specifically for reuse of these products and that they be allowed to opt out. This would make recycled products less attractive to hospitals and would severely hamper an important effort to make our hospitals “green.”

In sum, as hospitals move toward environmentally sound practices, the public must be educated about the safety of new “green” products. This education may take various forms, but without it the public is unlikely to accept alternatives that, at first blush, seem to put them at risk. There is no legal or ethical requirement, however, that physicians adhere to a patient’s request to use single-use products. A physician does not violate any duty to a patient by enforcing green policies in a practice.

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I wish to acknowledge the valuable comments and insights of my colleague Blake E. Frieden, MD.

Commentary 2

by Janet Brown

Hospital mission statements emphasize healing environments, community, wellness, respect, and quality care. Yet, in the process of providing that care, hospitals simultaneously have a negative impact on human health and the environment through intensive energy and water consumption, use and disposal of toxic materials, and waste headed to landfills and incinerators. With the increased understanding of man’s impact on global climate and public health, physicians and health care

administrators must demonstrate leadership in addressing health care's role in environmental sustainability [1].

Over the last several decades, numerous reusable medical devices have been replaced with disposable ones in the name of infection control and ease of use. These decisions are coming back to bite us in the form of reduced landfill space and overuse of red bags—disposal of which costs at least five times more than disposal of nonregulated or regular waste. The sheer volume of waste has prompted health care professionals to look closely at inefficient practices and consider the value of going back to reusables in a number of areas—sharps containers, dishware, drapes, isolation gowns, and hard cases for sterilizing instruments, to name a few. Hospitals are working to reduce red-bag waste generation through staff education, standardized receptacles, and signage, and to cut the overall volume of waste through decreased use, reuse, and recycling.

Waste regulations and segregation practices have sometimes been based on *perceived* risk associated with a certain item, device, or practice, and not on science. This is precisely why, in the early 1990s when medical waste washed up on the eastern shores, IV bags were regulated in certain states and had to be handled as potentially infectious—not because they were infectious—but because they resembled blood bags. It proved to be a huge mistake costing hospitals hundreds of thousands of dollars to treat noninfectious wastes as if they were potentially harmful. Several years later, this perception-based regulation was changed to reflect scientific reality, but these poor habits have persisted in many facilities, where unnecessary red bagging is commonplace.

Health care professionals are in the best position to demonstrate their leadership through evidence-based approaches in sustainability initiatives and by correcting misinformation. In some cases, where scientific evidence is not yet available or difficult to study (for example, acceptable levels of exposure to multiple chemicals or the timing of fetal exposure), facilities are urged to take the precautionary approach [2]. The Precautionary Principle presumes an ethical imperative to prevent rather than merely treat disease, even in the face of scientific uncertainty. This principle can be understood as: “when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically” [3].

In the case at hand, Ms. Chen is concerned about the possibility of infection from a reusable speculum. Dr. Patel can step in here to educate her on the safety and environmental benefits of reusable medical device use. Dr. Patel could ask the facility sustainability officer, safety director, or infection-control practitioner to demonstrate the sterilization or high-level disinfection of the reusable speculum recommended by the Centers for Disease Control and Prevention's Guideline for Disinfection and Sterilization in Healthcare Facilities. Cold-sterilant and high-level disinfectant manufacturers back up their disinfection claims through rigorous study and offer quality assurance controls through protocol of staff training, cleaning and

disinfection, and other quality control measures [4]. The quality assurance protocol includes infection control with standardized methodology, staff training, posted policies, verification testing, and periodic, unannounced inspections by safety and infection-control staffers. Joint Commission (on Accreditation of Healthcare Organizations) inspections often include a close review of protocol, including staff interviews and documentation review.

Taking a leadership role on sustainability does not mean cutting corners on safety, quality, or infection control. A diverse team with clinician participation considers all criteria for sustainability interventions, and implementation is preceded by pilot testing, evaluation, policy development, research review, and sign-off from leadership.

Some physicians are not fully engaged with the specific environmental sustainability programs in their health care facilities. “Higher-ups,” for example, sometimes don’t enforce basic training requirements and participation in sustainability programming for all staffers, so a physician may not receive specific training on recycling or red-bag segregation. Health care delivery is a complex organism, and the more engaged staffers (on every level) are in sustainability, the faster and stronger it develops and the more embedded it becomes in the culture of the organization. Having a separation between clinicians and other staffers creates a barrier that can lead to regulatory compliance violations, safety concerns, and reduced morale on the part of other staffers. When it comes to participation in sustainability programs, no one should have an opt-out clause.

Support staffers tend to feel greater respect when physicians and other clinical leaders take that extra step to maintain a safe and healthy environment. An individual who drops a needle should bend down and pick it up and properly discard it in a sharps container even if that individual is the division chief. A person who is rushing down a stairwell and tempted to drop disposable gloves on the ground should hold onto the gloves until a waste receptacle is found. Someone in a hurry after treating a patient at the bedside and tempted to leave the disposable kit with blood-stained material on the table for someone else to clean up should resist the urge. The generator of the waste material should be responsible for its proper segregation into the appropriate containers. Following these guidelines will go a long way in setting a tone of environmental excellence and respectful work environments. The next time someone complains, “Well, those doctors won’t participate”—someone will speak up, “Yes they will; they’re on board and want to participate.”

While new medical students may not feel powerful as they venture into the health care environment, they *are* the future of health care and have a voice and role in clinical leadership on sustainability. Clinical support of green building, energy and water conservation, and toxicity- and volume-reduction programs can help propel the initiatives to a new level. Clinical leadership has led to elimination of toxic cleaning chemicals and support for building with LEED certification as a goal. It can give a program the push it needs to attract the attention of senior leadership and help

connect action with public health; purchasing with disease; materials with air quality; and management with illness.

Often staffers accustomed to a pre-ecoconscious work environment are the most difficult to convince, which is why the incoming clinicians are critical to the mission with their commitment to responsible procurement, training, use, and management of equipment and materials. The next generation of clinicians has greater knowledge of environmental sustainability and eco habits well established in their homes and personal belief systems; they will infuse health care with the enthusiasm, commitment, and determination it needs to move the entire sector.

How do these committed clinicians know where their facility falls on the greening spectrum, where to start, and what to do next? One option is the Green Guide for Health Care, a self-certifying toolkit that steers facilities through greener design, construction, and operations [5]. A project of the Center for Maximum Potential Building Systems, Health Care Without Harm, and Practice Greenhealth, the toolkit breaks greening the landscape into manageable chunks. Facilities can use this toolkit to assess where they are and plot their course to improvements over the long term. Version 3, currently in development, strives to identify the restorative visioning of health care. Concepts like restoring ecosystems; zero waste; renewable energy; collecting rain water; toxin-free purchases, building materials, furnishings, and finishings; and hosting farmers' markets are part of this future. More and more hospitals and health systems are realizing the value of naming a sustainability officer to lead environmental activities. The activities are steered by a diverse committee—where clinical leadership is a must.

Physician leadership, knowledge, education, and ability to leverage authority are critical to environmental sustainability in health care. Increased physician involvement will help as we progress from a policy of “doing less harm” to one of “healing communities.”

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[Hospitals and “Used Goods”](#) June 2009

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CLINICAL CASE

Physicians' Duty to Be Aware of and Report Environmental Toxins

Commentary by Gina M. Solomon, MD, MPH, and Steven R. Kirkhorn, MD, MPH

Miguel's mother brought her 3-month-old son to a rural clinic for an urgent care visit. Miguel was vomiting and had diarrhea. Among his other worrisome symptoms were cyanosis, drowsiness, and rapid breathing. His physician told his mother he needed to go to the nearest ER by ambulance and she agreed. At the ER, they were rushed into an exam room, with the baby on oxygen.

Miguel was found to have central cyanosis which had not improved despite the oxygen. After talking to his mother about the baby and their living situation, the ER physician ordered some specialized blood tests, co-oximetry, and a methemoglobin level. The infant was diagnosed with methemoglobinemia, and therapy was started, alleviating the cyanosis almost immediately. Miguel went home on the second hospital day with no evidence of brain damage from hypoxia.

Miguel was the fifth child seen in the hospital over an 8-week period with methemoglobinemia. The doctors believed all the cases were caused by nitrate toxicity. The widespread use of nitrate fertilizers increases the risk of water contamination in rural areas. Infants under 4 months of age are at particular risk of nitrate toxicity from contaminated water. Physicians suspected that the water Miguel's mother was mixing with his powdered formula was contaminated with nitrates.

Her primary doctor at the rural clinic told her, "your well water is probably contaminated. So you see, Miguel's blood has been changed by this water; it can't transport oxygen from the air he breathes around his body. So, that's why he was turning blue. It was dangerous. He needs safe water in his formula. Try finding some bottled water for now."

Commentary 1

by Gina M. Solomon, MD, MPH

Diagnosis of methemoglobinemia means that an infant has been exposed to a toxicant in the environment that has seriously endangered his or her health. In a rural environment, by far the most common cause of this disease is nitrate-contaminated water. Depending on the source of the contamination, large numbers of infants may be in danger of illness or death. From an ethical perspective, it is as unconscionable to fail to address the root cause of this problem.

In fact, this case already demonstrates a serious lapse of medical ethics, given that four infants have been seen at this hospital over 2 months with the disease, yet apparently no action has been taken. The proper course would be to act after an index case is diagnosed. If the physicians had already acted on their ethical obligation, Miguel might not have become ill.

Nitrate contamination has been an increasing problem in water systems in the United States, probably due to the growing use of synthetic fertilizers since the 1950s [1]. Nitrogen contamination also results from intensive livestock operations, leaking septic systems, and municipal wastewater discharges. The most commonly contaminated water supplies come from shallow groundwater aquifers. According to the U.S. Environmental Protection Agency (EPA), about 4.5 million people—almost all in rural areas—have nitrate levels in their water supply in excess of the legal limit (maximum contaminant level) of 10 mg/L of nitrate [2].

Infants are the most susceptible to methemoglobinemia for a variety of physiological reasons [3]. High exposures cause Blue Baby Syndrome (the characteristic blue-gray cyanosis as seen in this case); but lower levels of exposure are also harmful, decreasing oxygenation of the central nervous system, impairing neurodevelopment, and potentially resulting in the formation of carcinogenic nitrosamines in the stomach [2]. Public health action is therefore required not only to prevent the acute presentation, but also to protect a larger portion of the population against more subtle or delayed health effects.

First and foremost, the physician has a direct obligation to Miguel and his family. Obviously it is of paramount importance to educate the family about the problem [4]. Once the physician is assured that the family will not continue to consume the tap water, there are several possible courses of action, depending on the exact circumstances in the community.

If the family is served by a public water system, the system is in violation of the EPA drinking water standard and must be reported to both the local water utility and the EPA for investigation. In this case, the physician must educate the family and report the problem to these two authorities in order to discharge his or her ethical obligation. The EPA would follow up and work with the utility to address the violation and warn others who are served by the contaminated water system.

Many people in rural areas drink from private wells, which poses another problem. Well water is not regulated by any government agency. The expense of testing the water and purchasing a reverse osmosis filtration system falls completely on the family. The fact that 5 cases of nitrate poisoning have been seen in this hospital clearly indicates that, if well water is the source of contamination, the affected aquifer is tapped by numerous wells in the community. In a poor community, the cost of addressing this contamination can be prohibitive for the families involved. Here is where the physician must decide whether to act as an advocate for the health and well-being of the community. The Principles of Medical Ethics state that “A

physician shall recognize a responsibility to participate in activities contributing to the improvement of the community and the betterment of public health” [5]. The physician’s obligation therefore clearly extends beyond his or her own patient to the broader community.

The physician should contact the state or county health department and press them to provide free testing of drinking water for families on private wells living in the area and to issue warnings in the local press. Warning and informational signs should be posted in the hospital and local clinics in all languages spoken in the area. Practitioners in the hospital and community should be educated to provide anticipatory guidance to families and to recognize the early signs of methemoglobinemia. Although these activities are partially the responsibility of the health department, physicians have an obligation to educate their patients and push the health department to act if it does not do so quickly.

One ethical responsibility not commonly discussed is physicians’ duty to know the communities in which they practice. This obligation encompasses the need to understand social and cultural practices, socioeconomic challenges, and environmental hazards prevalent in the local community. In a rural agricultural community, hazards associated with farming, as well as specific hazards such as nitrate contamination, pesticide drift, and common allergens, should be well-understood by local practitioners. This knowledge promotes correct and rapid diagnosis when problems occur and enhances the physician’s ability to practice prevention through anticipatory guidance and patient education.

In summary, the physician’s ethical obligation goes beyond educating the individual family affected in this case and extends to reporting to appropriate authorities. If there are no regulatory authorities, the physician may have the duty to advocate for the families that might be affected to ensure investigation, remediation, and education. If a polluter is identified, that entity may be held responsible for the cost of investigating and remediating the problem, medical expenses, and permanent injuries to the affected infants. Finally, physicians have a responsibility to inform themselves about the communities in which they practice, so they are prepared for environmental health threats that may arise.

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Commentary 2

by Steven R. Kirkhorn, MD, MPH

The case of Miguel illustrates how exposure to a toxin that can be lethal for infants may be overlooked because the resulting condition is not a reportable disease. Miguel responded to treatment for a diagnosis secondary to nitrate exposure with no recognized sequelae. The hospital staff was attuned to the condition because Miguel was the fifth child seen with a diagnosis of methemoglobinemia during an 8-week period. By contrast, Wisconsin, a state which has had an active surveillance program for methemoglobinemia, identified eight cases from 1990 to 1999, three of which involved infants with formula prepared with water from nitrate-contaminated wells [1].

This extremely high incidence could be considered a public health threat, so it is appropriate for the hospital staff or pediatrics department that recognized the trend to notify the county or state public health department. More than 2,000 cases have been reported worldwide and sporadically in the United States since the first case of a fatal ingestion by an Iowa infant of nitrate-contaminated well water was reported in 1945 [2, 3]. Other sources of acquired methemoglobinemia include nitrate-contaminated food and medications such as benzocaine (used for teething), lidocaine, sulfonamides, and topical silver nitrates used for burns [2, 4, 5].

Physicians who see infants 6 months and younger with cyanosis in agricultural or rural areas should consider the possibility of nitrate-contaminated rural drinking water. The disease is more common in infants who are bottle-fed with formula that has been diluted with water from private wells than in breast-fed infants. Boiling water used to dilute formula increases the concentration of nitrates, but breast milk does not appear to be affected by maternal consumption of contaminated water [6].

Nitrates are one of the most common water contaminants found in agricultural states. An estimated 43 million U.S. citizens—15 percent of the population—are served by private well water, and 4 percent of the wells in one national sample had nitrates above the federal drinking-water standard of 10 mg/L nitrates [7]. In Wisconsin, 6.5 percent of private wells sampled had nitrate levels above the federal standard [8].

This study identified the following associations with elevated well water nitrate levels: (1) living on a farm, (2) lower annual incomes, and (3) older and shallower wells than families whose wells were low in nitrates [8]. A study in upstate New York identified 15.7 percent of sampled wells as having above-standard levels and found a positive association between larger farms and higher percentages of samples with elevated nitrate levels [9].

An environmental health history should be obtained from the parents of children diagnosed with methemoglobinemia, asking where their water supply comes from, whether other household members have had similar problems, and what the parents' occupations are [10]. Further questioning of medications used, folk remedies, and breast-feeding status of the infant is a critical component of the environmental history. Infants may have other illnesses and may have dehydration, acidosis, and diarrhea from wells contaminated from coliforms, often associated with elevated nitrate levels. Where these conditions are present, physicians may fail to consider a diagnosis of methemoglobinemia.

Infants less than 4 months old are susceptible to methemoglobinemia due to a number of physiological factors: (1) alkaline gastric conditions increase gastrointestinal microflora which convert nitrates to nitrites; (2) lower circulating hemoglobin levels and higher fetal hemoglobin, which is more susceptible to oxidation; and (3) decreased amount of methemoglobin reductase [4, 5, 11]. Methemoglobin is oxidized hemoglobin and is incapable of carrying oxygen to tissues. After 4 months of age the gastrointestinal environment becomes more acidic and alters the microbial flora, methemoglobin reductase levels increase, and the proportion of fetal hemoglobin decreases to the point that there is less susceptibility to methemoglobinemia. The normal level of circulating methemoglobin in healthy individuals is less than 1 percent [5].

The maximum contaminant level (MCL) standard for nitrates set by the Environmental Protection Agency applies only to municipal water supplies since private wells are not subject to federal regulation [12]. Private water supplies do, however, fall under state health advisories in many if not all states. The advisories recommend that private well owners monitor nitrate levels every 2 to 3 years—or yearly if elevated nitrate levels have been previously detected—test for coliforms, and maintain nitrate levels below 10 mg/L nitrate. Monitoring annually is also recommended if there are infants under 6 months of age in the household or pregnancy is anticipated. Routine testing should be scheduled during the late spring or early fall of the year when the nitrate levels would be at the highest due to fertilizer application or rainfall [13].

Discharge planning should include education of the parents about environmental contamination of drinking water and safe drinking water for the family members at risk. Questions have been raised about chronic consumption of nitrate-contaminated drinking water and illnesses such as cancer and reproductive health concerns, but evidence is equivocal for such associations [2, 14]. Reproductive concerns include

complications and adverse outcomes such as anemia, preeclampsia, threatened spontaneous abortions, premature labor, neural-tube defects, low birth weight, congenital cardiac defects, and other congenital malformations. Not all studies identify sufficient evidence of a causal relationship between these outcomes and exposure to nitrates in drinking water [15]. Nevertheless, the goal should be avoidance of exposure above the federal standard, which is set to prevent methemoglobinemia in infants. Resuming the same patterns of diluting the infant's formula with water contaminated with high levels of nitrates will increase the likelihood of a recurrence of methemoglobinemia.

The drinking water source should not be used until the water has been tested for nitrates. Testing can be arranged by contacting the public health department and requesting that the county public health nurse arrange for evaluation of the water supply at the family's residence and take steps to coordinate the evaluation of the drinking water source of the other children with observed methemoglobinemia. If the family has not given permission to share its information with public agencies, be sure to review HIPAA regulations on release of personal health information.

Methemoglobinemia is generally not a reportable disease; few states have surveillance programs for methemoglobinemia, and there may not be another method for informing public health professionals that a community environmental health risk may exist. Because Miguel, in our case scenario, is the fifth child to have this diagnosis in a short period of time and in the same region, a common source of nitrate contamination that could lead to additional cases of toxicity should be sought. Mapping of the recent cases of methemoglobinemia and the associated water supplies to identify a common point source of pollution falls under the responsibility of the state epidemiologist of the public health department or state environmental control agency. An excellent account of the classic work of John Snow and others in unraveling the source of cholera in London and the role of epidemiological mapping was published in 2006 [16].

If the families of affected infants are migrant workers living in camps or other housing provided by their employers, the Occupational Safety and Health Administration (OSHA) should be contacted by the health professional or the employees of the agricultural operation. OSHA regulates migrant housing, and the housing inspection checklist addresses proper location and maintenance of wells and requires that the housing have an adequate water supply that has been approved by the appropriate health authority [17]. Some states, such as Ohio, also mandate testing of potable water for coliforms and nitrates on a regular basis as part of migrant labor-camp oversight [18].

Families that are not documented and do not have valid visas or worker permits may not cooperate with a public health referral. *Promotores*—lay health educators serving the Hispanic community—are excellent community resources who aid in health efforts and outreach and may help persuade the families to allow public health or environmental regulatory agencies to test the water and provide abatement. Migrant

labor camps, federally funded neighborhood clinics, and community health centers in many states have *promotores* [19, 20]. Testing well water for coliforms and nitrates (usually done together) costs from \$7 to \$25 and \$20 to \$40, respectively, per test and is usually carried out at the well owner's expense [21].

The only effective methods of lowering nitrate levels at the point of entry into the house are reverse osmosis, ion exchange, or distillation devices [22]. These devices are expensive and must be monitored because they can fail. Activated charcoal filters at the faucet or point-of-use are not effective. The end result may be that the family must move or buy bottled water to prepare formula for bottle feeding.

Practitioners who are not experienced in treating methemoglobinemia should consult the regional poison-control center or a medical toxicologist for aid in managing cases of methemoglobinemia. The hospital staff treating the children with methemoglobinemia in our case scenario should offer continuing medical education and public outreach to address a significant environmental health concern in their service area and increase awareness of potentially lethal exposures not otherwise commonly seen by the majority of practitioners. For online resources, see the CDC Agency for Toxic Substance and Disease Registry Case Studies in Environmental Medicine, nitrate/nitrite toxicity [2], the CDC National Agricultural Safety Database [23], and the EPA safewater homepage [12].

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The people and events in this case are fictional. Resemblance to real events or to names of people, living or dead, is entirely coincidental.

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MEDICAL EDUCATION

Climate Change and Human Health 101

Kristie L. Ebi, PhD, MPH

Climate change poses real health risks for U.S. populations [1]. Through rising temperature, changes in the hydrologic cycle, and sea level rise, climate change is projected to increase the frequency and intensity of heat waves and other extreme weather events (including floods and droughts); alter the geographic range and incidence of climate-sensitive vector-, food-, and waterborne diseases; increase diseases associated with air pollution and aeroallergens; and add to malnutrition in many regions. Often not the *sole* cause of increases in the burden of climate-sensitive health outcomes, climate change interacts with other public health stresses.

Understanding the full range of the health risks of climate change is beyond the scope of this article; for more information, the reader is referred to assessments recently conducted in the United States, Canada, and internationally or to a publication from the Ontario College of Family Physicians aimed at educating family physicians on climate change and health issues [1-4]. Many of these health risks—such as cardiorespiratory illnesses associated with or exacerbated by elevated concentrations of ground-level ozone or injuries and deaths from windstorms and floods—are familiar to most health care professionals. Other risks, however, could challenge health care professionals if unfamiliar climate-sensitive health outcomes become more common, change their distribution, or reemerge.

Greenhouse Gases

The uneven warming of the Earth's surface is the principal driving force for weather and climate, with complex and changing atmospheric and oceanic patterns redistributing solar energy from the equator to the poles. Atmospheric greenhouse gases (including water vapour, carbon dioxide, methane, nitrous oxide, and halocarbons) absorb and reradiate back to the surface some of the solar radiation emitted by the Earth, raising the surface temperature considerably. Increasing the atmospheric concentrations of greenhouse gases will cause further warming.

Carbon dioxide is a central anthropogenic greenhouse gas. It is not destroyed chemically but removed from the atmosphere through multiple processes that transiently store the carbon in land and ocean reservoirs and ultimately in mineral deposits [5]. Natural processes currently remove about half the incremental anthropogenic carbon dioxide added to the atmosphere annually. The balance is removed over 100 to 200 years [6]. This inertia in the climate systems means the Earth will inevitably endure decades of climate change, even with aggressive reduction of greenhouse gas emissions. About 75 percent of the anthropogenic

carbon dioxide emissions to the atmosphere during the past 20 years were due to fossil fuel burning, with most of the rest due to land-use change, especially deforestation [5].

Over the past 100 years, the global average surface temperature rose by 0.74 degrees C, with most of the warming attributable to human activities and with the 1990s being the warmest decade [5]. The linear warming trend over the past 50 years (0.13 degrees C per decade) is nearly twice that for the last 100 years. Under a range of scenarios of greenhouse gas emissions, the global mean surface temperature is projected to increase by 1.1 to 6.4 degrees C by 2100. The projected rate of warming is much greater than the observed changes during the 20th century and is very likely to be without precedent during at least the last 10,000 years.

Heat Waves

The risk of heat waves is generally not well appreciated by the health care community or the public. Heat is the major weather-related cause of death in the United States. From 1999 to 2003, 3,442 reported deaths resulted from exposure to extreme heat, 66 percent of them males [7]. Cardiovascular disease was recorded as the underlying cause of death in 57 percent of cases in which hyperthermia was a contributing factor. Approximately 70 percent of these heat-related cardiovascular deaths occurred among people with known chronic ischemic heart disease. Other underlying causes of heat-associated death included unintentional poisonings in 29 percent of deaths; endocrine, nutritional, and metabolic disorders in 3 percent of deaths; and all other underlying causes, including infection and psychiatric disorders, in 11 percent of deaths. The state with the highest average annual hyperthermia-related death rate was Arizona (1.7 deaths per 100,000 population), followed by Nevada (0.8), and Missouri (0.6). During the 2006 heat wave in California, heat-related emergency department visits increased more than sixfold and hospitalizations increased more than tenfold [8].

About 40 percent of heat-related deaths occur in adults over the age of 65 [7]. Members of this population are more vulnerable because of intrinsic changes in their thermoregulatory systems and the use of drugs such as diuretics, stimulants, beta-blockers, anticholinergics, digitalis, barbiturates, and others that interfere with normal homeostasis [9]. In addition, age correlates highly with increasing illness, disability, and reduced fitness, all of which heighten vulnerability to heat.

Simply informing individuals that they are at greater risk during a heat wave is insufficient. As homeostasis is impaired, the elderly may not be aware that they are becoming ill and therefore may not take appropriate actions to reduce their heat exposure. A survey of adults over the age of 65 in four cities (Dayton, Ohio; Philadelphia; Phoenix; and Toronto, Canada) found that 90 percent were aware that a heat wave early warning had been issued within the previous week, and approximately three-quarters could name at least one action they should have taken to reduce their heat-related risk—yet less than 50 percent actually changed their behavior [10]. The health care community should develop more active outreach to

those at increased risk during heat waves, in conjunction with local public health and meteorological departments and services.

Infectious Diseases

Increasing temperatures and changes in the hydrologic cycle provide opportunities for many pathogens and vectors to change their geographic range, replication rate, and transmission dynamics. Climate is a primary determinant of whether a particular location has the environmental conditions suitable for the transmission of several vector-borne diseases, including dengue fever, St. Louis encephalitis, and West Nile virus. A change in temperature may hinder or enhance vector and parasite development and survival, thus lengthening or shortening the season during which vectors and parasites survive. Small changes in temperature or precipitation can cause previously inhospitable altitudes or ecosystems to become conducive to disease transmission (or cause currently hospitable conditions to become inhospitable).

For example, a retrospective review of three independent patient databases in Alaska reported a statistically significant trend in the number of patients seeking care for insect reactions over 14 years [11]. Fairbanks had a fourfold increase in patients in 2006 compared to the 1992 to 2005 period, and Anchorage had a threefold increase between the 1999 to 2002 and 2003 to 2007 periods. A review of the Alaska Medicaid database from 1999 to 2006 also showed statistically significant growth in medical claims for insect reactions in five of six regions, with the largest percentage increases occurring in the most northern areas. Since 1950, average annual and winter temperatures in Alaska rose 3.4 degrees F and 6.3 degrees F, respectively. Average winter temperatures increased at least 6 degrees F in regions that reported a significant rise in bite or sting events, leading the authors to conclude that warmer temperatures may have been a contributing factor.

Climate change also may facilitate the emergence of infectious diseases. For example, *Vibrio parahaemolyticus*, the leading cause of seafood-associated gastroenteritis in the United States, is typically associated with the consumption of raw oysters gathered from warm-water estuaries. In 2004, an outbreak occurred in Alaska where the consumption of raw oysters was the only significant predictor of illness; the attack rate among people who consumed oysters was 29 percent [12]. All oysters associated with the outbreak were harvested when mean daily water temperatures exceeded 15.0 degrees C (the theorized threshold for the risk of *V. parahaemolyticus* illness from the consumption of raw oysters). Between 1997 and 2004, mean water temperatures in July and August at the implicated oyster farm increased 0.21 degrees C per year; 2004 was the only year during which mean daily temperatures did not drop below 15.0 degrees C. The outbreak extended by 1,000 km the northernmost documented source of oysters that caused illness due to *V. parahaemolyticus*. Rising temperatures of ocean water may have contributed to one of the largest known outbreaks of *V. parahaemolyticus* in the United States.

Conclusion

The inherent inertia in the climate system implies that climate will continue to change for decades after significant reductions in greenhouse gas emissions are achieved, committing future generations to increasing climate-related health risks. Basic understanding of climate change and its potential health impacts should be included in training and professional development courses for health care professionals to reduce current and projected injuries, illnesses, and deaths due to climate-sensitive health outcomes.

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JOURNAL DISCUSSION

Hospitals and “Used Goods”

Jason Gillman, MD

Moszczyński A. Is once always enough? Revisiting the single use item. *J Med Ethics*. 2009;35(2):87-90.

Reduce, Reuse, Recycle. We learn the three Rs as conscientious school children, after which we happily forget this plea for conservation as wasteful and busy adults. In general, it's probably good advice, but how does it apply to the so-called single-use items purchased in bulk by hospitals and ranging from anesthetic circuits to surgical instruments? According to Alice Moszczyński, reuse of single-use items in hospitals is a common, and often nondisclosed practice, despite current recommendations advocating single use only [1]. These items are frequently sterilized then used again, generally without informing the patient. In “Is Once Always Enough? Revisiting the Single Use Item” Moszczyński draws on several ethical frameworks to address this complex issue.

Moszczyński begins by emphasizing the most obvious point of ethics inherent in any hospital practice: that of informed consent. She cites the ethical theory of contractarianism, which highlights maximizing self-interest as a moral paradigm [2]. If a patient's autonomy is to be respected, she asks us, is it essential that use of a previously used single-use item be disclosed? It is certainly not a requirement to provide every detail of every procedure [3]. But if current recommendations advocate single use only of these items, it seems reasonable to conclude that any practice deviating from accepted guidelines would demand informed consent, especially in a country marked by increasing litigation and rising malpractice premiums.

Based on my own experience in Pittsburgh hospitals, it appears that most patients are unaware of the matter, and in fact, as Moszczyński implies, I have never been posed a question regarding the practice. Epstein, however, argues that just because a patient is unable or disinclined to frame the question, doesn't mean he or she would not benefit from the information [4]. Even if we assume that the reused item was properly sterilized and has the same safety and efficacy as an unused item—a separate concern addressed by the author—the choice could be compared to the selection of generic versus brand medications. In the latter case, patients are given an option between the two. Nevertheless, hospital policies often provide no guidance to physicians in allowing patients to decline a reused single-use item [5, 6]. This preemption of shared decision making, most likely viewed as a minute detail omitted

for the sake of convenience and saved time, could also be interpreted as a remnant of paternalism which pervaded medical culture until recently.

Although autonomy and informed consent are vital to maintaining the best possible individual patient care, Moszczynski points out that in our current economic climate, the needs of the health care community at large cannot be overlooked [1]. She applies utilitarianism in suggesting that reuse of items designed for single use may lessen the financial burden on society. Although she counters that no price can be put on a person's health, the practical fact is that we live in a nation of limited health care resources, the allocation of which is an area of active political debate. If used single-use items are sterilized and donated to third-world countries, those same items should be acceptable for a Western nation with rapidly escalating health care costs [1]. That said, it remains unclear without a definitive cost-benefit analysis that considers the labor, materials, and time required for sterilization procedures whether reuse actually saves money [1].

Finally, we would be remiss if we did not return to the patient who drove conservationists to coin the three Rs: Mother Earth. Moszczynski shows us that the contractarianism and utilitarianism analyses described above both appear in opposition to the "land ethic," which places value on the ecosystem as a whole. In the welfarist approach, the well-being of sentient creatures must be advanced at the expense of the inanimate [7]. Applied to the field of medicine, welfarism suggests that health care must be advanced at the expense of generating large amounts of medical waste. As anyone who has seen the Disney/Pixar feature film *WALL-E* understands, the well-being of the environment can directly impact the well-being of its inhabitants. A desolate planet covered with heaping piles of garbage and radioactive waste benefits neither the individual nor society. In fact, the movie depicts an environment so toxic that it forces the entire population of Earth to relocate into space and assume a sedentary, and almost certainly unhealthy, lifestyle.

Although *WALL-E* is fictional, real-life reports of medical waste washing up on beaches in England and the discovery of medical waste contaminated by *Mycobacterium tuberculosis* make it clear that the environmental footprint of a health care facility cannot be overlooked [8, 9]. While single-use items may advance patient care, they also contribute to our growing landfills, with potential risk to those living nearby. Similarly, reprocessing a used item requires chemicals that may end up in our water or even food supply [1]. While contractarianism, utilitarianism, and land ethic may seem to be in opposition at first glance, the NIMBY phenomenon of the 1980s proved that a neighborhood garbage dump is never in a community's self-interest.

There appears to be no single solution to the problems created by reusing single-use items. A blanket consent, signed at the onset of hospitalization, covering such matters as generic medications and single-use items, could adequately address the dilemma of informed consent. Official hospital policies will be essential in achieving this goal. More data is needed regarding the cost-benefit outcome of reuse and the

safety and efficacy of the practice. Unfortunately, there is little incentive from manufacturers, motivated primarily by sales, to perform these studies, making government funding critical. Although the environment cannot be overlooked, one need only walk through a single hospital wing to appreciate the sheer volume of medical waste we generate. Even if items cannot be reused, there is no reason why the plastic gowns, metal needle-drivers, and paper charts cannot be recycled. Moszczynski offers great insight as she interprets reuse of single-use items within three distinct ethical frameworks. Her work is undoubtedly a strong first step in developing a comprehensive and balanced solution to this complex problem.

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CLINICAL PEARL

Biochemistry, Diagnosis, and Treatment of Nitrate Toxicity

Amir Miodovnik, MD

Pediatric review books often contain a case of a previously healthy infant who comes to a clinic or ER with a recent history of diarrhea and vomiting followed by the onset of central cyanosis that does not improve with supplemental oxygen. The salient background information centers on the water source used to prepare the child's feedings, which often derives from a private well rather than a municipal water source. Cyanosis refractory to standard oxygen therapy suggests that the hypoxia does not stem from a congenital or acquired cardiac or respiratory defect. The dramatic improvement reported following treatment with the correct antidote belies the complex biochemical pathways underlying the condition known as methemoglobinemia. What I hope to do in this brief clinical pearl is highlight an important environmental cause of pediatric methemoglobinemia.

Background

Methemoglobinemia is a disorder in which the hemoglobin molecule is functionally altered and cannot transport oxygen. There are both hereditary and acquired forms of the disorder. The hereditary types are rare and usually show up in the first days of life, so I will not discuss them here. Most cases of reported methemoglobinemia are drug-induced, the major pharmaceutical culprits being benzocaine (a topical anesthetic often found in teething gels) and dapsone (an oral antibiotic used to treat certain skin conditions) [1]. Our discussion centers on environmental sources. Nitrate and nitrite are the chemicals most often implicated in epidemic methemoglobinemia as depicted in our clinical case.

The association between nitrate-contaminated well water and blue baby syndrome was first described in the early 1940s. Agricultural fertilizers containing nitrogen in the form of ammonia or ammonium nitrate are responsible for sustaining one-third of the Earth's population. Runoff from these fertilizers contains high levels of nitrates which leach into the groundwater that supplies shallow wells; additional sources of nitrate contamination include septic systems and manure storage or spreading operations [2]. Federal standards for public water supplies do not apply to private wells. Approximately 15 million families in the United States obtain their drinking water from unregulated, domestic wells, and an estimated 2 million of those homes may fail to meet the federal water-safety standard for nitrate of 10 ppm (mg/L) [3].

Babies consume large quantities of water relative to their body weight, particularly if water is used to mix powdered or concentrated formulas or juices. Nitrates are converted to nitrites by gastrointestinal bacteria, especially in young infants in whom

the lower acidity of gastric secretions allows for bacterial proliferation and increased production of nitrites. Nitrites react with oxygen to form oxygen-free radicals which are powerful oxidizers of cellular substrates, including hemoglobin. Events resulting in metabolic acidosis, such as severe diarrhea, dehydration, or sepsis in young infants may increase methemoglobin levels independent of nitrate ingestion. Given that infants begin with lower levels of protective enzymes against methemoglobin, they can develop severe symptoms after only brief exposure to contaminated well water [4].

Pathophysiology

- Methemoglobin (MetHb) occurs when the hemoglobin molecule becomes oxidized in the absence of molecular oxygen. In this oxidized ferric state, hemoglobin can no longer react with oxygen molecules.
- Red blood cells have multiple mechanisms to maintain the normal concentration of methemoglobin at less than 1 percent.

Newborn infants usually have around 1 to 2 percent concentration of methemoglobin. A serum MetHb concentration above 2 percent is termed methemoglobinemia [1]. Under normal circumstances, the most important reductive system involves nicotinamide adenine dinucleotide (NADH), a byproduct of cellular glycolysis. This enzyme system enables the rapid conversion of oxidized methemoglobin back to hemoglobin and clears more than 95 percent of the methemoglobin formed under normal circumstances.

- The enzyme system, however, is not fully active in normal infants until about 4 months of age; therefore, infants are more susceptible to conditions that favor the formation of excess methemoglobinemia [4].
- Methemoglobinemia occurs when the primary enzymatic mechanisms for eliminating methemoglobin are overwhelmed by an exogenous oxidizing drug or chemical agent.

Excessive levels of methemoglobin reduce the oxygen content of blood by reducing the oxygen-carrying capacity of hemoglobin. First, the oxidized ferric ion has a reduced affinity for binding oxygen. Second, methemoglobin results in a leftward shift of the oxygen dissociation curve causing normal hemoglobin to bind oxygen more tightly and preventing the oxygen from unloading freely at the peripheral tissues.

- The key clinical endpoint in methemoglobinemia is the severe tissue hypoxemia and metabolic acidosis (lactic acidosis) resulting from diminished oxygen delivery to peripheral tissues [5].

Presentation

- Patients with methemoglobinemia may have profound cyanosis but only minimal respiratory distress.

The classic chocolate-brown coloration of blood is usually seen at concentrations of 15 to 20 percent. Although patients may have clinical signs of cyanosis at this level,

they are typically asymptomatic. At methemoglobin concentrations between 20 to 50 percent, symptoms include anxiety, headache, weakness, and lightheadedness, and patients may exhibit tachypnea and sinus tachycardia. Infants may demonstrate generalized symptoms such as poor feeding, lethargy, and irritability. Methemoglobin concentrations of 50 to 70 may result in myocardial ischemia, dysrhythmias, depressed mental status (including coma), seizures, and severe metabolic acidosis. Levels above 70 percent are largely fatal [5].

Diagnosis

- The arterial partial pressure of oxygen in methemoglobin may be normal, reflecting the fact that the tissue hypoxemia is not a result of a cardiorespiratory defect.

In general, pulse-oximeter oxygen-saturation values drop linearly with increasing methemoglobin concentrations until the MetHb levels reach 30 to 35 percent, at which point the pulse-oximeter reading becomes stable in the low-to-mid 80s [4]. Further increases in MetHb do not lower the pulse oximeter oxygen saturation and supplemental oxygen does not increase the oxygen saturation.

- Significant MetHb levels are underestimated by conventional pulse-oximeter readings.
- Definitive identification of methemoglobinemia relies on co-oximetry.

Co-oximetry uses four wavelengths of light to measure the absorptive characteristics of oxy- and deoxyhemoglobin, methemoglobin, and carboxyhemoglobin species. It requires a sample of venous or arterial blood and is the most accurate method for determining the oxygen saturation of blood and the percentage of MetHb.

Treatment

- Patients who have methemoglobin concentrations below 20 percent and are asymptomatic require only admission and close observation, as their hemoglobin levels should normalize within 24 to 72 hours.

A methemoglobin concentration alone may not be an adequate indication of the need for therapy. Initial treatment is essentially supportive and involves maximizing the saturation of the remaining functional hemoglobin by providing oxygen. In general, the yield of gastric decontamination is limited because there is often a substantial time interval between exposure to the toxic agent and the development of methemoglobin.

A relatively minor pathway for reducing methemoglobin exists within the red blood cell, consisting of nicotinamide-adenine dinucleotide phosphate (NADPH) and the enzyme NADPH methemoglobin reductase [1].

- In the presence of an electron donor such as the pigment methylene blue, the NADPH methemoglobin reductase system is accelerated and becomes the primary method for reducing methemoglobin.

- Antidotal therapy with methylene blue is reserved for patients with symptomatic methemoglobinemia, usually at methemoglobin concentrations greater than 20 percent.

Symptoms may occur at lower concentrations in anemic patients or those with cardiovascular, pulmonary, or central nervous system compromise. Unstable patients with a presentation highly suspicious for methemoglobinemia should receive methylene blue empirically. All patients (especially infants and young children) with significant methemoglobinemia requiring therapy with methylene blue should be admitted to an ICU for continuous monitoring and supportive care.

The initial dose of methylene blue—1 to 2 mg/kg IV (0.2mL/kg of a 1 percent solution)—given over 5 minutes has a rapid onset of action; maximal effects usually occur within 20 to 30 minutes. Infants with methemoglobin resulting from diarrhea and acidosis may improve with aggressive hydration and correction of the acidosis [5].

Conclusion

Approximately 40,000 infants less than 6 months of age live in homes that have nitrate-contaminated water supplies [3]. Recognition of this unique route of exposure and clinical presentation are paramount for prompt diagnosis and proper management of methemoglobinemia. If your patient's family uses a private water supply, inform them that private water sources are not routinely tested for nitrates. Recommend that they have their water tested for nitrates at least annually if the source is surface water and at least once every 3 years if the source is groundwater [2]. If the water has elevated nitrate levels, advise them to purchase bottled water or find an alternative water supply for drinking and cooking. Little if any nitrate gets into breast milk, unless the mother is consuming very large quantities of nitrate.

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HEALTH LAW

Proving Causation in Environmental Litigation

Kristin E. Schleiter, JD, LL.M.

To recover damages in a personal injury lawsuit, a plaintiff has the burden of establishing a causal relationship between the defendant's harmful conduct and the plaintiff's injury. In environmental litigation, proving causation can be difficult for both physician and attorney. In environmental cases, courts commonly refer to two types of causation: general and specific. General causation addresses whether a substance is capable of causing a particular injury or condition, while specific causation addresses whether a particular substance caused a specific individual's injury [1, 2].

The difficulty of proving causation in environmental litigation is a significant barrier to recovery of damages [3]. To begin with, scientific knowledge about the toxicity of many substances is limited [3]. Second, how substances move through air, soil, and water is often unknown and difficult to trace, and, third, the level or timing of a plaintiff's exposure is also often unknown [3, 4]. Together, these factors can lead to ambiguity about the cause of a plaintiff's disease. Multiple causation poses the challenge of proving that a particular injury was the result of one substance rather than another or a combination of substances [4]. For example, while asbestos is known to cause lung cancer, so are the various toxins found in cigarettes and cigarette smoke [4].

Courts have provided assistance in dealing with these issues, generally allowing evidence from epidemiological or toxicological studies that establish a likely causal relationship between exposure and harm [4, 5]. Epidemiology studies, which examine existing populations for an association between a disease or condition and a factor suspected of causing that disease or condition, are increasingly indispensable in tort cases concerning toxicity where specific causation studies are lacking [1].

Courts are quick to point out, however, that proof of an association is not equivalent to causation [1, 6]. Rather, epidemiological studies show the degree of statistical significance between events and variables [1]. Further, a positive association between exposure to an agent and development of disease is only one piece of the causation puzzle. Once an association has been found, a medical expert must next determine whether the association reflects a true cause-and-effect relationship [1]. To do this, medical experts consider several factors, including: (1) the strength of the association; (2) the dose-response relationship (e.g., whether higher exposures to the agent increase risk of disease); (3) replication of findings; and (4) biological

plausibility [1]. No generally agreed-upon method exists for determining how much weight to apply to each factor [1].

If a medical expert's testimony establishing *general* causation is admissible, the court next determines whether the medical expert has established *specific* causation using differential etiology—the procedure by which a physician isolates an external factor as the cause of internal disease [1]. In performing a reliable differential etiology, the expert first compiles a list of hypotheses that might explain the clinical findings under consideration and engages in an evidentiary process of elimination to reach a conclusion about the likely cause of the disease [1]. At this “ruling-out” stage, the court focuses on whether the expert has a reasonable basis for concluding that a certain agent was likely the cause of the patient's symptoms [1].

Before an expert's testimony can be admitted into evidence, it must meet general standards for admissibility. The court decides whether the witness' knowledge, skill, expertise, training, and education qualify him or her as an expert. If the opinion involves science or specialized knowledge, trial courts must also determine whether the reasoning or methodology underlying the expert's opinion is scientifically valid [1]. Next, the court must determine whether the expert reliably applied the methodology [1]. Five factors are considered when determining reliability: (1) whether the theory or technique can be, or has been, tested; (2) whether the theory or technique has been subjected to peer review and publication; (3) whether there is a known or potential rate of error; (4) whether there are standards controlling the technique's operation; and (5) whether the theory or technique enjoys general acceptance within the relevant scientific community [1].

In the two tort cases that follow, both plaintiffs claimed damage from toxic substances, and the courts came to different decisions on the admissibility of expert testimony about causality.

Fraser v. 301-52 Townhouse Corporation

In *Fraser v. 301-52 Townhouse Corporation*, former tenants brought action against their former landlord, alleging they sustained respiratory problems, rash, and fatigue as a result of dampness and mold infestations in the apartment building [6]. The district court did not admit certain expert testimony on the plaintiffs' behalf, a decision the plaintiffs appealed [6]. The Supreme Court of New York, Appellate Division, upheld exclusion of the plaintiffs' expert testimony on the ground that the underlying casual theory lacked support in the scientific literature [6].

The higher court reasoned that, while indoor dampness and mold are known to be associated with upper respiratory complaints, the observed association is not strong enough to constitute evidence of a causal relationship [6]. As was stated above, association is not equivalent to causation [6]. The court held that the plaintiffs failed to demonstrate general acceptance of the notion that a causal relationship existed between the conditions and ailments in question [6].

Even if the medical expert's testimony regarding general causation was valid, the court noted, the plaintiffs' medical expert failed to specify the threshold level at which dampness and mold produced health problems similar to those the plaintiffs suffered [1]. Without evidence that the plaintiffs were exposed to a level of dampness or mold sufficient to cause their alleged injuries (specific causation), the court reasoned, the plaintiffs could not prevail [6]. Ultimately, the court rejected the entirety of the plaintiffs' medical expert testimony.

King v. Burlington Northern Santa Fe Railway Company

In *King v. Burlington Northern Santa Fe Railway Company*, the wife of a deceased former railroad employee brought a tort action against the railroad, asserting that her husband contracted multiple myeloma—a cancer originating in the bone marrow plasma cells—due to his exposure to diesel exhaust emissions over his 28 years of work for the railroad [1]. The plaintiff appealed the trial court's decision to exclude testimony of her expert witness regarding the cause of myeloma [1]. The Supreme Court of Nebraska held that the trial court erred in determining that the medical expert's opinion was unreliable [1].

The *King* appeal centered on the testimony of the plaintiff's primary medical expert, Dr. Frank, a physician board-certified in internal medicine and occupational medicine. Dr. Frank testified that diesel exhaust contains benzene, and that scientific evidence supported the opinion that benzene alone and diesel exhaust could cause multiple myeloma [1]. Another medical expert, a certified industrial hygienist, reviewed Burlington Northern's environment samples and concluded that the plaintiff's husband had a significant exposure to diesel exhaust, particularly in the early years of his employment [1].

Dr. Frank recognized that contrary statements existed in the medical records regarding benzene's effect on health and that he did not know of any studies that explicitly linked benzene or diesel exhaust to multiple myeloma [1]. He explained, however, that scientific studies generally point to a causal relationship rather than stating outright that such a relationship exists [1]. Dr. Frank argued that the plaintiff's husband's extraordinary exposure to diesel exhaust was most likely a contributing cause to his disease [1]. There were few known causes of multiple myeloma, he stated, and benzene was the only diesel-exhaust component that had been separately studied as an agent of disease [1]. Burlington Northern's expert focused on this lack of a determined causal relationship, arguing that, with the exception of radiation exposure, researchers did not know the cause of multiple myeloma and that the majority of studies failed to show a specific positive association between benzene and multiple myeloma [1]. Dr. Frank had ruled out radiation exposure as a cause of the plaintiff's husband's myeloma because he found no evidence of unusual exposure to radiation [1].

The district court ruled that, although Dr. Frank was qualified to give expert testimony, his opinion was unreliable because it did not have general acceptance in the field [1]. In addition, Dr. Frank could point to no study that conclusively stated

that exposure to diesel exhaust and benzene caused multiple myeloma [1]. The district court also ruled out Dr. Frank's testimony because: (1) the record did not show what causes other than diesel-exhaust exposure Dr. Frank had considered in his differential etiology, (2) Dr. Frank "ruled in" diesel exhaust exposure as a possible cause, even though no medical or scientific study concluded that such exposure causes multiple myeloma, and (3) Dr. Frank had failed to explain why he had "ruled out" any other potential causes [1]. The court criticized Dr. Frank's conclusion that diesel-exhaust exposure was the most probable agent, even though no medical or scientific study authorized such a conclusion [1].

The Nebraska Supreme Court disagreed, however, and reversed the district court's opinion [1]. In its decision, the court looked to the standards for general admissibility of expert testimony and admissibility of testimony establishing general and specific causation [1].

First, the court discussed whether Dr. Frank's expert testimony was admissible under general standards, asking whether his opinion was based on reliable, valid methodology, not what conclusions those opinions generated [1]. In this regard, the trial court acts as "evidentiary gatekeeper, not goalkeeper," and is free to exclude expert testimony if there is too great an analytical gap between the data and the opinion proffered [1]. The court ruled that Dr. Frank's testimony was reliable, though the ultimate weight of his opinion was considered a question for the jury to decide [1].

Turning to the issue of general causation, the court found that the district court had erred in concluding that Dr. Frank's general causation opinion was unreliable [1]. The higher court reasoned that individual epidemiological studies need not draw definitive conclusions on causation before experts conclude that the agent causes a disease [1]. Rather, if the medical expert's methodology appears to be consistent with the standards explained above, the opinion is admissible [1]. Though the district court had criticized Dr. Frank's supposed lack of reliance on the totality of information regarding multiple myeloma, the Nebraska Supreme Court noted that Dr. Frank testified to a body of evidence in support of his conclusion, including human data studies, animal studies, and toxicology studies [1]. Further, his testimony did not reflect a disconnect between his opinion and the underlying data from these studies [1].

In sum, the court found that Dr. Frank's reasoning was consistent with general causation criteria [1]. The court commented that, in considering the sufficiency of underlying studies, the focus should be on whether no reasonable expert would rely on the studies to find a causal relationship, *not* whether the parties dispute their force or validity [1]. Hence, the analysis of Dr. Frank's opinion should be based on the validity of his methodology and the grounds for his opinion, not whether his conclusion differed from that of other experts [1].

Finally, regarding specific causation, the higher court rejected the district court's holding that Dr. Frank's medical opinion failed to adequately "rule out" or "rule in" potential causes [1]. The court noted that Dr. Frank had considered other causes of multiple myeloma including radiation exposure, diabetes, pesticide exposure, and cigarette smoking, and believed that epidemiological studies of these agents failed to show a causal relationship with the plaintiff's multiple myeloma [1]. Ultimately, the case was remanded to the district court for further proceedings consistent with the supreme court's opinion [1].

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POLICY FORUM

Caring for the Health of the Community Means Caring for the Health of the Environment

Nancy J. Larson, RS

In fulfilling the obligation to care for their communities, hospitals and other health care facilities can have a negative impact on the environment. Over the past decade, the health care industry has come under the environmental microscope, and the daily work of treating patients has been discovered to be highly wasteful of natural and financial resources. In 1998, the U.S. Environmental Protection Agency (EPA), in partnership with the American Hospital Association and Health Care Without Harm, formed Hospitals for a Healthy Environment (H2E), to address some of the following major environmental concerns related to the health care sector.

- Medical-waste incinerators were the fourth largest source of mercury, a well-known persistent bioaccumulative and toxic substance. The National Academy of Sciences reported that, each year, 60,000 children may be born in the United States with neurological problems due to their mothers' having eaten mercury-contaminated fish.
- The health care industry generated more than 2.4 million tons of waste per year, often incinerated or deposited in landfills.
- The health care industry was an excessive user of toxic cleaners, pesticides, and sterilants that can affect both patient health and safety.
- Medical-waste incinerators were a source of dioxins and other hazardous chemicals.

Recognizing these environmental health concerns, hospitals across the country voluntarily established green teams, joined national voluntary organizations such as H2E, developed environmental policies to guide their purchasing practices, and set waste-reduction and toxic-elimination goals. Top management supports these policies, but physicians, surgical teams, nurses, and support staff make them work, exploring new ways to practice health care while minimizing its impact on the environment and ultimately the health of the community.

What are the environmental compliance obligations? Hospitals, like any business that produces waste as a part of its everyday work, are subject to a range of environmental regulations. These regulations may include:

- The Solid Waste Disposal Act and Resource Conservation and Recovery Act, which regulate the disposal of solid waste and hazardous waste.
- The Clean Air Act, which governs operation of onsite medical waste incinerators, as well as the venting of toxic chemicals such as ethylene oxide (a sterilant) into the atmosphere.

- The Clean Water Act, which covers discharge of wastewater that may contain high concentrations of chemicals.

Some hospitals have been motivated toward environmental awareness through voluntary policies, others through environmental compliance orders that have resulted from inspections by their state or regional environmental enforcement authority, like the EPA.

An example of the health care industry's lack of awareness of its environmental regulatory obligation is documented by results of a hospital compliance-monitoring program published by the EPA's Regional Office for New York, New Jersey, and Puerto Rico in August 2006. According to the summary data, the program completed 49 inspections and took enforcement actions at 36 facilities, noting that hospitals in the program had corrected 3,223 violations [1]. In the Midwest EPA Regional Office for Iowa, Kansas, Missouri, and Kansas, hazardous waste inspector Dedriel Newsome reported in October 2008 that the EPA and the states in that region had conducted about 55 inspections of hospitals in the preceding 5 years and had completed at least 35 enforcement compliance actions during that time [2]. Those inspections resulted in at least 35 formal compliance orders.

Both EPA regions reported that the most common violations at hospitals were related to hazardous waste; in the New York, New Jersey, and Puerto Rico region, 70 percent of the violations were hazardous-waste related. Failure to identify hazardous waste and improper hazardous waste-container management accounted for 56 percent of the Resource Conservation and Recovery Act violations cited in the 2006 program. These hazardous wastes typically involve spent solvents used in clinical and research labs; unused chemicals, drugs, and alcohols; respiratory machine media in the surgery and emergency departments; and acutely hazardous chemotherapy agents and other pharmaceuticals.

To assist the health care sector to better understand its compliance obligations, the EPA funded an online resource, the Healthcare Environmental Resource Center, that provides pollution-prevention and compliance-assistance information [3].

As a result of these compliance needs and heightened awareness, most hospitals now require staff who work in the lab and surgery to be trained in environmental compliance management for their areas. The hospital environmental health and compliance officers normally lead this program and act as a resource for regulatory and waste-management policies and questions.

Beyond compliance—successful toxics and natural-resource management. Many hospitals have gone beyond compliance and set goals to reduce and manage their wastes and natural resources more efficiently. In fact, most have virtually eliminated use of mercury-containing devices in patient-care areas, and nearly 200 facilities have been recognized with a *Making Medicine Mercury-Free* award given out by the H2E program through 2006, and now by Practice Greenhealth. Practice Greenhealth

continues the work begun by the H2E program and has become the primary membership and networking organization for health care institutions committed to sustainable, eco-friendly practices. Members include hospitals, health care systems, businesses, and others engaged in the “greening” of health care to improve the health of patients, staff, and the environment [4].

Physicians as part of the solution. Hospitals do not participate in these programs solely to be good environmental stewards—they can often save money at the same time. One Minnesota surgeon’s green efforts have saved his facility \$2,000 and 80 pounds of waste annually [5]. Dr. Rafael Andrade saw that waste could be reduced and implemented a program that eliminated needless, redundant supplies from surgical picks, switched to reusable gowns, promoted prudent use of sterile saline solutions, and minimized surgical prep waste. Several hospitals in Kansas have documented 40 to 70 percent reductions in the volume of their red-bag wastes, simply by educating staff about the written policy that defines what should and should not go into the red bags [6].

Nationally, Veteran’s Administration Hospitals have adopted Green Environmental Management Systems (GEMS), a set of policies designed to prioritize, integrate, and address compliance and pollution-prevention opportunities at their facilities nationwide. It considers a balance between environment and economics and uses a 9-step approach to environmental management [7]. Many hospitals have followed with their own version of GEMS.

According to Energy Star for Healthcare, a national program that supports hospital energy conservation, health care organizations spend more than \$8.3 billion on energy each year to meet patient needs. Every dollar a nonprofit health care organization saves on energy is equivalent to \$20 in new revenues for hospitals or \$10 for medical offices. Just a 5 percent reduction in energy costs in for-profit hospitals, medical offices, and nursing homes can boost earnings a penny per share. One Wichita, Kansas, hospital has used Kansas State University engineering interns to benchmark and identify energy-conservation opportunities. In the summer of 2008, it documented more than 3 million kWh conserved with a related savings of \$350,000 [8]. The hospital recently detailed a plan to expand the program that may result in a savings of up to \$6 million—money that will be put back into patient care.

You see it every day, and if you look for it at your hospital, it’s there—excessive waste of our natural resources and raw materials. Our medical profession stands by an oath to “First do no harm.” Physicians must use available tools, ask about the hospital policies, and be part of the “green” solution for the financial and environmental health of each facility and community.

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MEDICINE AND SOCIETY

Medicine's Role in Mitigating the Effects of Climate Change

Andrew Jameton, PhD

Although philosophies connecting our health to nature go back to Hippocratic times, these early ideas stressed that harmony with and imitation of nature promoted health. Only recently have we begun to appreciate the reverse—that human medicine, as a result of its manufacturing processes, buildings, and waste disposal, has an unhealthy impact on the natural world [1].

The greening of health care has joined our general efforts to reduce the environmental impact of our homes, industries, campuses, transportation, and so on. Greening health care is challenging. Relative to homes, offices, and campuses, hospitals and clinics use materials and energy intensively—serving vulnerable patients and families in acute settings when those involved are too immersed in the crisis to embrace long-term environmental goals.

The first wave of health care greening arose in the 1980s with attention to such practices as cleaner manufacturing methods and reduction in waste volume, toxicity of medical materials, and packaging. This movement is led by Health Care Without Harm (HCWH), which holds an annual CleanMed conference featuring green products. HCWH and others have tackled incinerator emissions, mercury in the waste stream, plastic materials that leach out environmental estrogens, disposal of electronics, and toxic hospital cleansers, among other targets.

The second major wave has been driven by the movement to reduce the environmental footprint of buildings. The U.S. Green Building Council developed standards known as the LEED criteria to assess and rank the sustainability of all buildings, including those that house health care services. Boulder Community Foothills Hospital was the first U.S. hospital to be LEED certified. Many have been built since, and dozens are on the drawing boards.

Climate Change

A hospital is a high-energy enterprise—with its bright lights, refined air filtration, stable temperatures (intensive heating and air conditioning), heavy-duty imaging devices (with highly complex manufacturing histories), exotic chemicals, endless reusables and disposables, and the need to keep everything clean, disinfected, and purified. As continuing global exploitation of fossil fuels warms the Earth to an extent that bodes global natural and health disasters, health care is beginning to experience increasing pressure to reduce its use of energy—its carbon footprint.

Whether we are able to mitigate climate change or not, the environmental and monetary costs of fossil fuels are likely to increase in the coming decades, and, since health care uses large amounts of energy, it is likely to face significant cost increases. Recycling itself is energy-intensive in health care where high reprocessing standards must be met. These factors combine to challenge health care's ability to sustain its level of operation without steep increases in its monetary and environmental costs.

Moreover, climate change is beginning to cause unpredictable health emergencies, such as heat waves, floods, storms, droughts, food shortages, and the spread of mosquito-related diseases, among others [2, 3]. The demand for basic care will increase, and it will become more difficult to maintain the environment—electric and water supply and rapid transportation, for example—needed for sophisticated medical procedures. Recall the terrifying fate of advanced medicine during Katrina in New Orleans, when caring for patients demanded considerable heroism of physicians and other staff [4].

Current excitement in medical education and research is stimulated mainly by innovations in intricate medical technologies, robots, genetic advances, and nanotechnology, with little thought toward their potential environmental consequences. At the same time, the greatest need tends not to be in this area, but in the areas of basic treatment of injuries, long-term debility, mass public misery, and basic adaptation to climate change [5]. Sophisticated medicine's high-level requirements for materials and energy are playing a modest part, both philosophically and materially, in undermining the Earth's capacity to supply the primary environmental necessities for population health—clean air, water, and soil [6]. Meanwhile, migration, poorer food supply, international conflicts over water and other scarce resources, and too many guns and armaments are likely to create regional disasters that will require heavy use of emergency medical services [7, 8].

The Right Approach

Medicine can play a part in mitigating the intensity of climate change, principally by reducing the scale of health care. At greater than 15 percent of GDP, the expense of U.S. health care, much more than that of other developed nations, indicates its disparately large environmental footprint [9, 10].

U.S. fossil-fuel consumption must be reduced by roughly 80 percent in the next few decades if we are to avoid the worst health emergencies of climate change [11, 12]. This can't be done without reducing national end-use consumption. And since health care's fossil-fuel consumption is disproportionately large, it must cut back even more [13]. Downwardly adjusting the scale of health care relative to the overall economy is itself a challenge, and further reduction is daunting. A 10 percent reduction in a medical center's budget is generally regarded as an emergency; how can we achieve an 80 percent discount, even over 50 years, especially while we have such good ideas for new and even more expensive technologies?

A likely source of some physicians' general dismissal of the global-warming news is the over-optimistic belief that technological changes external to health care will solve everything. This is naive. Although growing, solar and wind together comprise a tiny segment of the energy economy; it will take decades to scale up, and the fossil-fuel economy is still dominant, with billions of people dependent on it. If global intergenerational health is the goal, the main objective of medical research ought to be, though it is not, to reduce the environmental impact of human biology and health and, in particular, to mitigate climate change while maintaining a healthy population.

Regrettably, many medical educators don't think climate change is real. This is partly due to a healthy habit of skepticism so necessary in clinical practice. The clinical model of evidence—where the human body is the system, with diagnosis and prognosis doubtful and patient testimony and behavior essential—is likely to make physicians view climate change as just another clinical uncertainty. Compared to human illness, climate change is well studied, and evidence for it is overwhelming [14].

How are we to scale down health care if so many in the medical community don't understand that the capacity of the global environment to sustain human and global ecosystem health is headed for a nosedive?

Medical Responsibilities

Although one might argue that physicians have a responsibility to educate patients on how to live healthily at a reduced environmental impact, few physicians have been educated on this subject themselves. Moreover, physicians are already burdened with huge expectations for patient education, while their opportunities for communication dwindle under the time pressure of increasingly complex medical technologies.

Rather than focusing on patient education, a better direction for physicians is working with institutional designers and administrators to lower the overall energy consumption of clinical workplaces. Physicians can work with supply chain managers to select tools and materials that are both medically effective and environmentally leaner. They can work with facilities managers and hospital architects to design modestly scaled medical buildings that are well lit and ventilated at low energy consumption levels. And physicians can emphasize reductions in carbon footprint when determining the suite of medical services to be offered by hospitals and clinics.

Conclusion

Old but good advice has a way of returning in new clothing. The often repeated anthem that health care costs need to be reduced and public health efforts amplified is revisiting us with renewed emphasis, now underlined by the terrifying potential public health disasters of climate change. To avoid these, we will have to change the energetics and thus the culture and consumption patterns, of society, or the climate will change our world for us well beyond our control [15]. As part of reenvisioning society, health care must also be reworked organizationally, philosophically, and

technologically to a depth that boggles and staggers our nearer good-hearted and practical aspirations.

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HISTORY OF MEDICINE

The Lesson of John Snow and the Broad Street Pump

Mitali Banerjee Ruths, MD

In the mid-1800s, London physician John Snow made a startling observation that would change the way that we view diseases and how they propagate. He created a map depicting where cases of cholera occurred in London's West End and found them to be clustered around a water pump on Broad Street. This led him to believe that cholera was a waterborne disease, a conclusion that went against the Victorian "miasma theory" in which Londoners ascribed the source of cholera to bad airs or vapors entering the human body [1]. John Snow's conviction about the source for the London outbreak and his concern for public health compelled him to oppose the popular beliefs of his time and convince the local council in London's West End to disable the water pump on Broad Street. Although Dr. Snow could not identify the culprit under his microscope, the bean-shaped bacteria *Vibrio cholera* that thrives in brackish water, he had his map as evidence.

This map is a tremendous contribution to the field of epidemiology, for Dr. Snow recognized that part of treating disease requires viewing patients not as individual, isolated cases, but within the larger environment in which they live. From this perspective, he realized that he could best protect the health of his community by shutting down a water pump rather than waiting for cholera patients to visit his clinic in need of treatment. To achieve this, he used his geographic correlations of the outbreak as the logic to support a public health intervention to control London's cholera epidemic. Although John Snow's model is accepted as a way to frame our understanding of infectious diseases today, it can also give physicians a blueprint for approaching illness, particularly illness caused by or related to the patient's environment.

Today, epidemiologists view the strength, severity, and propagation of infectious diseases as a product of human and physical environment. They have pioneered our understanding of large-scale phenomena, like recent outbreaks of H1N1 (or swine flu), by tracking cases, monitoring the threat of a global pandemic, and cautioning the public through mass media. In a sense, each physician is called to be an epidemiologist on a smaller scale, viewing the people and cases of disease passing through a clinic within the context of their community and, more broadly, the environment surrounding that community, like Dr. Snow's patients in London's West End.

A [clinical case](#) in the issue of *Virtual Mentor* you are now reading discusses the role of a rural physician in bringing attention to a water source contaminated by runoff

from nitrate-based fertilizers used in agriculture. It examines the ethical responsibility a physician bears when several cases of methemoglobinemia in young children caused by environmental pollution occur in the local community and argues that the physician has a duty to notify authorities, help raise awareness, and address the pollution in the local water supply.

Some may regard the role of public health advocate to be independent and separate from the practice of medicine, undertaken only by those doctors who feel motivated to become activists and who identify specific causes to champion. But advocacy within our communities can have immediate and preventive effects on the prevalence of disease. Furthermore, community physicians are often the first to observe the effects of environment on the health of their patients. For these reasons, we can consider advocacy as part of our service to the community, part of the practice of medicine, and part of the oath we have taken to protect, restore, and ensure the health of our patients to the best of our abilities. Perhaps doctors have an ethical obligation to treat not only the “internal pathophysiology” of disease, for example how microorganisms like cholera cause illness, but also the “external pathophysiology” of health and disease—how our environment serves as a factor in determining our health.

Each passing day, week, and month bring new discoveries of how profoundly affected we are by our environment, as public attention is called toward the threat of mercury in fish, pollutants in the air, or trace amounts of medications in municipal water supplies. Certainly, more research must be conducted on how conditions rising in prevalence like asthma and cancer may be correlated with our environment. This research will largely be done in laboratories and in large-scale surveys and studies. Nonetheless, physicians are embedded in communities that are being affected by their environments now, making environmental education and advocacy a way to directly improve the health of the community. Doctors must stay informed about environmental changes and their impact on human health in the same way that they stay up-to-date on the latest diagnostic tools, current antibiotic guidelines, and new treatment modalities. Being aware of the big picture can shape how we use that knowledge to influence our practices and policies. As physicians, we can be watchful over the smaller communities that we serve; we can identify environmental factors that affect the health of our patients and their families; and, when we come across something that is causing harm to our patients, we can have the courage of John Snow to turn off the Broad Street pump.

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[Physicians' Duty to Be Aware of and Report Environmental Toxins](#), June 2009

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OP-ED

What Primary Physicians Should Know about Environmental Causes of Illness

William J. Rea, MD

Health and disease appear to have two main contributors—environment (which includes nutrition) and genetics. Since genetic manipulation is still in its infancy, medicine should devote energy to discovering what environmental triggers cause, exacerbate, and disturb bodily function. We all know that bacteria, viruses, and parasites can cause disease processes such as diarrhea, cardiac valvular disease subsequent to streptococcal rheumatic fever, arthritis, and pneumonia. Less is known about the more than 80,000 toxic chemicals in our air, food, and water that can cause adverse reactions to foods, (natural toxins and food sensitivity) and to airborne substances like molds, pollens, and terpenes (odors of plants and trees). These substances can also trigger the immune neurovascular system to initiate disease. The generalist should be aware of toxins in these three categories (air, food, and water); referring patients with possible toxin-related illness to an environmental specialist can prevent end-stage disease (e.g., organ failure of the brain, heart, lung, and spine).

Odor sensitivity can be the tip-off for a chemical or an environmental contributor to a patient's malfunction. Odor sensitivity can manifest as intolerance to perfumes, detergents, fabric softeners, newsprint, phenols, alcohols, natural gas, gasoline fumes, car exhausts, pesticides, formaldehyde, and cigarette and wood smoke. The clinician may also find odor sensitivity in some cases of asthma; vasculitis; autoimmune disease (lupus, scleroderma, rheumatoid arthritis, etc.); cerebral dysfunction; after anesthesia, surgery, and trauma; or in neuropathy and musculoskeletal disease.

A case in point is a woman who came to our clinic after having had her right first rib removed and a cervical sympathectomy. Following surgery, she immediately developed intractable atrial fibrillation that medications could not control; she had been treated with the usual anti-arrhythmic medications to no avail for 2 years. Subsequently she entered the Environmental Health Center in Dallas and was found to have five foods that triggered her atrial fibrillation—beef, cane sugar, yeast, wheat, and corn. She has avoided these substances for the last 5 years and has remained free of her atrial fibrillation without medication.

Chronic inflammatory diseases of unknown cause can often be a sign of environmental sensitivity or overload. Conditions such as thrombophlebitis, vasculitis, arthritis, colitis, Crohn's disease, esophagitis, and sinusitis can have triggering agents such as molds, foods, and chemicals. If these conditions continue to

recur in a patient, the environmental stimuli should be sought, found, and eliminated or treated with intradermal provocative neutralization therapy and proper nutrition.

Some patients who take medication such as insulin, anti-hypertensives, antibiotics, steroids, and thyroid medications for chronic conditions will become sensitive to their medication, then their substituted medication, and then to most medications. This sensitivity can spread to local, regional, and general anesthetics. Such patients also have immune deregulation. There may be changes in blood parameters such as T and B lymphocytes and their subsets—helper cells, suppressor cells, or natural killer cells. B cells may be suppressed. Gammaglobulins (IgE, IgA, IgM, or IgG) may be elevated or suppressed. The IgG subsets on 1, 2, 3, 4 may be suppressed, signaling the need for gammaglobulin injections.

Recurrent infections in the sinus, bronchi, throat, bladder, and vagina can have environmental causes or contributors. If a patient has more than two or three infections per year, triggering agents should be sought, and the environmental causes eliminated where possible. A Phagocytic Index may be drawn. This test—which demonstrates the ability of the neutrophils to engulf and kill bacteria and fungi, e.g., candida—has to be done after the patient has been off antibiotics for a minimum of 2 weeks. When the index shows reduced neutrophil ability to engulf and kill microorganisms, patients should be referred to an environmental medicine specialist for definitive treatment.

An example here is the case of a woman who developed sore throat four times a year, then sinusitis, bronchitis, and cystitis. After 3 years of suffering, she saw an environmental medicine specialist who found that her lymphocyte subsets and gammaglobulin were suppressed. She worked in a flower shop where many pesticides were used on the plants—an environment that caused her immune system to be suppressed, which resulted in the recurrent infections. After elimination of the daily pesticide exposures, her immune system returned to normal, and she has been infection- and antibiotic-free for the last 5 years.

Since 75 percent of the immune system and autonomic nervous system are in the gut, they are frequently disturbed by food sensitivities, food and water additives and preservatives, chronic medication use, mold and mycotoxin exposure, and even air pollution. When patients enters the generalist's practice complaining of abdominal bloating; sleepiness after eating; chronic gas; diarrhea or constipation; pain in the abdomen accompanied by a diagnosis of irritable bowel syndrome, duodenal ulcer or duodenitis; regional enteritis; or nonspecific colitis or Crohn's disease, food, food additives, drinking-water contaminants, mold sensitivity, mycotoxin overload, or air pollution should be considered as agents. Often elimination of a few agents solves the problem; however, many cases are more complicated and require the expertise of the environmental medical specialist, who is an expert in controlled environments, intradermal provocation-neutralization techniques, nutrition, and immune modulators.

The generalist should also be aware that chronic fatigue often has environmental elements and medication as triggering agents. These agents range from food and food additives to mold and mycotoxins, volatile organic hydrocarbons, heavy metals, particulates from African and Asian dusts, car exhausts, and factory and farm emanations. Any of these incitants can cause arrhythmias, heart failure, GI upset, cerebral dysfunction, fibromyalgia, and neuropathy. Often they cause or propagate chronic fatigue, which then progresses or is prolonged for years. Recurrent fibromyalgia often accompanies chronic fatigue with pain in the muscles and spasm, which often responds to magnesium compounds like magnesium citrate, gluconate, glycinate, or chloride in doses of 500 to 1,000 mg per day. Diarrhea is the limiting factor in this type of treatment. Successful treatment comes in eliminating as many triggering agents as possible. Often, molds and mycotoxins cause chronic fatigue and fibromyalgia.

An example here is a man whose office became extremely moldy. He developed chronic fatigue and fibromyalgia, which became incapacitating. Mold cultures in the office showed high levels of *Aspergillus niger*, ochratoxins, and stachybotrys. Mycotoxin levels in his urine showed elevated levels of aflatoxin, ochratoxin, and tricothecene. Intradermal skin tests proved positive for the three molds and mycotoxins. He eliminated his exposure by moving his office to a mold-free area and received subcutaneous neutralization shots for the offending molds and mycotoxins, intravenous and oral nutrients, and heat depuration (sauna) therapy. After 3 months' treatment, he was again vigorous, free of fatigue and fibromyalgia.

Sometimes patients with chronic fatigue or peripheral and central neuropathy who have short-term memory loss, headaches, and dizziness are unable to walk a straight line with their eyes open or closed and cannot stand on their toes. They may have high venous oxygen-extraction levels, which indicates the inability to extract oxygen in the tissues even though oxygen exchange across the lung membrane is from 95 to 100 percent. Frequently, there is enough oxygen in the tissues to keep the patient alive but not enough for optimum function. Such patients need extended oxygen therapy.

There are many more examples of chronic diseases with air-, food-, and waterborne toxin contributors. In general, when a physician has been treating chronic or recurring ailments without success or is stumped regarding the cause or exacerbating agent in a patient's condition, that physician should seek the consult of, or refer the patient to, an environmental medical specialist.

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