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Achieving a viable equilibrium: exploring the connections between human health and the world we inhabit

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In recent decades, the Western medical establishment has become more cognizant of the connection between our environment and our health, a relationship Eastern medicine has respected for centuries. Throughout history, physicians, scientists, and scholars have postulated that the health of humans is dependent, at least in part, on the health of the planet. Objective data now exist that allow us to better understand this relationship so that we may work to continue to improve the health of individuals, communities, the human race, and the planet we inhabit.

Setting aside a day to venerate the health of the planet

2010 marks the 40th Anniversary of Earth Day (Figure 1). Former Wisconsin Governor and US Senator Gaylord Nelson is credited as being the founder of Earth Day. Twenty million demonstrators and thousands of schools and local communities across the United States participated in the events of the first Earth Day, held April 22, 1970.[1] The national awareness created by the publicity of that first Earth Day ignited so much passion about our collective responsibility in caring for our planet that by the end of 1970 the Nixon Administration had created the Environmental Protection Agency.[2]

According to the Washington, DC–based Earth Day Network, Earth Day is now celebrated every year by more than a billion people in 180 nations around the world.[3] In 1995, Gaylord Nelson was the recipient of the Presidential Medal of Freedom, the highest honor bestowed upon a civilian.[4,5] As President Bill Clinton presented the award, he stated of Senator Nelson:

> As the father of Earth Day, he is the grandfather of all that grew out of that event—the Environmental Protection Act, the Clear Air Act, the Clean Water Act, the Safe Drinking Water Act. In the 1970s, when a river was so polluted it actually caught on fire, Gaylord Nelson spoke up . . . He insisted that Americans deserved the safety that comes from knowing the world we live in will not make us sick. He warned that our leaders should never let partisan politics divert us from responsibility to our shared environment. He inspired us to remember that the stewardship of our natural resources is the stewardship of the American Dream . . .[6]

In preparing his remarks, President Clinton acknowledged the critical link which Senator Nelson articulated nearly two generations ago: the interconnectedness between health and our environment.

The United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is a group composed of 194 of the world's countries that has assembled to set policy and regulatory goals for addressing climate change.[7] The most recent UNFCCC

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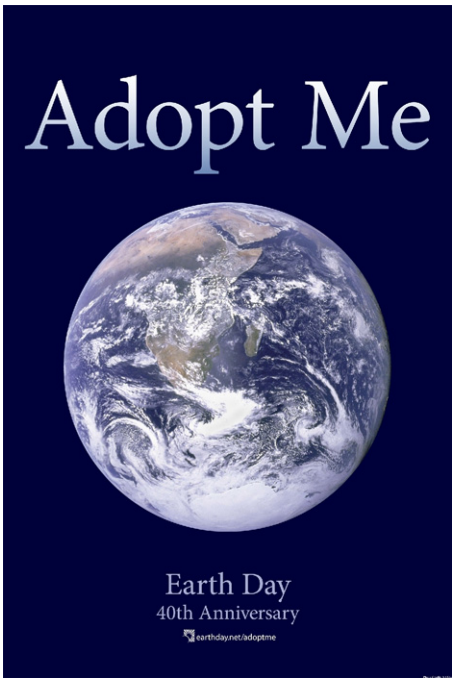

Figure 1 Reprinted with permission from the Marketing Department of the Earth Day network.

summit was held in December 2009 as the nations of our planet convened in Copenhagen, Denmark, to re-examine the progress made in achieving consensus policy in addressing global climate concerns since the creation of the UNFCCC's Kyoto Protocol in 1997.[8] A source of great international contention, the United States and Australia were the only two industrialized nations not to formally ratify the Kyoto agreement. The 2009 meeting witnessed the needs of developing countries being pitted against the needs of developed countries. Concerns were raised about the expected impact on the environment of the world's largest contributors to greenhouse gas emissions, including China, India, and the United States. At the conclusion of the Copenhagen meeting, key questions remained unresolved, as no consensus agreement was realized regarding priority issues such as emissions caps or funds for poor nations.[9]

During the meeting in Copenhagen, the World Health Organization (WHO) held an event for public health officials in an effort to bring attention to the health concerns embedded in the climate change dialogue. According to Diarmid Campbell-Lendrum, a senior scientist in the department of Public Health and Environment at WHO, "We're reminding people that climate change is not just an environmental issue or an economic issue—it's a health issue that's actually about people's survival."[10]

Global environmental impact on human health

Airborne effects on human health

WHO estimates that across the globe, 2 million people die from the impact of air pollution each year.[11] The risks to health stem from exposure to particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)[12] in both developed and developing countries. Short- and long-term exposures to air pollutants have significant health impact, and children, the elderly, and the poor are most susceptible to detrimental effects such as respiratory and cardiac diseases (Figure 2).

The effect of fossil fuel consumption on respiratory health has long been recognized. The degree to which human utilization of fossil fuels affects health became even more apparent during the 1996 Olympic Games in Atlanta. Before the onset of the games, to decrease the air pollution in what was at the time the nation's 13th largest metropolitan area,[13] for the benefit of the athletes' performance, large-scale public campaigns were undertaken to encourage citizens to abandon the use of personal automobiles in favor of taking mass transit.

A study published in the *Journal of the American Medical Association* in 2001 examined pediatric emergency department visits during the more than 2-week period of the Games, compared with the periods immediately before and after the Olympics.[14] The results were most significant for children covered by Medicaid. Although there was a 22.5% decrease in the peak weekday AM traffic count, there was a 42% decrease in the childhood acute asthma events claims for Georgia Medicaid–covered lives.

Mitigation and adaptation directives to effect improvement in air quality and health[15] include more aggressive emissions controls to address reduction of PM, O_3, NO_2,

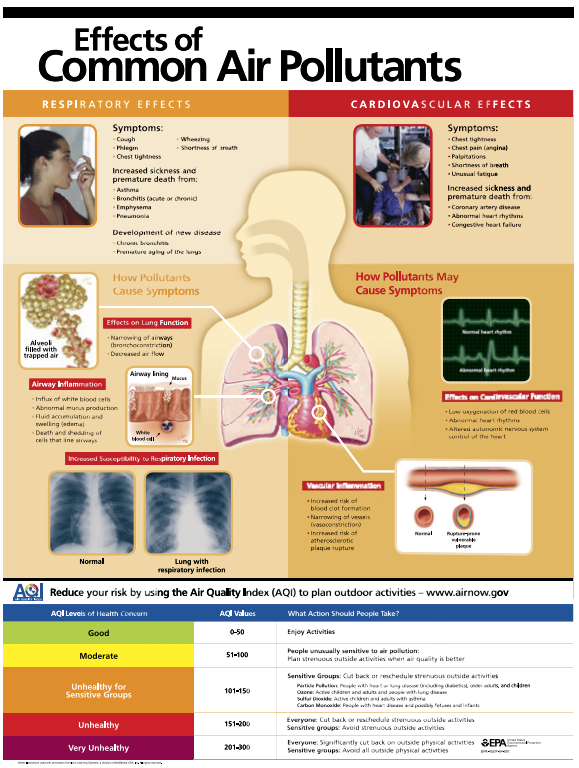

Figure 2 Reprinted courtesy of the United States Environmental Protection Agency.

and SO_2 in the environment. Using emerging technologies, clean energy sources, and developing improved surveillance and early response programs will all contribute to decreasing the health impact of airborne sources of disease burden.

Waterborne effects on human health

Waterborne diseases continue to account for significant morbidity in the United States. In 2002, there were 1330 water-related disease outbreaks throughout the nation.[16] Thirty-four of these were from recreational water sources and 30 were from drinking water sources.[17,18] There can be more than 100 different pathogenic organisms identified in contaminated water sources, including protozoa, viruses, and bacteria, many of which cause waterborne illnesses.[19-21]

The Earth's water is continuously in motion. According to the US Geological Survey, the water cycle, or hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Because the water cycle is truly a "cycle," there is no beginning or end.[22] Water can change states among liquid, vapor, and ice at various places in the water cycle, with these processes occurring anywhere along a time continuum that ranges from instantaneous to over millions of years (Figure 3).

The evidence-based consensus reached by the 2007 Intergovernmental Panel on Climate Change describes an expectation that, along with warming temperatures and sea-level rise, the hydrologic cycle will continue to intensify throughout the 21st century, translating into an increase in extremes of droughts and floods.[23]

In many communities throughout the nation, existing water systems become easily besieged by extreme rainfall events. When these systems are overwhelmed, untreated sewage mixes with storm water to be released directly into receiving waters. The US Environmental Protection Agency estimates that nearly 850 billion gallons of combined sewage is released into the nation's waterways annually.[24]

In exploring the causes of waterborne disease outbreaks, three key factors become apparent, including seasonal prevalence, clustering in vital watersheds, and association with heavy precipitation.[25] For example, The Great Lakes, which serve as a drinking water source for more than 40 million people, have been susceptible to fecal contamination, acting as reservoirs for waterborne diseases. In 1993, a *Cryptosporidium* outbreak in Milwaukee, which caused illness in more than 400,000 people, occurred in concert with record high flows in the Milwaukee river.[26]

Numerous interventions can be used to address the impact of climate change effects on the safety of the water supply. These include a broad range of activities such as data collection and surveillance, infrastructure improvements, land use planning, education, and further research,[27] all of which will allow for mitigating the impact of potential contamination events, ultimately serving to limit the risks to the drinking and recreational water supply.

Food production and consumption pattern effects on human health

The health benefits of reducing red meat consumption have long been well established, and are known to result in a reduction in the incidence of certain cancers, such as colorectal and breast cancer. Other health conditions that have been linked to the consumption of red meat are ischemic heart disease and arthritis.[28,29] Considering the impact of livestock raising on the earth's resources, diets rich in fruits and vegetables have positive far-reaching effects for the planet. According to the Food and Agriculture Organization, approximately one-third of the earth's arable land is devoted to the growing of feed-crops for livestock, whereas

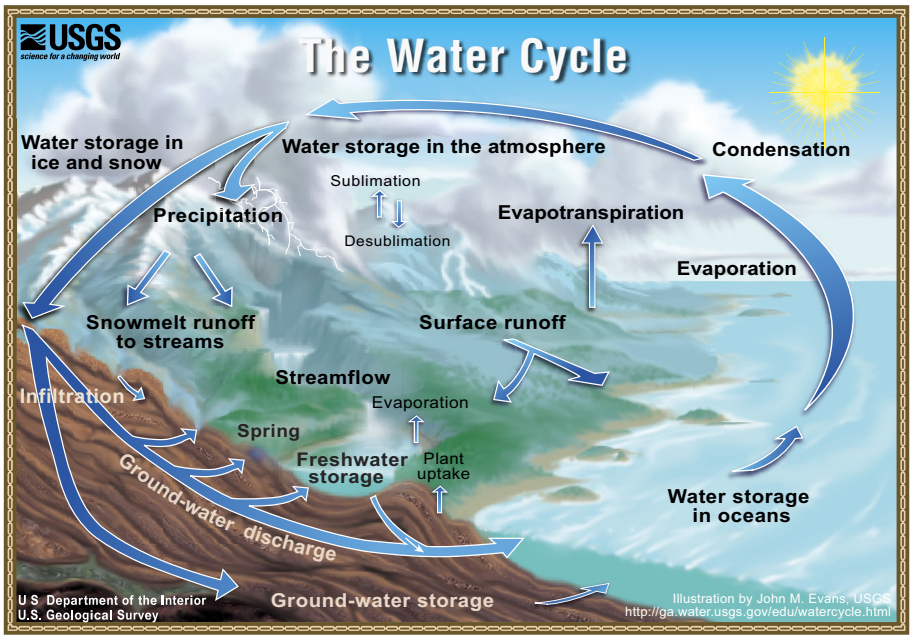

Figure 3 Reprinted courtesy of the United States Geological Survey.

an additional 26% of land (not inclusive of ice-covered regions) is dedicated to grazing.[30] A major contributor to climate change, livestock production accounts for nearly 20% of total global anthropogenic greenhouse emissions.[31,32] Further negative impacts of livestock production on the environment include deforestation to create grazing opportunities in the form of pastureland and the growing of feed-crops, as well as fossil fuel use and fertilizer production, inherent in agricultural activities."

According to an article in the *Journal of Animal Science*, published in 2007, the production of "1 kg of beef is estimated to have the same climactic impact as driving an average automobile 155 miles."[33] Similarly, the difference between a vegetarian diet and a diet high in red meat could be likened to the difference between an extremely fuel-efficient hybrid and a conventional automobile.[34] Following this reasoning, choosing a diet that contains greater amounts of cereals, grains, fruits, and vegetables, and less red meat, could have positive, long-range consequences for the reduction of greenhouse gas emissions.[32,34]

Altering dietary practices may well lead to a decrease in the severity of symptoms for many chronic diseases. Further benefits afforded by a decreased reliance on a diet high in animal products include reduced risk of exposure to bacterial contaminants. *Escherichia coli*, *Campylobacter*, and *Salmonella* infection, along with emerging infectious diseases such as Nipah virus and bovine spongiform encephalopathy, are examples of conditions for which the prevalence could be lessened through rethinking choices regarding red meat intake.[35-37]

Vector-borne disease effects on human health

With the introduction of West Nile virus into the United States in 1999, awareness among Americans of mosquitoes as vectors of disease has markedly increased. Although the developing world has long battled malaria parasite infection, many decades have lapsed without mosquito vector illness playing a significant role in the United States. This, however, is not the case in the nations of Sub-Saharan Africa, Asia, and South America, where half a billion people become infected with malaria each year.[38] In the 106 nations where malaria remains endemic, infection continues to claim lives at a rate of more than one million people annually.[39] Chiefly responsible for the widespread incidence of illness are two prominent species of mosquito, *Plasmodium vivax* and *Plasmodium falciparum*, with *P. falciparum* proving the most dangerous and deadly of all strains.[40] Although not occurring on a scale commensurate with malaria in terms of incidence or disease burden, the rapid spread of West Nile virus southward and westward in the United States has resulted in more than 15,700 human cases and 650 fatalities to date.[38] In recent decades, Lyme disease has also gained prominence as a substantial health concern, as it has now become the most common tick-borne disease in the United States.[41] Initially identified in the mid-1970s along the coastal communities of Southern New England, Lyme disease is caused by the bacterium *Borrelia burgdorferi.* The black legged tick, *Ixodes scapularis* (deer tick), is the principal vector on the East Coast,[42] whereas *Ioxodes pacificus* (Western black legged tick) and *Amblyomma americanum* (lone star tick) remain competent vectors in other regions of North America.[43]

The influence of climate on the transmission and spread of vector-borne diseases such as malaria, West Nile virus, and Lyme disease cannot be underestimated (Figure 4). Alterations in vector-host-pathogen relationships are brought about by changes in temperature, precipitation, and land use.[44] It is the variability of environmental conditions that changes mammalian, avian, and other species' relationships to parasitic vectors.[45] In the case of Lyme disease, the life cycle

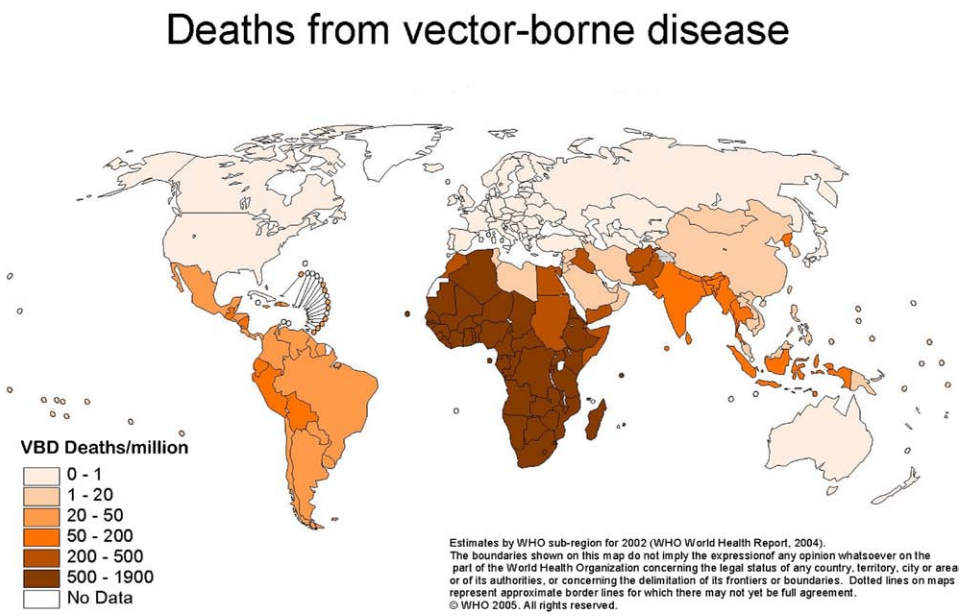

Figure 4 Reprinted courtesy of the World Health Organization.

of the *Ixodes scapularis* tick involves the white-footed mouse (*Peromyscus leucopus*) and the white-tailed deer (*Odocoileus virginianus*). Considering the woodland and edge habitats of these animals, increased suburban development has put humans at heightened risk of infection because of their proximity to the vector's hosts.[46] Human activities, such as deforestation, lead to both alterations in weather and vector breeding areas.[47] Although a single factor is insufficient for explaining human West Nile virus and malaria risk, increasing temperatures on a global scale have upset an already delicate balance between arthropod vectors of disease and their human hosts.

Although risk cannot be reduced to zero, measures can be undertaken to lessen the chance of infection with Malaria, West Nile virus, and Lyme disease. Infection generally occurs in warmer climates and during the summer months, which are characterized by elevated temperatures and increased prevalence and activity of both mosquitoes and ticks.[48] Using insect repellent and wearing clothing that covers the arms and legs when outside guard against the possibility of tick and mosquito bites.[49] The elimination of standing water in flower and plant containers, receptacle lids, and areas of pipe run-off reduces possible breeding habitats for mosquitoes.[50] Inspection of children and pets for ticks before their entering households, especially after time spent in wooded areas or residential backyards that border forested lands, aids in the prevention of infection.

In the case of malaria, there exists some controversy over the use of DDT and the draining of wetlands—both measures that have served to effectively eradicate the disease from the more temperate climates of the earth, such as southern Europe and the United States.[51,52] Although employing the use of DDT, along with the pervasive destruction of fragile wetlands, does not seem sound from an environmental perspective, one must weigh the environmental impact with the cost of not pursuing these measures. Apart from interventions centering upon environmentally questionable practices, campaigns supporting the widespread implementation of protective netting for sleeping areas has proven an inexpensive and effective disease-preventing measure.[53] Surveillance of individual activities can have far-reaching impact in terms of prevention and, in turn, holds the possibility of facilitating cooperation at the broader community, state, national, and global levels in lessening the substantial burden of infection and its inherently deleterious consequences.

Closing thoughts

This review is being presented in conjunction with the 40th Anniversary of Earth Day to raise the shared awareness of osteopathic family physicians regarding the relationship between our environment and our health. Following the conclusion of this text are numerous links that, when utilized, can foster a better understanding of human health impact for clinicians and patients, as well as provide tools to use in the quest to improve our collective health.

Although every April we set one day aside to celebrate our mutual awareness for the vulnerability of the planet we all inhabit, one could ascribe to the perspective that "Every Day is Earth Day." Each of us—as individuals, as communities, and as nations—bears a responsibility for our own well-being and thus we are all entrusted with the stewardship of our individual health, the health of the environment, and the health of our planet.

The public health lessons we have learned in the past have driven the improvements that afford our improved health today. This insight begs the question "What lessons will be learned in 20 years time because of the actions or inactions we currently pursue?" It is imperative that physicians remain engaged, informing policy-makers in a thoughtful, honest and unbiased manner to effect meaningful change. Although the Copenhagen talks did not achieve the definitive policy goals that had been hoped for, climate-related public health accomplishments have been realized in other arenas. Nearly 40 years after its creation, The United States Environmental Protection Agency, in December 2009, classified greenhouse gas emissions as a "public health threat."[54]

The examples of effects on human health included here represent just a small sample of the broad range of potential climate impacts on the health of individuals, communities, and the earth. These data illustrate the tangible negative health impact, which physicians have the ability to address. As primary care providers on the front lines of medical care, osteopathic family physicians are in a unique position to use this information to improve patient care needs, while advancing the health of our citizens, our communities, and our planet.

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Additional Resources

Center for Health and the Global Environment, Harvard Medical School: http://chge.med.harvard.edu/
World Health Organization: http://www.who.int/en/
Intergovernmental Panel on Climate Change: http://www.ipcc.ch/
Centers for Disease Control and Prevention: http://www.cdc.gov/
Environmental Protection Agency: http://www.epa.gov/
Occupational Safety and Health Administration: http://www.osha.gov/