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# Biometeorology

## *What It Is and How It Affects Our Health*

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A hallmark of holistic medicine is that its practices take into account an individual's total internal, social, and external environment when considering disease prevention and treatment. The interdisciplinary science of biometeorology studies the effects of weather and climate on organisms' adaptation mechanisms and the consequences of human and natural impacts on the atmosphere. Although the late University of Maryland Professor Helmut Landsberg, who is considered the father of modern climatology, wrote a landmark text on the subject in 1969,<sup>1</sup> only recently has broader attention been focused on this discipline in the United States. In Europe, biometeorology has been used for more than a decade to provide public health information. For example, the national German weather service offers, to the public,<sup>2</sup> and to doctors and medical facilities, area-specific advisories about conditions that may aggravate arthritis, depression, and respiratory and other health problems.<sup>3</sup> The British National Health Service is piloting the use of weather reports to predict its workload.<sup>4,5</sup>

Hippocrates had anticipated the contention of biometeorologists and bioclimatologists that human bodies are hardwired to react to weather cues; circa 400 BC, this father of modern medicine wrote: "South winds induce dullness of hearing, but, if the north winds prevail, coughs, infections. . . occur."<sup>6</sup>

According to Laurence S. Kalkstein, Ph.D., director of the University of Delaware's Center of Climatic Research in Newark, "we've known that weather

affects organisms for 100 years or more. The real breakthroughs today are due to the fact that we have computers that allow us to evaluate much more data."<sup>2</sup>

This article focuses on what science is discovering about environmental influences on health and how this knowledge may be utilized in disease prevention, integrative treatment, and public health planning.

### **Weather-Health Links: Epidemiologic Research, Clinical Observations, and Patient Perceptions**

"Epidemiology has met ecology" is how one writer characterizes this line of research.<sup>7</sup> Recent studies have confirmed the climatic influences and seasonal variations that have been clinically observed in the incidence of, and mortality from, cardiovascular disease (CVD), and the exacerbation of asthma, migraine headaches, arthritis, and seasonal affective disorder (SAD).

#### *Cardiovascular Disease and Seasonal Affective Disorder*

Epidemiologic research identifies winter as the peak time of year for sudden cardiac death.<sup>8</sup> Extreme cold may stress the circulatory and regulatory systems. Winter-induced depression may also contribute to coronary heart disease by promoting infections and having other negative effects on health.<sup>9</sup> SAD, a form of depression commonly known as "the winter blues," is the classic example of a health problem associated with seasonal changes.<sup>10</sup> The existence of disorders with seasonal patterns underscores the importance of comprehensive clinical assessment and consideration of treatment options for

all illnesses.<sup>11</sup> Extreme temperatures may also affect reflexes and cognitive ability.<sup>1</sup>

#### *Asthma and Other Respiratory Disorders*

Hospital admissions for asthma in a United Kingdom region increased during thunderstorms irrespective of pollen counts, fungal spores, rainfall, and ozone levels.<sup>12</sup> An Australian case-controlled study of emergency hospital admissions for asthma also revealed that the atmospheric conditions accompanying late spring and summer thunderstorms resulted in higher-than-expected epidemics of asthma exacerbations.<sup>13</sup> Extreme or changeable weather is among the stressors that can depress the immune system and increase susceptibility to flu and colds.<sup>1</sup>

#### *Migraine Headaches*

Weather also appears to be among the diverse triggers of migraine headaches. Patients and physicians have long suspected that changing weather patterns are associated with symptoms and even with the ability to forecast upcoming weather changes. Dr. Charles Matthews, director of a headache clinic in Raleigh, North Carolina, found that having a barometer in the office "would kind-of tell us what our day was going to be like." Likewise observing a connection between migraine headaches and weather conditions, Dr. Alan Rapoport of the New England Center for Headaches in Stamford, Connecticut, investigated this link in a study of 77 patients over a 2-year period. More than half of the study patients had an identifiable weather trigger that preceded the onset of a migraine attack. A strong, positive relationship was found between migraines and cold weather

## Migraine headaches in 43 percent of patients in one study coincided with the Chinook wind.

and low humidity. Some patients were affected most by barometric or temperature changes.<sup>14</sup>

A blinded study of 75 Canadian patients at the University of Calgary Headache Research Clinic, Calgary, Alberta, Canada, correlated their migraine symptom diaries with the weather phenomenon known as a Chinook wind, a warm westerly wind with a predictable annual pattern affecting that region of Canada. Migraine headaches in 43 percent of patients coincided with the Chinook wind. With regard to these results, Dr. Werner Becker, a professor in the University's department of clinical neurosciences commented that "it's always nice to validate what patients are saying." In addition, this knowledge can be used to help avert symptoms.<sup>15</sup> As noted by Michael John Coleman, executive director of the National Migraine Association in Washington, D.C., "you can't control the weather, so it is particularly important to know which triggers can bring on your migraine. If you know your triggers, you are going to manage your treatment much more proficiently."<sup>16</sup>

Similarly, at the University of Calgary's department of community health sciences, a study of women patients ages 20–49 with histories of chronic conditions found that such patients were more likely to visit a health care professional on days affected by Chinook wind conditions.<sup>17</sup>

### *Arthritis and Other Conditions*

Many patients who have arthritis and those with allergies, broken bones, and other conditions, such as multiple sclerosis, have considered themselves to be "human barometers." Based on his clinical experience and a small-scale 1960

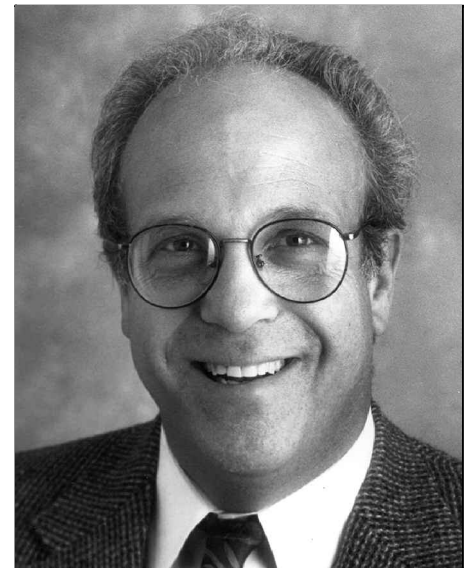
study of patients placed in a chamber in which the barometric pressure and humidity were adjusted, Dr. Richard Pope, chief of rheumatology at Northwestern Memorial Hospital, Chicago, Illinois, believes that these claims are valid. Dr. Pope's explanation is as follows:

You take a balloon and you put it into a vacuum. As the pressure is reduced around that balloon, it expands. And so the same thing [happens] within the tissues around the joints. If there's already swelling, inflammation, [and] abnormal mechanics in the joint, as the pressure goes down, the gas and tissue expand, and this is felt as more pain by the patient. This is why they sense a change in barometric pressure.<sup>18</sup>

How barometric pressure affects human tissues may also account for the apparent relationship between the inducement of labor in pregnant women and drops in atmospheric pressure, as reflected by hospital admissions at these times.<sup>1</sup>

In the case of atopic eczema, an inverse relationship between itch intensity and air temperature was significant at the  $P < 0.001$  level in a study of the disease in Swiss patients and fifteen meteorologic conditions over a 7-year period. However, the link between atopic eczema and meteorologic variables such as air pressure, water vapor pressure, and hours of sun exposure was more tenuous.<sup>19</sup>

A retrospective study of more than 20,000 deaths in French public hospitals from acute intestinal vasculitis (swollen blood vessels) and hospitalization and deaths from variceal bleeding (caused by portal hypertension) during 1987–1996, likewise revealed that mortality from such causes significantly peaked in Jan-



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uary and was at the lowest level in July. The researchers concluded that awareness of such seasonal patterns could allow practitioners to reduce mortality via early diagnosis and treatment.<sup>20,21</sup>

### A Multivariate Relationship

Seasonal patterns between mortality and diseases, however, may well turn out to be multivariate rather than univariate, as was demonstrated by investigators who examined the relationship between mortality caused by CVD and climatic factors in urban areas in Norway and Ireland from 1985 to 1994. While the researchers did confirm a link between CVD and cold weather for both men and women ages 60 and older, the association

## Dr. Kalkstein developed a warning system to alert people in cities of impending unusually hot weather that can result in increased depression, hospital admissions, and heat-related deaths.

was stronger when wind-chill temperature was factored into air temperature.<sup>22</sup> Researchers also found a seasonal factor to be operative in a complex manner in the quality of life of patients with ankylosing spondylitis (AS), a form of spinal arthritis. Assessed by both a self-administered questionnaire and a clinical measure (the Schober index), the quality of life and lumbar spine flexibility of 106 patients with AS correlated significantly with climatic temperature, wind speed, atmospheric pressure, and humidity. Curiously, while higher temperatures and lower wind speed were associated with greater measured lumbar spine flexibility, subjective quality of life was rated lower under the same conditions.<sup>23</sup>

Similarly, from epidemiologic correlations of weather reports to medical reports, Dr. Kalkstein's research team has also found that "[w]e need to take into account many more things than just temperature and humidity. It's the whole air mass that's over us at any given time that affects us—cloud cover, sunshine, rain

and so on. Our scheme evaluates how these other variables also affect human health."<sup>2</sup>

### An Application of Biometeorologic Research

As an application of his findings, Dr. Kalkstein developed a Heat/Health Warning System to alert people in cities of impending unusually hot weather that can result in increased depression, hospital admissions, and heat-related deaths—particularly in elderly, immune-impaired, and poor patients. This system is currently being used in selected cities in the United States including Philadelphia and Washington, D.C., and is scheduled to be deployed soon in other cities in the U.S. and abroad.<sup>24</sup> Dr. Kalkstein has also been involved in projects exploring the links between climate and asthma and Lyme disease deer tick populations and the evaluation of methods to gauge weather effects in pollution-mortality correlations.<sup>25</sup>

### Empirical Research on the Weather-Health Link

Most of the research in this area has understandably focused on the correlation of weather variables and health effects. However, Michael Persinger, Ph.D., a clinical psychologist at the Behavioral Neuroscience Laboratory at Laurentian University, Sudbury, Ontario, Canada, has made a somewhat controversial career of claiming that, and attempting to measure how, organisms react to geophysical stimuli.<sup>6</sup> Dr. Persinger believes that sudden infant death syndrome and, in adults, cardiac arrhythmias are both consistent with the role of weather-related geomagnetic variables in producing electrical anomalies in brain function.<sup>26</sup> Dr. Persinger asserts that: "biometeorology matters because the way in which we order our lives in the twenty-first century leaves us especially vulnerable to weather insults. Our indoor environments have become extraordinarily physically constant. . . . One thing we

## Organizations

### American Academy of Environmental Medicine (AAEM)

7701 East Kellogg, Suite 625  
Wichita, KS 67207  
Phone: (316) 684-5500  
Fax: (316) 684-5709  
e-mail: administrator@aaem.com  
Web site: [www.aaem.com](http://www.aaem.com)

Emphasizing that the human body is dynamically coping with its environment, the AAEM promotes an integrated, proactive, preventative approach to environmentally triggered diseases.

### American Institute of Biomedical Climatology (AIBC)

1050 Eagle Road  
Newtown, PA 18940  
Phone: (215) 968-4483  
Web site: [www.aibc.cc](http://www.aibc.cc)

This volunteer organization promotes better

multidisciplinary understanding of the effects of the geophysical environment on health. The AIBC disseminates information via the *Journal of the AIBC*, other resources, seminars, and consultations. The organization was known as the American Institute of Medical Climatology from 1958–1988.

### International Society of Biometeorology (ISB)

Department of Physical Geography  
Maquarie University  
Sydney, New South Wales  
Australia 2109  
Phone: +61-2-9850-8399  
Fax: +61-2-9850-8420  
Web site: [www.es.mq.edu.au/ISB](http://www.es.mq.edu.au/ISB)  
e-mail: [pbeggs@ocsl.ocs.mq.edu.au](mailto:pbeggs@ocsl.ocs.mq.edu.au)

Since 1956, the ISB has promoted interdisciplinary collaboration of meteorologists, physicians, biologists, ecologists, and other

scientists who are interested in environmental problems. The ISB maintains close ties with agencies such as the World Health Organization and holds international forums such as the International Congress of Biometeorology. Contact: Dr. Paul Beggs, Secretary General of the ISB.

### National Environmental Health Association (NEHA)

720 South Colorado Boulevard, Suite 970-S  
Denver, CO 80246-1925  
Phone: (303) 756-9090  
Fax: (303) 691-9490  
e-mail: [staff@neha.org](mailto:staff@neha.org)  
Web site: [www.neha.org](http://www.neha.org)

The NEHA offers credentialing in several environmental health professions and continuing education in the field, as well as publishing the *Journal of Environmental Health* and policy position papers.

## It has been estimated that 40 percent of deaths globally can be attributed to environmental factors.

do know about biological systems is that they tend to respond to contrast. And one of the things that fluctuates most these days is the weather."<sup>6</sup>

### Long-Term Adverse Environmental Effects

Long-term climatic changes, such as global warming with its "greenhouse effect" caused by an increase in carbon dioxide and subsequent disruption in the planetary ecosystem, have serious implications, directly and indirectly, for public health. Many experts believe that global warming caused by air pollution and natural forces is already resulting in greater mortality and morbidity caused by heat stress in response to higher temperatures<sup>27</sup> and in new patterns of infectious disease outbreaks.<sup>28</sup> Skin cancer caused by overexposure to ultraviolet radiation, which is the result of a diminished protec-

tive ozone layer, has dramatically increased in recent decades. Deaths from melanoma, the malignant form of skin cancer, has escalated by 1800 percent since 1930 (over a period of 70 years).<sup>1</sup> It has been estimated that 40 percent of deaths globally can be attributed to environmental factors, such as long-term overexposure to the sun, air pollution, and pesticides.<sup>29</sup> The World Health Organization has ranked deaths from air pollution among the top ten causes of preventable mortality.<sup>30</sup>

The weather pattern known as El Niño was significantly related to hospitalization of females with viral pneumonia in several California counties from 1983 to 1998. The investigators concluded that "an understanding of population sensitivity under different weather conditions could lead to an improved understanding of virus transmission."<sup>31</sup>

In a Greek study of the effects of atmospheric circulation, specific air circulation types were correlated with daily and seasonal death rates in Athens, Greece. Southeasterly air flows correlated significantly with the highest daily mortality and northwesterly flows correlated with the lowest mortality. Potential confounding variables such as ambient temperature and particle concentrations were controlled for statistically. These researchers at the Laboratory of Meteorology at the University of Ioannina, in Ioannina, Greece, concluded that their weather classification scale is useful for studying weather-health associations.<sup>32</sup>

A meta-analysis of 59 peer-reviewed studies found that the risk of Parkinson's disease increases with exposure to pesticides and other environmental factors in rural living.<sup>33</sup> A survey of rural health care providers on environmental health issues facing their communities reported

### Summary of Research That Supports Weather and Climate Effects on Health Conditions

Health condition	Weather/climate effects	Research reference numbers in text
Asthma	Spring/summer thunderstorms have resulted in increased hospitalizations; air pollution increases incidence	Refs. 12, 13, 30
Arthritis	Barometric pressure changes produce joint pain and swelling	Ref. 18
Atopic eczema	Inverse relationship between itch and air temperature	Ref. 19
Cardiovascular disease/ sudden cardiac death	Cold weather may produce depression, which, in turn, can affect the immune system	Refs. 9, 22
Heat stress	Temperature extremes can depress immune system and result in death, especially in elderly people	Refs. 1, 2, 24, 27
Infectious diseases	El Niño and climate change may increase disease incidence	Refs. 28, 31
Labor in pregnancy	Drops in atmospheric pressure may induce labor, as reflected in higher hospital admissions of women in labor	Ref. 1
Migraine headaches	Triggers include cold weather, low humidity, barometric changes, and warm westerly Chinook winds	Refs. 14–17
Psychiatric illness	Small, significant correlation found between inpatient length of stay and cold weather	Ref. 37
Seasonal affective disorder	Decreasing light in winter results in depression, weight gain	Ref. 10
Skin cancer	Increased exposure to ultraviolet radiation as a result of diminished ozone layer protection	Ref. 1
Vasculitis	Mortality found to peak in winter	Refs. 20, 21

## “Contact with nature may be right up there with some medications or surgery as ways of improving health.”

### Recommended Reading

*Human Health & Global Climate Change: A Review of Potential Impacts in the United States*

By John M. Balbus, M.D., M.P.H.,  
and Mark L. Wilson, Ph.D.

Prepared for the Pew Center on Global Climate Change

Pew Center Web site.

Online document at:

[www.pewclimate.org/projects/humna\\_health.cfm](http://www.pewclimate.org/projects/humna_health.cfm) December 2000

water pollution and pesticide effects among the main concerns.<sup>34</sup> British researchers found urban neighborhood environment stressors, such as continual high levels of noise and pollution, to be associated with chronic stress and self-reported poor health, regardless of an individual's socioeconomic status.<sup>35</sup>

Environmental stresses, such as particulate air pollution, appear to elevate a risk factor for CVD, namely, high blood pressure. Therefore, these investigators recommend “wider use of noninvasive cardiovascular measurements in studies of air pollution and weather stresses” in order to understand response mechanisms better and to identify populations at risk.<sup>36</sup> Recognizing the impact of such contextual factors as climate on health care utilization is also advised by researchers at the Bedford Veterans Affairs Medical Center in Bedford, Massachusetts, who found a modest but significant positive correlation between inpatient length of stay for its psychiatric patients and weather variables such as cold temperatures.<sup>37</sup>

### Positive Environmental Effects

Contact with nature can also be measurably beneficial to health. From a review of the scientific literature, Howard Frumkin, M.D., Dr.P.H., professor and chair of environmental and occupational health at Emory University in Atlanta, Georgia,

concluded that: “Contact with nature may be right up there with some medications or surgery as ways of improving health.”

Dr. Frumkin's view extends sociobiologist E.O. Wilson's “biophilia” hypothesis that humans are innately attracted to other living organisms, to nature more generally. Dr. Frumkin has reviewed studies that cited positive impacts from even minimal interaction with nature on such populations as hospital patients and prisoners. Direct weather impacts were not investigated, although the effects of plants, views of landscapes, wilderness, and animal contact were considered. Because the reasons for this environment–health link are unknown, Dr. Frumkin advocates further research as well as consideration of such factors in medical practice and urban planning.<sup>38</sup>

A recent study unexpectedly found scientific validation for the preference for mountaintop locations for health sanitariums in the nineteenth and early twentieth centuries. Environmental challenges to cells, such as from high altitudes and pollution, activate the production by monocytes and macrophages of cytokines such as interleukin-1- $\beta$  that mediate physiologic adaptations to stress.<sup>39</sup>

### Conclusions

Empirical evidence lends support to patients' complaints and the clinically observed relationship between the effects of weather and climatic conditions on morbidity and mortality in cases of cardiovascular and other health conditions. Such effects interact in complex ways with atmospheric pollution and global warming trends. While scientists concur about the effects of sunlight, temperature, and perhaps barometric pressure on health, many scientists are not as receptive to the possibility that the body chemistry is altered by gases released from soil during turbulent weather and the effect of the Earth's magnetic fields.

Nor does epidemiologic evidence prove cause-and-effect or even clinical significance.

At the very least, however, weather influences behavior indirectly, which can have health consequences, such as the effect of lessened physical activity in inclement weather on the blood sugar levels of patients with diabetes.<sup>40</sup>

Further research could identify the characteristics of patients who appear to be particularly sensitive to specific weather conditions. Another interesting research question to pursue is whether predicted higher winter temperatures could actually result in one positive consequence: a decline in cardiovascular deaths, which tend to be higher in winter. Even allopathic medicine is recognizing that “we can't just focus on the microbe anymore. . . ,” as observed by Jonathan Patz, M.D., of the Johns Hopkins University Program on Health Effects of Global Environmental Change, Baltimore. With regard to infectious diseases, Dr. Patz said that “it is not just a simple relationship between weather variables and pathogens. We need to connect existing databases on such factors as land use patterns, deforestation, and soil moisture to public health outcomes.”<sup>7</sup>

As these statements indicate, there is recognition that that environmental factors deserve as much focus as the current emphasis on lifestyle factors in health. Consequently, indirectly, we can counter the cliché that there is nothing that can be done about the weather by investigating its health impact and taking biometeorology into account in disease prevention, diagnosis, and treatment. Conversely, it must be remembered that the natural environment can also affect well-being positively.

Regarding long-range climatic changes, the authors of a major report released in 2000, “Human Health & Global Climate Change: A Review of Potential Impacts in the United States,” caution that “uncer-

tainty about adverse effects should not be interpreted as certainty of no adverse health effects.”

As with short-term weather effects, design of better methods of evaluating such impacts can assist health and resource development planning. □

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