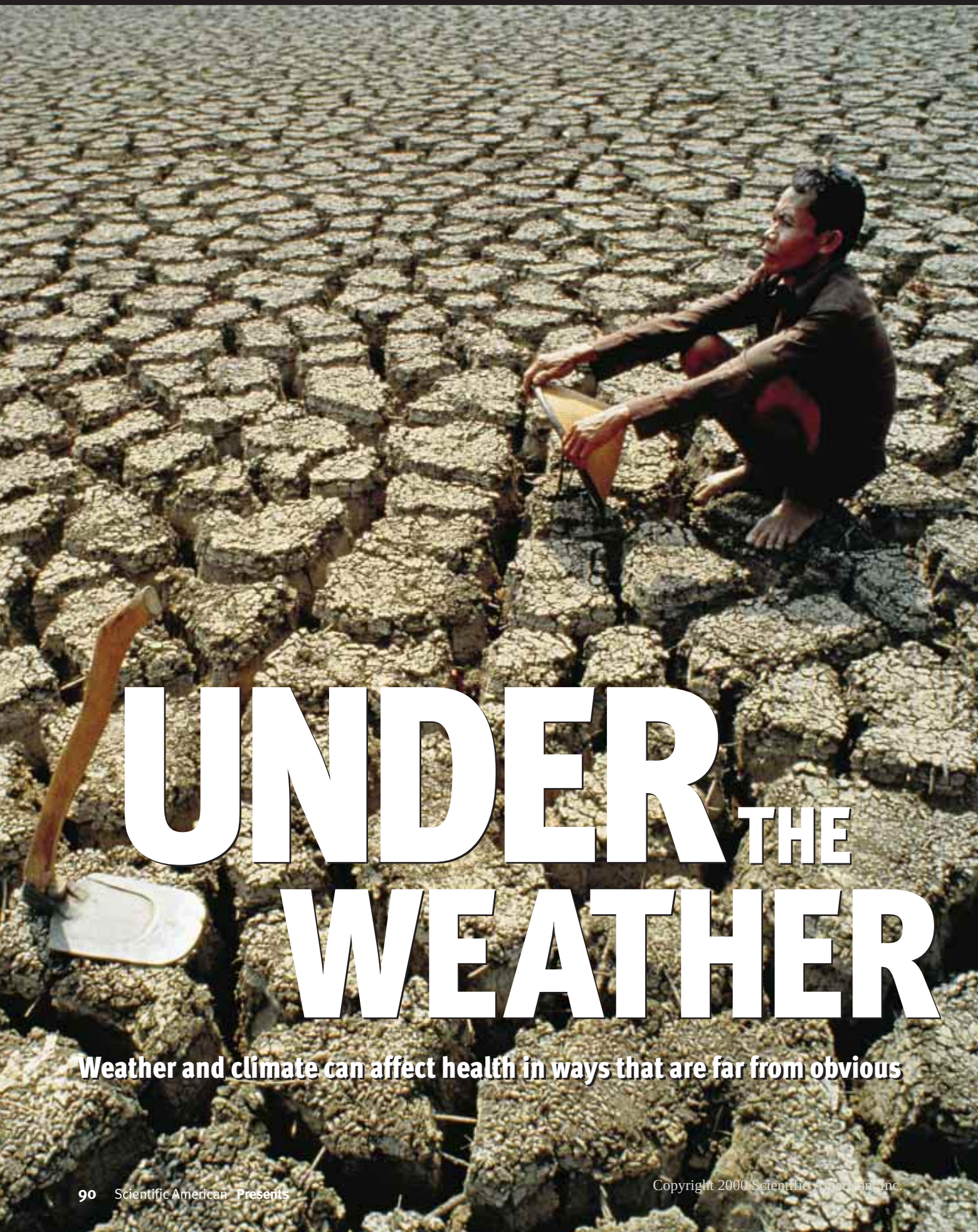


UNDER THE WEATHER

Weather and climate can affect health in ways that are far from obvious

by RITA BARON-FAUST

The wind has different names: the poison *simoom* of North Africa, the bad-tempered *melteme* of the Aegean, the violent *mezzar-ifoullousen* of Morocco. Cultures throughout time have reasonably feared dangerous winds and other weather catastrophes because of the immediate effects on fortune and health: high heat can kill directly, as can rampaging floods from hurricanes or monsoons. Yet weather works less overt mischief as well, such as when it fosters the proliferation of pests that transmit infectious diseases or when it disrupts the integrity of water supplies.

The weather's power over health was demonstrated dramatically several times in the space of just a few weeks in 1999:

- In three states along the U.S. East Coast, weeks of drought and intense heat created ideal breeding conditions for mosquitoes that turned out to be carrying an encephalitis virus never before seen in the Western Hemisphere. Fifty-six cases were reported, with seven deaths.
- Runoff from heavy rains in late August apparently swept a dangerous strain of *Escherichia coli* bacteria into a well at a county fair in upstate New York. More than 1,000 fairgoers became sick after sipping drinks made with the well water; two died.
- In Asia, from China to the Philippines, torrential rains during an unusually severe monsoon season unleashed floods, leaving thousands dead and compromising water supplies and already weak sanitation systems.
- The summer of 1999 was among the hottest ever in the U.S. More than 250 people died during its heat waves. Hot weather and high pressure also trapped air pollution for up to three weeks in some locations, crowding emergency rooms with people suffering from asthma and other chronic respiratory conditions.

CHARLES DHARAPAK *Associated Press*

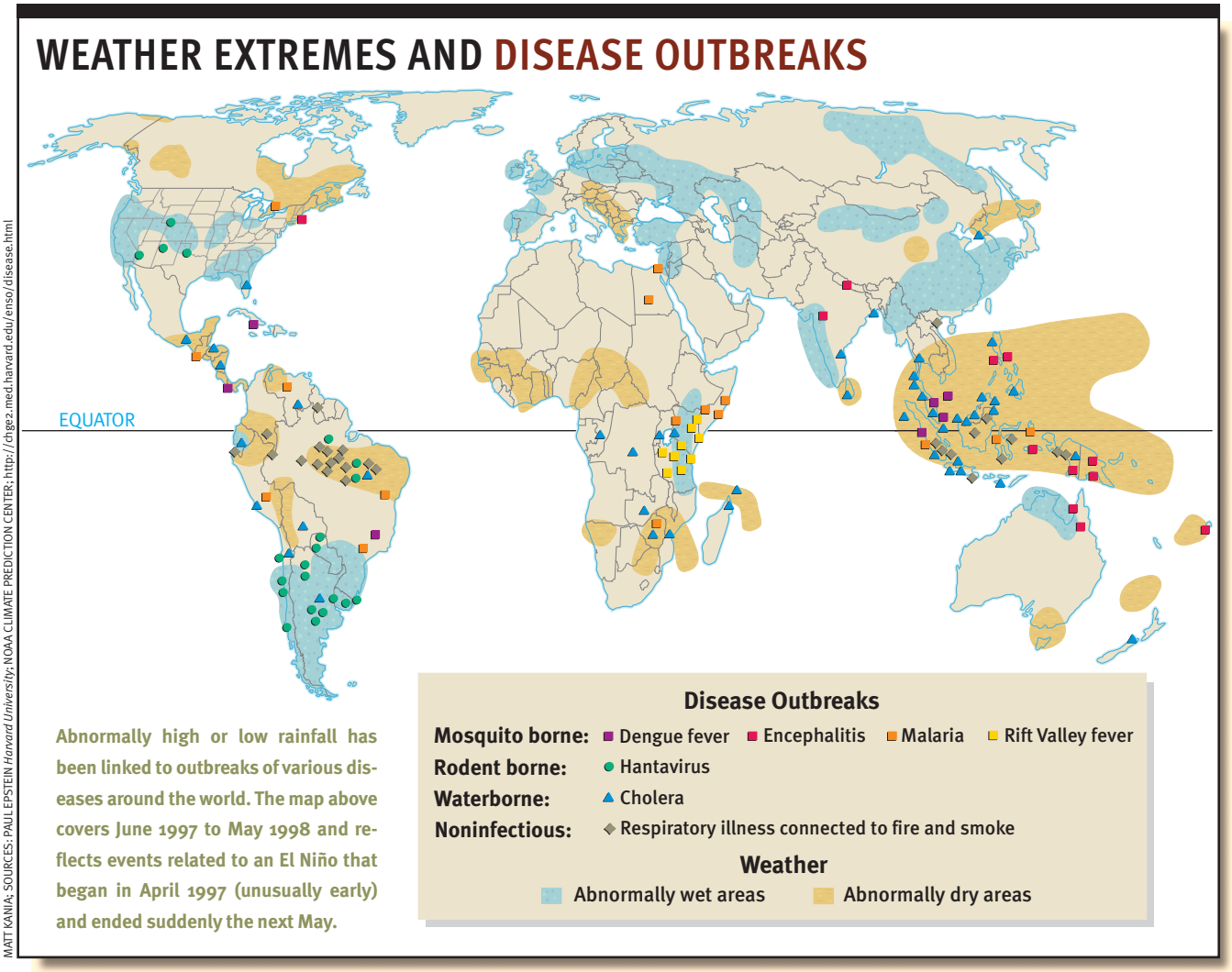
WITH DROUGHT COMES DISEASE: Drought in Indonesia (*opposite page*) has apparently contributed to the spread of several infectious disorders. About two years ago a dry spell brought increases in cholera, malaria and dengue fever—the last of which afflicted the child above and killed hundreds of others.

Weather can influence the range and activity of insects and other animals that transmit diseases, thereby affecting the timing and intensity of disease outbreaks, notes Paul R. Epstein, associate director of the Center for Health and the Global Environment at Harvard University. And changes in climate (long-term weather patterns) are a concern as well: "One of our most important tasks right now is to understand the climate change and instability now occurring and what this means for human health."

Of course, humans can also tip the balance of nature, Epstein adds. Loss of forests to indiscriminate logging and depletion of buffering coastal wetlands lead to more severe flooding and death when heavy rains hit. Clogging freeways with more cars, vans and trucks creates more pollution and ozone, exacerbating respiratory disorders during hot spells.

The infamous El Niño and its opposite, La Niña, seem to be major sources of the

SHENG *UNEP/Still Pictures/Peter Arnold, Inc.*



ill winds that blow no good in many parts of the world, including in the U.S. El Niño, the cyclical warming of the central and eastern Pacific Ocean, occurs every three to seven years around Christmastime and usually lasts for about a year. It is "the strongest driver of regional weather conditions around the world next to the seasons and has major effects on human health," says Jonathan Patz, director of the Program on Health Effects of Global Environmental Change at Johns Hopkins University.

El Niño can produce warmer and wetter years in certain regions around the world and can lead to a drastic drop in rainfall, causing drought conditions and wildfires, in other areas. La Niña's tropical Pacific chill can set up atmospheric pressure changes that keep rainfall away from land or that whip up an especially strong hurricane season (as happened in 1998 and 1999).

The health effects of these climate patterns are diverse. For instance, torrential downpours from El Niño can promote the growth of plankton that harbor the cholera bacterium *Vibrio cholerae* in coastal estuaries and rivers. Floods can then flush the diarrhea-causing bacteria into water systems. Cholera epidemics linked to El Niño have occurred across Africa and South America. "At the other extreme, drought conditions leading to water shortages can make it hard to maintain hygiene, also increasing the incidence of diarrheal diseases," Patz notes.

Dramatic increases in the incidence of malaria—a parasitic disease marked by fever and chills—have been tied both to excess rainfall and to drought caused by El Niño. In normally dry regions, heavy rain leaves pools of water in which parasite-carrying *Anopheles* mosquitoes can breed, explains Paul J. Beggs, secretary-general of the International Society of Biometeorology. "In areas that are normally very wet, a decrease in rainfall allows rivers and streams to stagnate, providing a breeding ground for mosquitoes."

In fact, a report by the Center for Health and the Global Environment at Harvard noted that in 1998 increased malaria outbreaks coincided with above-average rainfall in South America and in Rwanda and with below-average rainfall in Sri Lanka. The report also linked outbreaks of a number of other disorders to extreme weather that occurred between June 1997 and May 1998 [*see map above*].

A Killing Heat

When people think of weather as a killer, they often recall major disasters, such as the La Niña–related floods that killed more than 3,000 people in China in 1998. In the U.S., however, the largest numbers of deaths related to weather are caused by extreme

heat. The elderly are usually hardest hit.

During a record-breaking heat wave in 1995, as many as 1,000 people died, 522 of them in Chicago alone, according to the Centers for Disease Control and Prevention (CDC). In the unusually hot summer of 1999—when Chicago and New York City suffered consecutive days of temperatures exceeding 100 degrees Fahrenheit and when Cincinnati saw temperatures above 90 for three weeks in July and August—at least 256 heat-related deaths occurred.

The cities likely to have the most heat-related fatalities are actually those in the midlatitudes, such as New York, Philadelphia, Chicago and St. Louis, which have irregular but intense heat waves, says Laurence S. Kalkstein, a University of Delaware climatologist. In New Orleans or Miami, he points out, fewer heat-related deaths occur because people have already acclimated to higher temperatures and humidity. Extremely hot and dry weather can at times be more deadly than the sultry weather in the South, because perspiration evaporates more rapidly when the air outside is dry. "If you do not replenish fluids, you can become dehydrated, and your ability to maintain a cool core temperature is diminished," Kalkstein explains.

Another problem in Northern and Midwestern cities, he notes, is that low-income housing tends to be multistory brick tenements with a flat tar roof that holds heat in. With the sun beating down, a room could get to be 120 degrees F, and many people can't afford air-conditioning. In the South, poorer people tend to live in one-story, white frame buildings with windows on all sides and a metal roof that deflects heat, keeping interiors cooler.

The number of consecutive days of heat is also significant. Ongoing elevations in daytime and nighttime temperatures have a cumulative effect on body stress, which in turn can contribute to heart attacks and stroke as well as to heat exhaustion, Kalkstein says.

Experts generally agree that our world is getting warmer, although they do not agree on whether the cause is human activity (such as the burning of fossil fuels) or a natural process. What this climate trend will mean for human health is still unclear. "We don't know whether global warming will simply make each day warmer or bring more frequent extreme heat events, which are the most dangerous for human health," Kalkstein adds.

SHEZAD NOORANI *Still Pictures/Peter Arnold, Inc. (top);* MARK EDWARDS *Still Pictures/Peter Arnold, Inc. (bottom)*

RUINOUS RAINS: Floods, such as those that swamped Bangladesh in 1998 (*top*), promote infectious diseases by contaminating water supplies and encouraging the breeding of mosquitoes and other transmitting agents. Cholera is a major risk. In the bottom photograph, a resident of Bangladesh carries his cholera-stricken wife away from a flooded area.

Something in the Air

Heat has another killing effect: hot, sunny weather bakes the emissions of cars, trucks, power plants and factories into a thick, ozone-laden smog. Ground ozone is a powerful lung irritant and a major hazard for people with asthma and chronic obstructive pulmonary disease (COPD), both of which can hamper breathing. Wind patterns and humidity can help trap pollution for days or weeks. Last summer's heat waves made 1999 one of the worst years for ozone pollution in recent memory.

Ozone alerts have been correlated with increased numbers of hospital admissions and emergency room visits for asthma attacks and exacerbations of COPD. According to the Clean Air Network, a nonprofit watchdog group based in Washington, D.C., federal data on 37 Eastern states show that in 1997 (the latest year available), Texas had the highest number of ozone-related hospital admissions, ER visits and reported asthma attacks. Florida beat out New York State for second place, but citywide totals put populous New York City squarely on top.

"Air pollution certainly worsens asth-

ma for people who have asthma, but there's a question as to whether it actually causes it," says George D. Thurston, an environmental scientist who heads the community outreach program of New York University's Nelson Institute of Environmental Medicine in Tuxedo, N.Y. "While tailpipe emissions have declined, asthma rates continue to rise. So there may be other compounds in air pollution that we haven't measured. For example, diesel particles and tiny particles generated by wear and tear of tires can become windborne. Tire-wear particles contain latex, which can be allergenic. Asthmatics are especially at risk."

Paul Beggs, who teaches environmental and life sciences at Macquarie University in New South Wales, Australia, believes weather and climate can also influence levels of other allergens that provoke asthma attacks, such as pollen.

N. RICHMOND *The Image Works*

HIDDEN PERIL FROM HEAT: Hot, sunny weather can increase levels of ozone in the air, which in turn can aggravate asthma.

Came the Deluge

Heavy rains in areas along the U.S. East Coast during the 1999 hurricane season (made worse by La Niña) may not have produced floods of biblical proportions, but they were bad enough, coming on the heels of record summer heat and drought.

According to the U.S. Geological Survey, rainfall in September 1999 from Hurricanes Dennis and Floyd in some areas of North Carolina added up to nearly half the state's average annual rainfall total. Floyd dumped 20 inches of rain on parts of the state, killed at least 49 people and left two million livestock dead. A month later Hurricane Irene dropped another half foot of rain along the Carolina coast.

Concerns have been raised about the possible long-term health effects of bacteria and dangerous chemicals flushed into the state's waterways. Floyd flooded 24 municipal sewage treatment plants and 46 hog-farm waste pits, caused spills from gas stations, farms and chemical plants, and left the landscape littered with rotting animal carcasses. There were only a few reports of waterborne illnesses, although state health officials worried about molds as residents returned to waterlogged homes. In New Jersey, extraordinary flooding forced nearly two million residents to boil drinking and bathing water for more than a week, but again no major outbreaks of illness occurred.

That outcome contrasts sharply with the aftermath of torrential rains in many developing nations, such as Bangladesh (where massive flooding from monsoons also hit in September). Bangladesh has no central water filtration or chlorination, and fuelwood to boil water is scarce, so epidemics of cholera and other diarrheal diseases are commonplace, notes Rita R. Colwell, director of the National Science Foundation (NSF), who has studied cholera for 25 years.

In 1998 flooding in Bangladesh was very severe. At its peak, as many as 1,000 people a day entered the central cholera hospital, Colwell recalls. Plankton from coastal estuaries was swept into inland waterways, carrying along *V. cholerae*. "We wouldn't see this happen in a developed country unless there was a massive breakdown in our sewage and water treatment systems," Colwell says. She is spearheading tests of simple filtration systems in Bangladesh in hopes of curbing future outbreaks.

Even with the best water filtration and treatment systems, dangerous organisms can still slip through. Chlorination does not kill the parasite *Cryptosporidium parvum,* which causes the intestinal illness cryptosporidiosis, and standard filtration systems do not keep it out. In 1993 an outbreak of cryptosporidiosis occurred in Milwaukee after severe rains and flooding along the Mississippi River overwhelmed water treatment and sanitation facilities. In excess of 400,000 people came down with the illness after drinking contaminated water; more than 100 died.

Even small gaps in the system can be vulnerable to weather. Health experts believe a downpour the night before the opening of the Washington County Fair, a century-old agricultural event held in Easton, N.Y., led to an outbreak of illness from a virulent strain of *E. coli* (0157:H7). This strain releases powerful toxins into the blood and can kill quickly. At least 1,050 who attended the fair in late August were affected, among them a little girl and an elderly man who died. The most likely source was a cattle exhibition; fecal matter mucked out from the stalls was probably swept up in runoff that leached into an unchlorinated well. The state has issued new regulations for water and food vendors at mass gatherings.

Unhealthy Confluences

Sometimes it may not be a single kind of weather but an unlucky combination of weather and environmental factors that causes illness. For those whose lives are lived close to the land, there's nothing new about the notion that weather, health and the environment are bound up in a delicate balance. Such is the belief of the Navajo, who saw this interconnectedness play out dramatically during an outbreak of hantavirus—a deadly hemorrhage-causing infection—on reservations in New Mexico and Arizona several years ago.

In 1993 the CDC drafted Ben Muneta, a Navajo physician with the Indian Health Service, to help track down the source of the disease. "The investigation was going slowly, and I decided on my own to talk to medicine men and women on the reservation," Muneta recalls. "They believed the illness was caused by heavy rains that had caused the piñon trees to bear too much fruit, upsetting the bal-

TODAY'S FORECAST: INCREASED COLD AND HEART ATTACKS

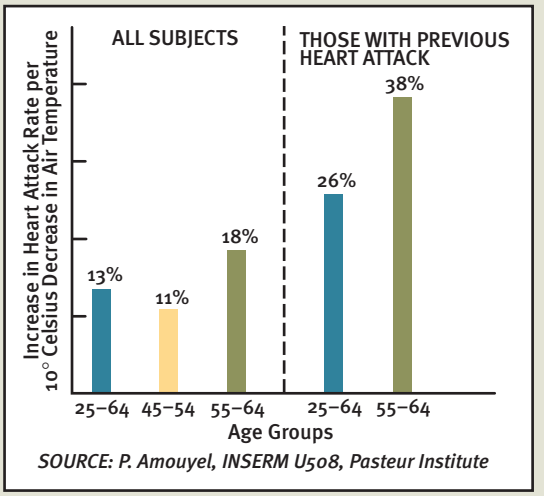
People with heart disease, migraines or circulatory disorders may want to listen more closely to weather forecasts. Two 1999 studies, including a large one published in the journal *Circulation,* found that below-normal air temperatures may trigger heart attacks in vulnerable people, especially those living where climates are normally moderate.

"If you have a 10-degree [Celsius] decrease in any temperature, you will have an increase of 13 percent in the rate of myocardial infarction, or heart attack, for a particular region," says Philippe Amouyel, a professor at INSERM and the Pasteur Institute of Lille in France, who was lead author of the *Circulation* report.

That study, which looked at 10 years' worth of data monitoring 257,000 men aged 25 to 64 living in the north of France, found that extreme atmospheric conditions, such as a big drop in atmospheric pressure with an approaching storm, may also pose a risk. "When atmospheric pressure increases from almost sea-level atmospheric pressure or decreases from that point, heart attack increases. In each age group we have this same relationship for temperature and atmospheric pressure. But it was stronger in older ages, 55 to 64," he notes.

The second study, from Scotland, finds that cold temperatures can increase blood pressure, make blood more likely to clot and strain the heart, especially in overweight or sedentary individuals. It's also believed that cold weather can trigger irregular heartbeats and enhance pain syndromes, such as migraines.

Amouyel advises older people, particularly those with heart disease, to take precautions during very cold weather—and maybe have the neighbor's kid shovel the walk. *—R. B.-F.*



SOURCE: P. Amouyel, INSERM U508, Pasteur Institute

CASUALTIES OF THE COLD: When air temperature declines by 10 degrees Celsius (18 degrees Fahrenheit) in a temperate region, the heart attack rate goes up, according to a study of men aged 25 to 64 living in northern France.

SARAH L. DONELSON

ance of nature. They were also very clear that the mode of transmission was the deer mouse, whom the Navajo believe should not live in proximity to man."

The medicine men and women turned out to be right. Piñon nuts are food for the deer mouse, which carries the deadly virus. An unusually mild winter and excessive rains had produced an abundance of piñon nuts, and six years of drought conditions had also decreased predators, such as owls and coyotes, that limit mouse populations. The result: a 10-fold increase in deer mice and an outbreak of the hantavirus strain dubbed Sin Nombre ("without name" in Spanish). Hantavirus is spread when people inhale aerosolized virus particles from the saliva, urine and feces of mice that have invaded a home or other building.

Since 1994 the CDC has continuously monitored rodent populations at nine sites in Arizona, Colorado and New Mexico. Weather is one of the factors used in tracking hantavirus, and it helped the agency to prepare for another outbreak.

"We had increased rainfall from El Niño in 1997. Then in the spring of 1998, we saw tremendously increased populations of rodents at many of the sites. Even though not that many were infected, we had 16 cases of hantavirus," recalls James N. Mills, chief of the Medical Ecology Unit of the CDC's Special Pathogens Branch. In the spring of 1999 the rodent population grew again, although not as much as before. Now up to 40 percent of the animals were infected, because many mice carrying the virus had survived the unusually mild winter; another 16 people were diagnosed. "This," Mills adds, "is compared to only three to five cases a year in 1995, 1996 and 1997. So the preliminary evidence was that weather was definitely a factor… in both outbreaks."

An imbalance in nature caused by weather may have also promoted an outbreak of encephalitis in New York, New Jersey and Connecticut in August and September of 1999. After two dozen people became ill, investigators discovered that the cause was West Nile virus, which had never been found in that part of the world. Experts still don't know how the virus got there, whether it arrived in infected birds or perhaps in mosquitoes that found passage by ship or airplane.

In any case, the weather seems to have cooperated with the virus. In June, July and much of August, parts of the area were hit with the worst drought in years, coupled with long bouts of hot weather. Together these events created the ideal conditions for the spread of the virus, which is transmitted by *Culex,* the common northern house mosquito, an insect that breeds in stagnant water.

"The hot weather helped incubate the virus in birds and breed larger numbers of mosquitoes that bit the birds, which spread the virus further. And, at some point, the mosquitoes transmitted it to humans," says Durland Fish, an epidemiologist at Yale University, who has studied diseases borne by insects and other pests for 30 years.

Northern house mosquitoes spend the winter in damp basements, walls and

PHOTOGRAPHS BY ED BETZ *Associated Press*

CITY UNDER SIEGE: Last summer health officials began spraying insecticide in New York City (*above*) and its suburbs after a cluster of encephalitis cases led to the discovery that mosquitoes (*left*) were transmitting a dangerous virus. The West Nile virus apparently flourished in last year's heat and drought.

tunnels, so there is a huge possibility that the virus could reemerge in the spring of 2000, Fish warns. Problem is, there is no wide-scale system in place for monitoring mosquitoes in New York State.

"Vector-borne diseases are multifactorial. You have to have a susceptible population, the virus has to be present, and weather conditions have to be right. It's important to look at climate in the context of these other factors," Patz says. In the case of malaria in the U.S., he notes, "it's more an issue of having the parasite being transported into this area through international travel, rather than having certain weather conditions that favor the mosquito."

Early-Warning Systems

Forecasting weather can be an inexact science. Forecasting the future of our climate and its effects on our health may be almost impossible. But biometeorologists are taking a stab at it.

A consortium of government agencies and research teams from many regions in the U.S. is expected to issue a National Assessment of Climate Variability and Change this year, along with steps that need to be taken to maintain the health of humans and the planet, including establishing early-warning systems.

"We have the technology to help monitor climate and predict disease outbreaks, so we can take preventive measures and not have to operate in crisis mode," says Cynthia E. Rosenzweig, a research scientist at the National Aeronautics and Space Administration Goddard Institute at Columbia University. Rosenzweig also heads the Metro–East Coast study group for the national assessment.

Global monitoring via remote-sensing satellites of sea-surface heights and temperatures and of atmospheric and weather conditions helped to predict the 1997–98 El Niño event almost a year ahead, allowing some advance warning of extreme weather conditions. In the fall of 1999 this same technology indicated that La Niña would influence weather in the winter and spring of 2000 in ways that could affect health. For example, it predicted warmer than normal temperatures interspersed with bouts of bitter cold and storms for the Northern, Central and Eastern states; these conditions might be hazardous to people's hearts [*see box on preceding page*].

Remote-sensing satellites are also being used to detect plankton blooms that could threaten coastal areas with cholera during rainy seasons. The goal, again, is an early warning, so resources can be deployed to lessen, if not prevent, epidemics of cholera, says the NSF's Colwell.

At Johns Hopkins, computer simulation models of air pollution and climate change are being used to try to predict future patterns of temperature, air inversions (which trap pollution) and pollution. This could help alert health systems to prepare for conditions that might be deadly for people with COPD or asthma.

Kalkstein has developed a system of air-mass categories for use as an early-warning system for heat waves. In many Midwestern cities, the most dangerous is a dry, tropical air mass, which leads to 30 to 40 percent more deaths from all causes. "We can predict two to three days in advance whether excess deaths will occur," he notes.

The hot-air-mass early-warning system was used in Philadelphia during 1995 and did save lives by prompting quicker deployment of measures such as establishment of air-conditioned centers where the elderly poor could congregate, Kalkstein says. He is now working with the United Nations to develop heat-warning systems for Rome and Shanghai.

As for mosquito-borne diseases, long-range climate and weather forecasting can provide some early warning of danger as well. And local monitoring can track the numbers of mosquitoes and whether they carry a virus, so that public health authorities can institute control measures.

It's conceivable that daily weather forecasts of the future will include a health outlook. In addition to pollen counts and ozone alerts, your local biometeorologist might report the global warming index or might issue a hot-air-mass warning coupled with advice to ward off heatstroke. Mosquito, rodent or tick alerts might also give a heads-up about disease-bearing pests, so you can get out the bug spray and long pants.

Until then, as scientists advised in one old sci-fi movie: look to the skies.

RITA BARON-FAUST is a medical journalist and author of books on women's health.