Chapter 1

OVERVIEW OF ENVIRONMENTAL MEDICINE

Michael Gochfeld

Physicians in many types of practice, including primary care[11] and public health, are increasingly confronted by patients with signs, symptoms, or concerns that they attribute to one or more chemical, physical, or biologic agents in their home, community, or workplace. For example, questions arise concerning radon exposure, hazards of electromagnetic fields, and the neurodevelopmental consequences of early childhood lead exposure. Evaluating and managing such patients and identifying, quantifying, and preventing their exposure is the domain of environmental medicine.[17]

An important purpose of this book is to furnish a comprehensive resource of scientific information on environmental health, "the study of effects upon human beings of external physical, chemical, and biologic factors in the general environment."[6] This is a book for health professionals who must face these issues and especially for the practitioner who takes care of patients on a regular basis. A national study conducted by the Institute of Medicine showed that most environmental and occupational medical services are provided by primary care practitioners.[11] It is anticipated that by providing this resource, practitioners and other health professionals can effectively manage patients who are ill and communicate to healthy citizens who are concerned about the risks from various environmental exposures. There is a need for an approach to deal with the very important and unique features of environmental medicine.

FOCUS OF ENVIRONMENTAL MEDICINE AND RELATIONSHIP WITH OTHER DISCIPLINES

Environmental medicine centers on the interface between the person and the environment. Most diseases arise when the body is exposed to some agent or stressor in the environment, and the assessment of exposure assumes the utmost importance as the pivotal feature of environmental medicine.

The diseases one encounters in environmental medicine, for example, contact dermatitis, obstructive lung disease, nephritis, neuropathy, various cancers, and anxiety, are essentially the same diseases that confront colleagues in other fields of medicine and public health. It is the emphasis on the evaluation, documentation, modification, and prevention of an environmental exposure that gives environmental medicine its cohesiveness.

Environmental medicine is closely related to other medical and nonmedical disciplines, as shown in Fig. 1-1. Several disciplines focus on the environment: ecology, environmental science, environmental health, and environmental medicine. Fig. 1-2 expands on this theme, showing further relationships with other medical disciplines such as preventive medicine, community medicine, and occupational medicine.

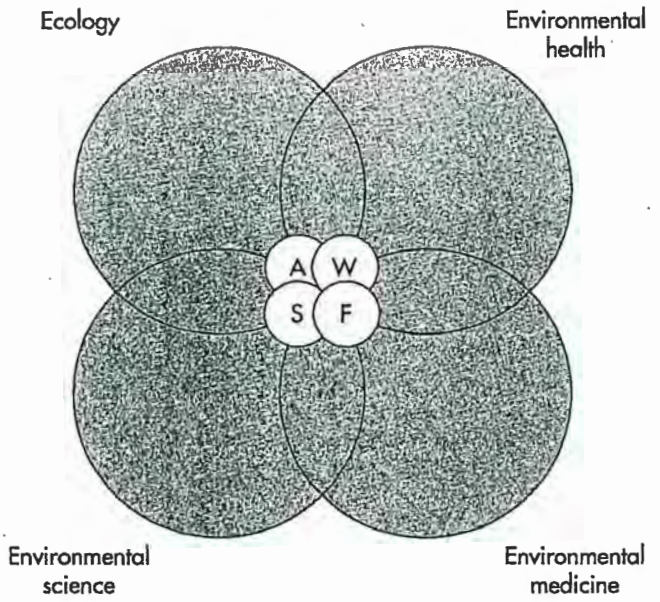

Fig. 1-1. Venn diagram showing relationships among four disciplines, all of which have some focus on the four major environmental media: A = Air, W = Water, S = Soil, F = Food. Ecology is primarily a basic science discipline with a heavy theoretical emphasis as well as an applied emphasis on conservation biology. Environmental science focuses more on the physical or abiotic components of the environment, air, water, and soil. Environmental health is a public health domain, partly overlapping environmental science but carrying it into the sphere of human health, and environmental medicine broadly overlaps environmental health and environmental science and serves as their clinical arm. (With permission of Environmental and Occupational Health Sciences Institute.)

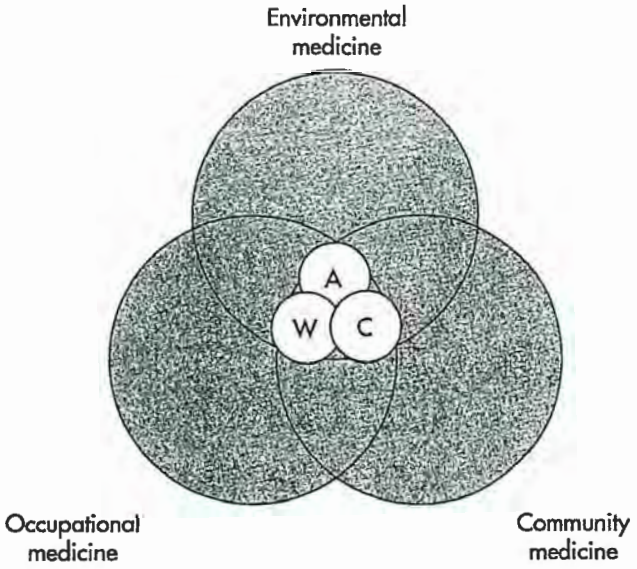

Fig. 1-2. Venn diagram showing relationships among three branches of medicine and their relationships to the three major human environments: A = Abode or Home, C = Community (including schools, shopping areas, recreational areas), W = Workplaces. There is a broad overlap between environmental medicine and occupational medicine. Both overlap community medicine, and all three are part of preventive medicine, although as often practiced some aspects of occupational medicine do not seem to be preventive in nature. Various permutations of the four disciplines are represented in academic departments in about two thirds of American medical schools. The void in the remaining one third of schools is disheartening. (With permission of Environmental and Occupational Health Sciences Institute.)

Ecology, environmental science, environmental health, and environmental medicine all deal with the four environmental media: air, water, soil, and food. Ecology, emerging mainly in the early twentieth century, is the basic and theoretical study of the relationships between living organisms (including humans) and their environment.[14] Environmental health emerged mainly after World War I as a public health endeavor studying the control of environmental factors harmful to human health, initially with a heavy emphasis on sanitation and control of communicable disease.[16] Environmental science, arising mainly after 1960, focuses mainly on the physical environmental media, particularly with regard to pollutants in air, water, and soil. Environmental medicine, arising mainly after 1975, can be viewed as the preventive medicine *and* clinical arm of environmental health, closely related to the above disciplines,[10] focusing on how pollutants in the environmental media enter the body and cause harm. A generic exposure matrix is shown in Table 1-1, and the relationships between contaminated media and routes of exposure are elaborated in Chapter 2 (Types and Sources of Environmental Hazards).

Although historically environmental health was heavily involved in studying and controlling infectious diseases, modern environmental medicine specialists are inclined to relinquish much of the area of infectious disease to other disciplines and to focus mainly on chemical and physical hazards in the environment.

Not only do the various disciplines overlap, but the media interdigitate as well. Airborne pollutants can be deposited on soil, water, and food. Waterborne pollutants can volatilize into the air, can contaminate soil, and may be taken up by plants, thereby entering the food chain. Soil-borne contaminants can enter the air when dust is created, can be carried into surface and groundwater, and can be taken up by plants. Food-borne contaminants contribute less to the other media, although microbial degradation of foods, potential foods, or food wastes can contribute to soil and water pollution.

The fact that there are overlaps among the disciplines is obvious. Pesticides provide an example. Pesticide residues in a community's soil can be a concern of all of these disciplines, albeit in somewhat different ways. Ecologists may focus on how pesticides alter the structure and function of ecosystems by eliminating one or more sensitive species. Environmental scientists may focus on how pesticides move through soil and how they are degraded. Environmental health may focus on the number of people exposed to pes-

Table 1-1. The generic media x route matrix for exposure assessment

Environmental medium	Routes of exposure		
	Ingestion	Inhalation	Dermal
Air	Particulates TSP	++++ PM-10	Variable Vapors Liquids
Soil	Children (100 mg/day)	Re-entrained dust	Muds
Water	++++	Showers Aerosols	Liquids
Food	++++	0	0

Modified from Gochfeld M: *A matrix of routes and media of exposure for risk assessment scenarios,* Piscataway, NJ, 1991, Environmental and Occupational Health Sciences Institute.

ticides. Finally, the practitioner interested in environmental medicine will focus on how individuals or a community are exposed and how exposure can be recognized and prevented.

APPROACH TO ENVIRONMENTAL MEDICINE

For the primary care practitioner, environmental medicine involves the familiar approach of individually evaluating and treating patients who report either an exposure or an illness implicating hazardous substances in the home, community, or workplace environment. Occupational medicine, the specialty involving the health of workers and workplaces, can be considered in part a special form of environmental medicine practice, but the emphasis of this book will be on the nonoccupational environment and the medical issues and disorders associated with exposures in the home, playground, school, highway, mall, and community at large.

In the final analysis no single health professional can address all aspects of environmental medicine such as documenting exposures or recognizing and preventing disease. Our hypothetical community with pesticide contamination in the soil will require an environmental scientist to measure contaminant levels in soil and basements, an environmental health professional to characterize the population at risk, and an environmental medicine practitioner to perform clinical evaluations of people.

BOUNDARIES OF ENVIRONMENTAL MEDICINE

Throughout the book *Enviromental Medicine: Concepts and Practice,* we will use the term *enviromental health* to denote the broader public health province, while the tasks of *environmental medicine* will refer to the responsibilities of the physician or public health specialist who provides assessment and/or management of the individual patient or community.

Confusion may arise regarding the term *environmental medicine* because a group of clinicians, often identified as "clinical ecologists," have called their field "environmental medicine" (they have developed a Board of Environmental Medicine, which, however, is not under the American Board of Medical Specialties). They focus attention mainly on patients who appear to be unusually responsive to very low levels of chemicals, and some of their therapeutic approaches are controversial and not adequately validated. Environmental medicine in the context of this book covers a much broader domain built on scientifically documented principles. However, the basic tenet that clinical ecologists voiced as early as the 1960s,[15] that illness can arise from hitherto unexpected interactions between human susceptibility and environmental hazards, is basic to environmental medicine by any definition.

While Fig. 1-1 examines the relationships of the environmental disciplines to the environmental media, Fig. 1-2 examines the relationships of several branches of medicine to the major human habitats or environments: the home, the community (including schools, shopping areas, places of recreation), and the workplace. The overlaps between the environments are shown in Fig. 1-1. A school may be a community environment for the children, but a work environment for the teachers and other staff. The home may be contaminated by chemicals brought home on the clothes of factory workers and may be the workplace of homemakers and other domestic workers.

ENVIRONMENTAL MEDICINE VERSUS OCCUPATIONAL MEDICINE

Occupational medicine became prominent mainly after 1930 and is concerned with the recognition and prevention of diseases related to the work environment. The tools of the specialty, epidemiology, toxicology, and public health and clinical expertise, are shared with environmental medicine.[6] Community medicine (arising mainly after 1960) shares many of the concerns of environmental health and environmental medicine but has more of a social science emphasis and is more likely to be concerned with health economics and the health infrastructure. Environmental medicine clearly overlaps occupational medicine when the workplace environment is the source of exposure. Environmental medicine somewhat less clearly overlaps community medicine when the community is the focus of exposure. Thus people who identify their specialty as community medicine may have only modest interest when a community being studied has chromium-contaminated soil, while most (though not all) occupational physicians would claim an interest in chromium contamination in the workplaces they encounter.

Although many occupational physicians have focused narrowly on their discipline and have tended to ignore diseases arising from other environments, there has been an increasing recognition that the agents of concern for the workplace (for example, pesticides, heavy metals, noise) are often the same agents that are of concern in the commu-

founded, but to assert this the clinician bears the responsibility of adequately evaluating the patient—through history, physical examination, appropriate tests, and where necessary through consultation or referral. An environmental basis for disease should not be a diagnosis of exclusion.

ENVIRONMENT AND CANCER

Some of the naturally occurring and artificial substances encountered in air, soil, water, and food are known to cause cancer (see Chapter 25). Some substances can be shown to cause cancer in animals; others cause mutations in in vitro tests such as the Salmonella reversion test or Ames Assay. A few are actually linked to cancer in humans through epidemiologic studies. At present only about 40 to 50 compounds are known to be human carcinogens; an equal number are probable human carcinogens, but many others are listed as possible human carcinogens, based upon their carcinogenicity in animals.[12] It is equally important, however, to note that most chemicals do not have carcinogenic properties.

Frequently one reads that 75% of cancers are environmental in origin. This estimate can be traced to a World Health Organization Expert Committee on the Prevention of Cancer,[18] which actually said that 75% of cancers were preventable. This estimate, of course, refers to all environmental factors, including diet and smoking. The National Institute for Occupational Safety and Health estimated that as many as 20% of cancers might be related to occupation.[3] Two British epidemiologists challenged this view, arguing that no more than 4% were related to work and that the main environmental factor responsible for cancer was smoking (30% of cancers).[5] The truth is somewhere in between, as Davis[4] has proclaimed, relating some of the increases in cancer rates to changing environmental exposures. Recent research has suggested that even breast cancer may have a nondietary environmental component—Wolff et al.[18] reported excess breast cancer cases related to chlorinated hydrocarbon pesticide residues in tissue.

PHYSICIAN AS RISK COMMUNICATOR

Physicians play a unique role in communicating information about risks to patients. Opportunities for risk communication may be missed if the patient does not ask specific questions. However, it is not always easy to answer a patient's specific questions regarding the risks of developing disease or the urgency of eliminating a hazard from their lives.

Very often patients have unbalanced fears. They may worry about pesticide residues in their food while continuing to eat an otherwise unhealthy diet (see Chapter 25) or continuing to smoke. They may worry about the siting of an incinerator in their community while neglecting to test their homes for radon. The clinical interview offers the chance to put these risks into perspective.

Practitioners must be clear that estimates of risks frequently change as we discover more about the health aspects of an environmental subject. The practitioner is an appropriate person to convey this information, perhaps using words such as "based on current understanding or knowledge." Fig. 1-3 exemplifies the history of a hypothetical hazard. At first society ignores it or takes it for granted; then the hazard potential is recognized and there may be a profound reaction of alarm, following which the true magnitude of the hazard may be recognized. This pattern describes societal response to hazards as diverse as nuclear power, asbestos, electromagnetic fields, and pesticide residues in food.

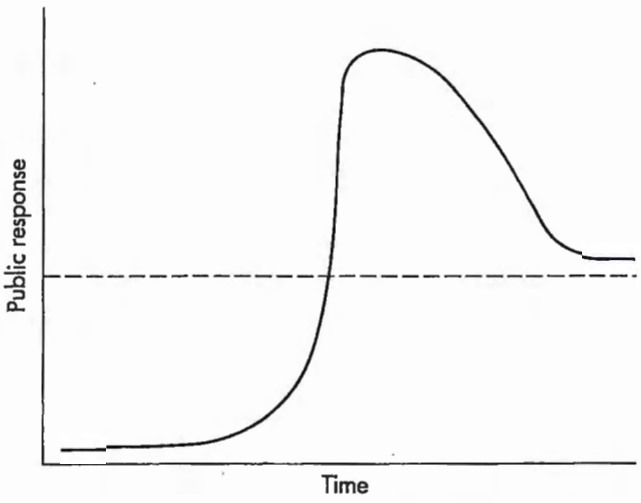

Fig. 1-3. This exemplifies the history over a period of years of a hypothetical environmental hazard. At first the public seems unaware or ignores it; hence zero response. Then the hazard potential is recognized and there may be a profound reaction of alarm. Thereafter the true hazard potential (*dashed line*) comes into focus, and the public response becomes (hopefully) more appropriate. This pattern describes societal response to hazards as diverse as nuclear power, asbestos, electromagnetic fields, and pesticide residues in food, although there often remains a gap between response and reality. (With permission of Environmental and Occupational Health Sciences Institute.)

CONCLUSION

Environmental medicine, the clinical arm of environmental health, involves the diagnosis and prevention of illness caused or influenced by external agents (particularly chemical and physical agents) in a person's environment. It is a very important preventive discipline. Once an environmental disease has occurred, its treatment is often within the domain of internal medicine, but its recognition and prevention is the essence of environmental medical practice. Once hazards have been recognized, control and reduction of exposure should follow swiftly.

The closing of a century and a millennium is a perfect foil for writing about almost any topic. Most biomedical science developed in the past century, and most of what we know about the environment that we share with all manner

nity.[7,9] In 1989 the directors of occupational medicine residency training programs responded to this recognition by agreeing to rename their training programs "occupational and environmental medicine." In 1991 the American College of Occupational Medicine followed suit by renaming itself the American College of Occupational and Environmental Medicine.[1] The American Board of Preventive Medicine considered renaming the subspecialty of occupational medicine but decided against it because its other subspecialties, public health/preventive medicine and aerospace medicine, are also heavily focused on environmental medicine.

Most classes of agents pose the greatest threat in occupational settings where the concentrations or amount of exposure is the greatest and the duration of contact and hence the opportunity to absorb hazardous materials is also the greatest. Moreover, because of their reliance on their income, workers usually do not feel free to walk away from hazardous conditions, particularly those that do not immediately cause adverse effects.

However, increasingly, people have realized that some of the vague and minor discomforts they experience in life may be due to hazardous exposures encountered in their home and community. While this is readily apparent to those who suffer the severe, acute, and time-limited symptoms of hay fever, it is often much less apparent to those who are exposed to vapors emitted by new building materials, household pesticides, and tobacco smoke, although certainly in the last case the risk of significant disease from secondhand smoke in the home is now well documented.

The challenge facing environmental medicine lies not only in the evaluation and management of patients with these exposures, but in research into the contribution of long-term low-level exposure to many environmental agents. Where such exposures are found to cause disease in many people or in a small proportion of unusually susceptible individuals, steps—analagous to those employed by industrial hygiene—must be taken to measure and control the exposures and to ultimately eliminate the hazards. Where exposures do not appear to cause disease, this should be documented as well. In either case a balanced and unbiased perspective, clear educational efforts, and sound public health policies are necessary goals.

THE DISCIPLINE OF ENVIRONMENTAL MEDICINE

Environmental medicine is a broad discipline. Historically clinicians have been trained in the importance of environmental factors as causes or influences of disease. The environment includes all agents outside of the body, including infectious organisms, toxins, and food. The intrinsic factors include the genetic makeup of the host as well as its underlying state of health and history of past illnesses. Disease results from an interplay of these factors when the host defenses are overcome by the agent.

Rosenau[16] defines the domain of preventive medicine in two parts: "... namely, that which deals with the person (hygiene) and that which deals with the environment (sanitation) ... in its relation to health and disease includ(ing) ... discussion of food, water, air, soil, disposal of waste, vital statistics, diseases of occupation, industrial hygiene, school hygiene, disinfection, quarantine, isolation and other topics of sanitary importance, as well as subjects of interest to health officers."

ENVIRONMENTAL PHYSICIANS AND THE ENVIRONMENT

Apparent in all these views of environmental health and environmental medicine is the emphasis on human health rather than environmental quality. The biodiversity and the survival of snail darters or whooping cranes, which capture the attention of conservationists, is not likely to be found in the literature on environmental health or environmental medicine. However, the factors responsible for the decline of some species, such as pollution by chlorinated hydrocarbon pesticides and the health status of fish-eating birds, may have human health significance. Environmental health may use biomonitoring of indicator species to provide early warning of some human health hazards. However, until recently even the major federal agencies responsible for research and protection of the environment (U.S. Environmental Protection Agency [USEPA] and National Institute of Environmental Health Sciences [NIEHS]) have focused almost exclusively on health rather than environmental quality.

The tide is changing, as we shall see. Ecological risk assessment is becoming an important aspect of environmental risk assessment,[2,13] but the distinction between environmental health (human) and ecological health (everything else) remains strong. Environmental medicine plays two major roles in environmental health. It provides the diagnosis and treatment of health complaints attributable to the environment, and it contributes to a much broader understanding of the unity of human health with environmental quality. It provides the basis for understanding what we must do in the next decade and century to ensure that environmental quality will be sufficient to sustain life as we know it.

Sadly, the recognition that this may very well not be the case has come from disciplines (meteorology, evolutionary biology, ecology) lying largely outside the health domain. Moreover, clinicians trained to be skeptical of new and loud claims have not been the first to recognize the importance of environmental impacts, both local and global, on human health.

A specific example is New Jersey, where year after year through the 1980s the public proclaimed environmental health and quality as the number one public policy issue (Eagleton Star Ledger Polls), yet practicing physicians infrequently recognize an environmental basis for their patients' fears or symptoms. Of course, this may be due to the fact that in some cases a patient's fears or concerns are un-

of organisms has been learned this century as well. Predicting society's needs for the twenty-first century is no longer a quest for writers of science fiction. It is safe to say that we will need clinicians who are well versed in ecology and environmentalists who understand exposure and health. Both will play an important role in educating the public as well as public policy makers, preparing them for the difficult and costly decisions that we will face in the next century.

Clinicians should understand that people generally tend to underestimate risks that are large but voluntary (for example, smoking or riding in a car) and to overestimate risks that are much smaller, but involuntary (pesticide residues in food, electromagnetic waves). Usually, neither alarm nor complacency is warranted.

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ENVIRONMENTAL MEDICINE

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Printed in the United States of America
Composition by University Graphics, Inc.
Printing/binding by Maple-Vail Book Mfg. Group

Mosby–Year Book, Inc.
11830 Westline Industrial Drive
St. Louis, Missouri 63146

Library of Congress Cataloging in Publication Data

Environmental medicine / Stuart M. Brooks . . . [et al.].
p. cm.
Includes bibliographical references and index.
ISBN 0-8016-6469-1
1. Environmental health. 2. Environmentally induced diseases.
I. Brooks, Stuart M.
[DNLM: 1. Environmental Health. 2. Environmental Pollution—adverse effects. 3. Environmental Pollution—prevention & control. 4. Environmental Pollutants—toxicity. WA 30 E63887 1995]
RA565.E52 1995
616.9'8—dc20
DNLM/DLC
for Library of Congress 94-42249
CIP

94 95 96 97 98 / 9 8 7 6 5 4 3 2 1