8 · Environmental/ Occupational Issues and Cancer

CHAPTER CONTRIBUTORS

COMMITTEE MEMBERS

Clifford Mitchell, MS, MD, MPH (CHAIR)
Infectious Disease and Environmental Health Administration,
Maryland Department of Health and Mental Hygiene

Shannon Brown, PhD
Johns Hopkins Bloomberg School of Public Health

Mary Fox, PhD, MPH
Johns Hopkins Bloomberg School of Public Health

Jennifer Hayes, MEd, MPH
Center for Cancer Surveillance and Control,
Maryland Department of Health and Mental Hygiene

Kathy Helzlsouer, MD, MHS
Prevention and Research Center, Mercy Medical Center

Diane L. Matuszak, MD, MPH
Public Health Consultant

Jed Miller, MD, MPH
Maryland Department of the Environment

Colleen Ryan Smith
Montgomery County Department of Health and Human Services

Amir Sapkota, PhD
University of Maryland, College Park, School of Public Health

Katherine Squibb, PhD
University of Maryland School of Medicine

Kimberly Stern, MHA, CTR
Center for Cancer Suveillance and Control,
Maryland Department of Health and Mental Hygiene

8

ENVIRONMENTAL/ OCCUPATIONAL ISSUES AND CANCER

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

This chapter addresses the complex relationship between cancer and environmental and occupational factors.

The chapter's goals are to:

- Describe the current state of knowledge regarding environmental and occupational hazards and cancer, especially related to these factors in Maryland.
- Describe specific environmental and occupational hazards that may be related to cancer, stressing ways in which exposures can be decreased or eliminated.
- Talk about the role of cancer surveillance in helping us understand these questions, especially when investigating possible cancer clusters.
- Address research needs that would specifically contribute to either improved understanding or improved management/prevention of cancer related to environmental and occupational factors.

Environmental Factors

The Maryland Comprehensive Cancer Control Plan takes a specific view of "environmental factors." The term "environmental factor" in this chapter specifically refers to chemicals, physical agents such as radiation (including ultraviolet radiation), and other non-biological agents that could potentially be reduced or eliminated. Also, while most attention to environmental and occupational hazards has usually been on those that cause (initiate) cancer, the focus in this chapter is more comprehensive. Some hazards included in this chapter may not necessarily cause cancer, but may instead promote cancer (that is, make it easier for a cancer to grow). This chapter, however, does not include viruses or other biological agents linked to cancer, which may be covered in specific disease chapters (for example, human papilloma virus is covered in Chapter 13 on Cervical Cancer). Finally, tobacco smoke, which is the most important environmental factor in cancer, is briefly addressed here in the section on indoor air, but is addressed primarily in Chapter 5: Tobacco-Use Prevention/Cessation and Lung Cancer.

WHAT IS THE "RISK" OF CANCER?

There is often confusion about terms like the "risk" of cancer, "risk analysis," and "risk assessment." When we speak of "risk" in this chapter, we mean the probability (not certainty) of developing a case of cancer. A "risk" of 1 in a million means the probability that there would be one extra case of cancer in a million people. Risk assessment is a formal process for estimating risk, using mathematical models.

Why use risk assessment? It is not possible to completely eliminate exposures to potential environmental carcinogens; therefore, we assess the risk of exposures and use "acceptable levels of cancer risk" to set environmental standards. These cancer risk levels estimate how many cases of cancer attributable to a hazard would be expected to occur in a population of a given size. For example, a cancer risk level for a chemical in drinking water of 1 in 100,000 means that, for every 100,000 people exposed, one extra case of cancer would be expected to occur because of exposure to the contaminant in drinking water in a given period of time (usually either over a lifetime or per year).

Occupational Factors

This chapter also discusses workplace or occupational factors and cancer. Workers exposed to chemicals are often exposed to higher concentrations than are found outside the workplace, and there are different regulations and different regulatory agencies involved in controlling occupational exposures. However, the line between occupational and environmental exposures may be blurred. For example, there are so-called "para-occupational" exposures, in which the hazard is brought out of the workplace (typically by the worker without his or her knowledge) and into the home. One example of this is when asbestos workers unknowingly brought asbestos into the home. In this chapter, we recognize that the difference between the workplace and other environments is somewhat artificial, and when considering the cumulative exposure of an individual one should consider all possible sources of exposure.

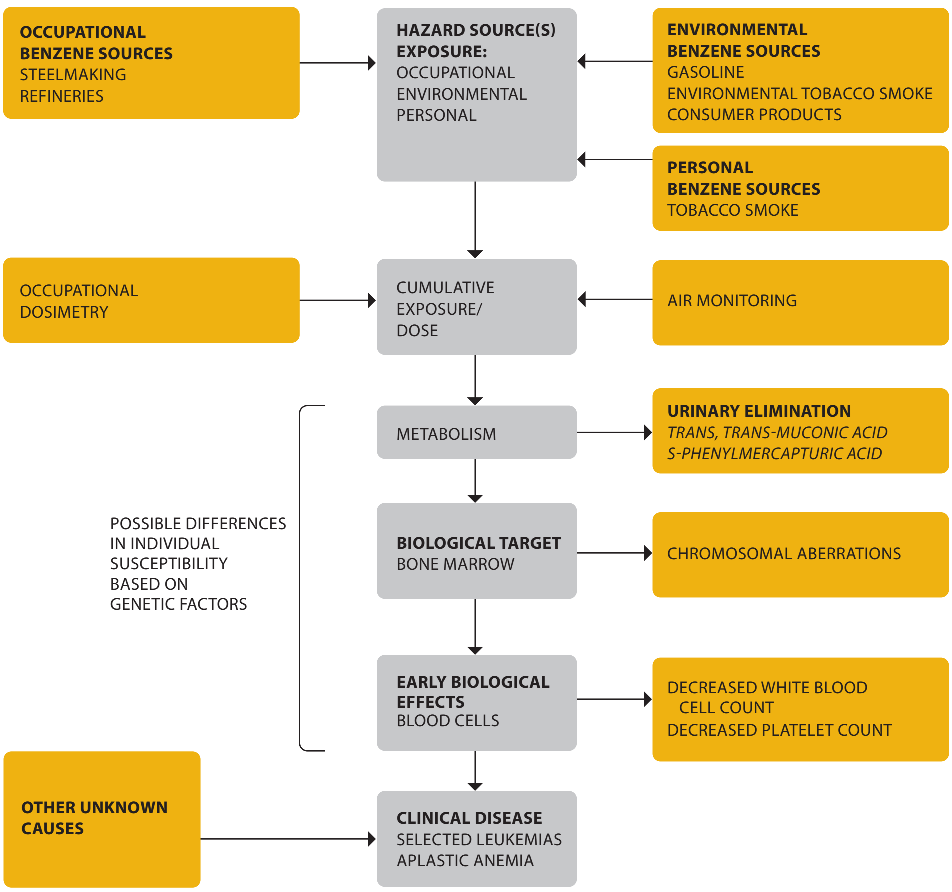
Environmental and Occupational Factors of Concern to Marylanders

Some clues to which environmental and occupational factors are of concern to Marylanders come from questions that have come to the Department of Health and Mental Hygiene or local health departments over the years; some clues come from the kinds of industries in Maryland today or in the past. Types of chemicals considered range from asbestos (used in steelmaking, shipbuilding, and insulation), to naturally occurring radioactivity in drinking water, organic solvents that have been found in groundwater leaching from underground storage tanks or hazardous waste sites, environmental chemicals found in consumer products, and low-level electromagnetic fields. While some of these represent well known causes of cancer, in other cases, the relationship between exposure and any specific type of cancer, or cancer at all, may be very much in question. This can make it very challenging—for individual patients with questions, for their healthcare providers, and for the public health community—to offer specific guidance or conclusions about the significance of specific exposures to cancer, as shown in the example of benzene in Figure 8.1.

As Figure 8.1 shows, in the case of a compound like benzene there may be more than one source of exposure, including occupational, environmental, and personal (tobacco smoke) sources. Furthermore, in most cases of aplastic anemia or certain leukemias, the cause is not exposure to benzene, but remains unknown. Typically only in the case of individuals with significant occupational exposures is there enough confidence to conclude that the cause was probably specific exposure to benzene.

Another issue related to environmental/occupational factors and cancer concerns health disparities and vulnerable populations. Most discussions of health disparities concern access to care, but in the world of environmental factors, disparities may also involve disparities in exposure. We have come to understand that while it is not always possible to "prove" that a specific cancer is linked to a specific exposure, it

FIGURE 8.1 **Exposure-Dose-Effect Model for Benzene**



is not uncommon for different groups (separated by race, gender, age, socioeconomic status, or occupation) to have differences in both exposures and in rates of cancer, as well as cancer outcomes. The policy questions may then be both how to reduce elevated exposure and elevated cancer rates, while not necessarily assuming that a reduction in exposure will inevitably lead to a reduction in cancer rates.

CASE STUDY

Occupation, Gender, Race, and Lung Cancer in Maryland

A recent study by Amr et al. examined possible racial and gender differences in non-small cell lung cancer rates among participants in the Maryland Lung Cancer Study in various industries. This is an example of the type of analysis, using surveillance and other data, that can be used to identify opportunities for workplace educational interventions, disparities in health status among different occupational cohorts, and, potentially, diseases associated with different occupational exposures.

Amr S, Wolpert B, Loffredo CA, Zheng YL, Shields PG, Jones R, Harris CC. Occupation, gender, race, and lung cancer. J Occup Environ Med. 2008 Oct;50(10):1167-75.

Types of Hazards

Occupational Hazards

One important determinant of risk is the occupational profile of the population. Employment patterns in Maryland have shifted over the past 30 years, changing the patterns of exposure and, probably, of disease. In past decades, Maryland's industry was a mix of manufacturing, agriculture, services, education, research, and government. The 2002 economic census showed that the largest employers in Maryland were state and local government (combined); retailing; healthcare and social assistance; and professional, scientific, and technical services.[1,2]

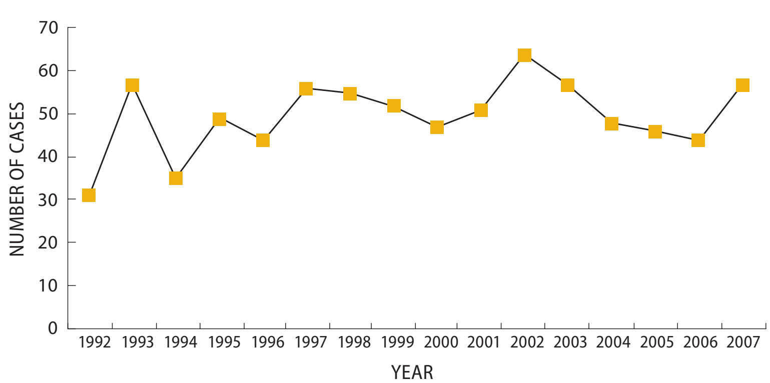
Maryland's current cancer profile is, in part, a product of past occupational exposures. For example, it typically takes two to three decades for some cancers related to asbestos exposure (found in Maryland's shipbuilding and steelmaking industries, among others) to develop. The decline of those industries as major employers, which occurred several decades ago, means that their contribution to the overall cancer rate should begin to decline as well. At the moment, however, there is no discernible decline in number of cases of mesothelioma annually (Figure 8.2). There has been improvement in the control of many occupational chemical exposures. However, there are still significant opportunities for exposures to carcinogens in many industries. This points to the need for surveillance of and research into occupational contributions to cancer, as well as the need for collection and analysis of information about both current and former employment as potential risk factors.

Outdoor Air Pollution: Airborne Toxics

Air pollution is a complex mixture of chemicals, many of which are known to cause cancer. These chemicals may be present as gases, or bound to small, inhalable particles known as particulate matter (PM). Air PM is generally divided into categories based on the size of the particles. The smaller particles—"fine particulate matter," or those of 2.5 micrometers or less in diameter (PM2.5)—are the particles that can be inhaled deeper into the lungs and are generally considered the particles more likely to be related to health problems.

The relationship between exposure to airborne chemicals and cancer risk is a significant public health concern because even if the associated risk of cancer is low, the number of people exposed to air pollutants is large and people may be exposed to poor air quality for their entire lifespan. Although not all air pollutants cause cancer, 187 hazardous air pollutants (HAPs), some of which are known causes of cancer, were defined under the 1990 Clean Air Act Amendments.[3]

FIGURE **8.2** Mesothelioma Cases in Maryland by Year, 1992-2007



N=793
Source: SeerSat Static Data as of December 01, 2009, Maryland Cancer Registry.

TERMS TO KNOW

PM

Particulate matter (PM) refers to particles that can be inhaled. The smaller particles (those of 2.5 micrometers or less in diameter [$PM_{2.5}$]) can be inhaled deeper into the lungs.

HAPs

The 1990 Clean Air Act Amendments identified 187 hazardous air pollutants (HAPs), some of which are known to cause cancer.

1990 Clean Air Act Amendment Hazardous Air Pollutants (HAPs)

- The HAPs list contains 187 chemicals that are known or suspected to cause cancer or other serious health effects.
- Examples of HAPs known or suspected to cause cancer are:
    - Benzene
    - 1,3 Butadiene
    - Dioxin
    - Polycyclic Aromatic Hydrocarbons (PAHs)
    - Metals, such as cadmium (Cd), Hexavalent Chromium (Cr+6) and nickel (Ni)

Many chemicals on the HAPs list are known human carcinogens, including benzene. A primary source of benzene in ambient air is gasoline. Therefore, depending on the number of gas stations and "mobile sources" (moving gas-powered vehicles, cars, trucks, etc.) in an area, inhalation of outdoor air can be the primary exposure pathway to benzene for many people. More information on the health effects of specific hazardous air pollutants can be found at http://www.epa.gov/airtoxics/hlthef/hapindex.html.

Exposure to carcinogenic air toxicants is a problem nationally as well as in the state of Maryland. The Environmental Protection Agency's 2002 National-Scale Assessment Program has estimated that:[4]

- More than 284 million people in the US live in areas with cancer risks greater than 10 in a million due to exposure to HAPs (this is a lifetime risk of cancer-defined by EPA as the "plausible upper limit to the true probability that an individual will contract cancer over a 70-year lifetime as a result of a given hazard").
- More than 2 million people in the US live in areas with HAPs-associated cancer risks of greater than 100 in a million.

In Maryland, cancer risks associated with exposure to HAPs range from:[5]

- 1 to 25 in a million in rural areas.
- As high as 100 in a million in the Baltimore City area.

Many epidemiological studies have begun to examine the role of individual HAPs in the initiation of cancers, but have found it difficult to identify specific chemicals of greatest concern. Results of two studies suggest that benzene is one of a number of chemicals associated with excess cancer risk.[6,7] Also, the strong association of $PM_{2.5}$ levels with excess cancer is most likely due to the many chemicals bound to the fine $PM_{2.5}$ particles. The fact that Baltimore does not meet EPA's standards for $PM_{2.5}$ concentrations in ambient air makes this an important target for lowering Maryland's cancer burden.

SOURCES OF OUTDOOR AIR CARCINOGENS

Most HAPs, like other common air pollutants, are produced by mobile sources (mainly vehicles) and stationary sources (factories). Mobile sources include highway vehicles and on-road and off-road equipment that release engine exhaust or evaporative emissions. Industrial emissions have been better characterized for larger industries through information gathered as part of EPA's Toxic Release Inventory (TRI) Program.[8]

On a national level, vehicle exhaust is thought to be the dominant source of most HAPs, followed by industrial emissions;[9] however source distributions differ for different areas depending on vehicular traffic patterns and the types of industries located within an area. Modeling results suggest that as much as 60% of ambient concentrations of benzene, 1,3-butadiene, and POM are attributable to mobile sources.[10]

Although EPA's National-Scale Air Toxics Assessment (NATA) results for Maryland provide a general view of cancer risks associated with inhalation of ambient air carcinogens in our state, monitoring data for air toxics in Maryland are sparse, both in terms of the number of air toxics measured and the low number of monitoring sites present in the Eastern and Western Maryland areas. The extent to which NATA results accurately predict the concentrations of HAPs in Maryland's ambient air is not known; nor do we know which of the industrial chemicals are the most important of the reported cancer risks. This makes it difficult to identify specific sources and develop effective control measures. In addition, the NATA data do not account for small local sources; thus, it is desirable to cross-validate NATA-modeled data with monitoring data for Maryland. Without local data, it is difficult to reliably quantify the temporal as well as spatial variability in HAPs across Maryland. For instance, due to lower volumes of traffic in Western Maryland, non-vehicular sources of carcinogenic pollutants may be of greater relative significance in this area of the state compared to the urban Baltimore-Washington corridor.

It is also important to consider the impact of multiple chemical exposures on health. To date, both EPA's and Maryland's research and regulatory focus has been on individual pollutants, as exemplified by the National Ambient Air Quality Standards (NAAQS). However, in reality, people are exposed to many chemical pollutants simultaneously. Therefore, increased emphasis should be given to determining how chemical mixtures can be collectively regulated and their health risks quantified. In addition, the impact of other co-exposures, such as smoking and occupational exposures, needs to be taken into consideration when assessing health risks to determine how they might interact synergistically. It also remains unknown how cancer risks associated with HAPs may be modified by genetics and other conditions such as nutritional deficiencies, chronic pulmonary inflammation, and other pre-existing health problems.

Waterborne Exposures

All Marylanders consume and use water every day. Because of this, preventing exposure to waterborne contaminants that pose a cancer risk is a significant public health issue. Water may contain contaminants from various sources. Contaminants may occur naturally, can be manmade, or may be formed when water is disinfected to make it suitable for drinking. Contaminants that were originally released into the air or soil can make their way into water. In addition, some contaminants can accumulate in fish that are consumed by Marylanders.

In order to protect Marylanders from waterborne carcinogens, water standards are developed and enforced by the Maryland Department of the Environment. Standards are used for surface waters under the Clean Water Act and for publicly supplied drinking water under the Safe Drinking Water Act. Maryland adopts drinking water standards for public water supplies that have been established by the US Environmental Protection Agency, although Maryland-specific standards could be developed if a national standard does not exist for a given contaminant. Table 8.1 lists examples of waterborne carcinogens that are regulated in Maryland under water quality standards. It is important to recognize that the drinking-water quality standards and required periodic testing for water quality do not apply to private wells. This means that people who drink from private wells cannot be certain about the possibility of carcinogenic chemicals in their drinking water unless they test the water themselves.

TABLE 8.1 Examples of Regulated Waterborne Carcinogens

Contaminant	Category
Benzene	organic chemical
Dioxin	organic chemical
Vinyl chloride	organic chemical
Chlordane	organic chemical/pesticide
Haloacetic acids	byproduct of disinfection
Uranium	radioactive element

Consumption of fish caught in Maryland waters is another route of exposure to water contaminants that pose a cancer risk. Mercury and PCBs (polychlorinated biphenyls) are contaminants that can accumulate in fish. PCBs are suspected to cause cancer in humans. The level of mercury and PCBs in Maryland fish has prompted the Maryland Department of the Environment to issue fish consumption advisories. The advisories recommend how often certain fish from a given location can be eaten so that health risks are minimized (www.mde.state.md.us).

Foodborne Hazards

The United States possesses one of the safest and most nutritious food supplies in the world. Unlike countries in which the risk of malnutrition is high, in Maryland and the United States there is growing concern about overconsumption leading to obesity and its related health consequences. However, food as a source of exposure to carcinogens remains a concern to many. Broadly speaking, the sources of carcinogens in food may be considered to be naturally occurring (such as mycotoxins; that is, toxins from fungi) or related to human

Examples of Foodborne Carcinogens Related to Human Activities

- Industry: environmental dioxins entering into fish, meat, dairy products, etc.
- Agricultural practices: pesticides and feed additives.
- Food cooking methods: acrylamides and furans.
- Introduction of food additives and dyes.
- Food preservation: nitrosamines.
- Lack of food preservation: e.g., growth of fungi-producing mycotoxins.
- Chemical migration from packaging into food and water: bisphenol A.

Federal Agency Responsibilities Regarding Foodborne Hazards

Environmental Protection Agency (EPA)
- Regulation, control, mitigation of toxic substances in the environment.

Food and Drug Administration (FDA)
- Regulation of food and milk processing.
- Monitoring foods for contaminants including pesticide residues.

United States Department of Agriculture (USDA)
- Regulation of meat and meat products, shellfish, eggs, poultry, and farm-raised fish.
- Surveys of pesticide usage.

activity (See the text box "Examples of Foodborne Carcinogens Related to Human Activities"). The vast majority of chemicals found in food remain unevaluated as to their potential as carcinogens.

A number of known human and animal carcinogens have been detected in food. Technology continues to improve, allowing the detection of ever-smaller concentrations of chemicals. The biological activity of extremely low concentrations of these chemicals is not calculable with our current level of knowledge. Food is also known to have compounds and properties that reduce the risk of cancer, including such chemicals as antioxidants, flavinoids, omega-3 fatty acids, and plant fiber.

Research on the carcinogenicity of foods is often conducted using experiments involving animals, particularly rodents. Dosages for exposure (amount of chemical per unit of body weight) are often far in excess of exposures that might be reasonably encountered by humans in the course of ordinary activities. Extrapolation of animal data to humans for estimation of exposure dose and risk is difficult. Current data do not allow the estimation of cumulative risks posed by exposure to extremely low levels of multiple chemicals in food. However, these cumulative low-level risks do not appear to substantively contribute to the overall lifetime risk of cancer on a population basis.

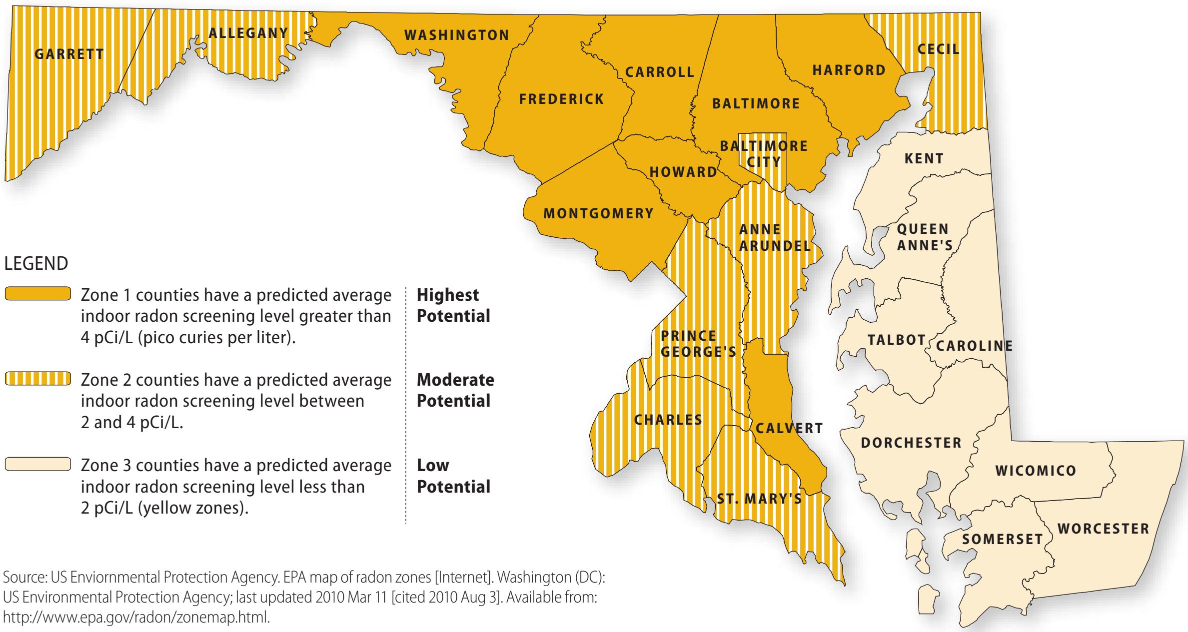
The Food and Drug Administration (FDA) is responsible for the protection of processed foods, produce, imported foods, and milk and dairy products. The Federal Food, Drug, and Cosmetic Act governs FDA regulatory activities. In 1958, the law was amended to prohibit any known animal or human carcinogen as a food additive (the Delaney Clause). The Food Quality Protection Act of 1996 repealed the Delaney Clause and replaced it with a strict standard regarding pesticide chemical residues in foods as discussed above. The safety standard now requires that the administrator determine "that there is a reasonable certainty that no harm will result from aggregate exposure to pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information" (Title 4, Section 408, 21 U.S.C. 346a). In addition, this statute requires coordination between USDA, EPA, and FDA in the collection of adequate data on food consumption patterns of infants and children and provides for an additional tenfold margin of safety for exposures for infants and children. (See the text box "Federal Agency Responsibilities Regarding Foodborne Hazards").[11]

Physical Agents

Physical agents include radiation (both ionizing and non-ionizing) and particles such as asbestos. These agents are known carcinogens, and information about them has been changing significantly in the past few years, especially regarding radiation.

Ionizing radiation exists everywhere. Until recently, most of the radiation exposure that a person in Maryland received was due to natural sources (also known as "background" radiation).

FIGURE **8.3** **Predicted Radon Concentrations in Maryland**



LEGEND

Zone 1	Zone 1 counties have a predicted average indoor radon screening level greater than 4 pCi/L (pico curies per liter).	**Highest Potential**
Zone 2	Zone 2 counties have a predicted average indoor radon screening level between 2 and 4 pCi/L.	**Moderate Potential**
Zone 3	Zone 3 counties have a predicted average indoor radon screening level less than 2 pCi/L (yellow zones).	**Low Potential**

Source: US Enviornmental Protection Agency. EPA map of radon zones [Internet]. Washington (DC): US Environmental Protection Agency; last updated 2010 Mar 11 [cited 2010 Aug 3]. Available from: http://www.epa.gov/radon/zonemap.html.

The main sources of background radiation in the environment are cosmic rays from space, naturally occurring radioactivity given off by radioactive elements in the earth, and small amounts of radiation given off by naturally occurring radioactive elements in our own bodies. This naturally occurring background radiation historically has accounted for more than 80% of the average radiation dose to someone living in the United States.[12]

RADON

The most important preventable source of background radiation for people in Maryland is radon. Radon is an invisible, odorless radioactive gas produced as a decay product of uranium in the ground. The radon is able to enter a home through cracks and holes in a foundation, but because it is heavy, it generally stays at ground level (in the basement). When inhaled (and only when inhaled), the radioactivity given off by the radon can increase the risk of lung cancer, both in smokers and in non-smokers. Fortunately, an inexpensive and simple radon test kit can be used to measure radon levels. If the radon is above recommended levels, the solution is also usually simple and relatively inexpensive, typically requiring increased ventilation of the basement space. The US Environmental Protection Agency estimates that radon is the most important risk factor for lung cancer in people who do not smoke, so measuring and eliminating radon is very important.

Figure 8.3 is a map developed by the EPA that shows predicted radon concentrations for Maryland. The map was developed using five factors to determine radon potential: indoor radon measurements, geology, aerial radioactivity, soil permeability, and foundation type.[13]

DID YOU KNOW?

The most important preventable source of background radiation for people in Maryland is radon.

PERSONAL RADIATION

Recently, studies suggest that an increasing fraction of personal radiation doses come from the use of medical imaging technologies. In particular, the increasing use of computed tomography (CT) scans has been pointed out as a significant challenge and has caused the US Food and Drug Administration (FDA) to focus on the problem.[14,15]

ULTRAVIOLET (UV) RADIATION

Ultraviolet radiation is a known carcinogen. There is increasing concern about cancers related to sunlight exposure, including melanoma and basal and squamous cell carcinomas. Groups at increased risk include outdoor workers, teenagers (especially teens who use artificial ultraviolet tanning beds), and people with certain medical conditions.[16] More information on ultraviolet radiation can be found in Chapter 7: Ultraviolet Radiation and Skin Cancer.

Household/Personal Exposures

Americans spend most of their time indoors. Indoor air pollution can be a significant source of exposure to carcinogens, depending on the location of a home, how it is constructed and maintained, and activities within the home. Indoor air pollution is a mixture of pollutants entering from the outdoors and those from sources within the home.[17] More information on indoor air pollution can be found at http://www.epa.gov/apti/course422/ap4.html.

Potential indoor sources include building materials, furniture, household cleaning products, and sources that release combustion gases such as wood stoves and fireplaces. The toxicants that are of particular concern from cancer risk perspectives include formaldehyde, p-dichlorobenzene, chloroform, acetaldehyde, benzene, naphthalene, dichloromethane, and asbestos. In addition, environmental tobacco smoke and radon are two important carcinogens that are present in the indoor environment. These pollutants are covered in other sections within this chapter.

In addition to airborne agents, drinking water can be a source of carcinogens. Chemical contaminants in drinking water are discussed in the section on Waterborne Exposures. Chemical contaminants may be of particular concern in homes with private wells, as these wells generally have fewer requirements for testing than public water supplies.

Sources of Data for Environmental/ Occupational Cancer

For general information about cancer surveillance data and the Maryland Cancer Registry (MCR), see Chapter 2 on Cancer Surveillance. In this section we discuss the specific challenges and opportunities for using surveillance data to investigate possible links between environmental conditions and cancer. Use of cancer surveillance data, including the MCR data, for evaluating environmental causation or association is challenging for a number of reasons, including:

- Cancer is usually caused by more than one factor, including a combination of genetics, environment, and personal lifestyle factors.
- Cancer has a long incubation period (latency) from initiation (the starting event) to the development symptoms and disease.
- Cases are classified by their address at diagnosis, rather than where they lived when they might have been exposed to particular environmental agents. The address at diagnosis may or may not reflect where the person lived before the cancer diagnosis.
- Environmental exposures may occur at a place of work; however, the person's occupational information (and therefore potential exposure information) is often missing in cancer registries, including the MCR.
- Personal risk factors such as tobacco use, body mass index, diet source/composition, water source/intake, exercise, UV exposure, prior screening for cancer, etc., are typically not collected by cancer surveillance systems, including the MCR.
- Some cancers are often diagnosed in an outpatient setting, particularly skin cancer and urologic cancers. This limits the reporting of full data on these cancers to state registries.

"Ecologic associations" between cases of cancer and certain environmental factors can be investigated by examining the relationship between rates of all or certain types of cancer and various environmental factors. Such analyses usually are most useful for raising possible avenues for

TABLE **8.2** Data Sources for Environmental and Occupational Factors

DATA SOURCE	CONTENTS	COMMENTS
OCCUPATIONAL		
Maryland Occupational Safety and Health	No provision for occupational cancer reporting.	Maryland DHMH has received a grant from National Institute for Occupational Safety and Health for occupational health surveillance. Cancer reporting should be a priority.
AIR		
Toxics Release Inventory (TRI) Program (http://www.epa.gov/tri/#hts1)	Toxic chemical releases and waste management activities reported annually by specific types of industries and federal facilities.	Downloadable TRI data files are available for individual states, including Maryland (http://www.epa.gov/tri/tridata/current_data/index.html). Mobile source data available (compounds emitted from standard gasoline and diesel engines and alternative fuels such as ethanol, biodiesel, and compressed natural gas) (http://www.epa.gov/otaq/regs/toxics/420b06002.pdf).
Air monitoring program for Criteria Air Pollutants	23 monitoring stations across the state of Maryland collect data on Criteria Air Pollutants: ozone, PM10, PM2.5, carbon monoxide (CO), nitric oxides (NOX) and sulfur dioxide (SO2).	Most monitoring sites located in Central Maryland, with a single monitoring site in Millington on the Eastern Shore and two in Western Maryland in Hagerstown and Piney Run. Not all Criteria Air Pollutants measured at all sites (http://www.mde.state.md.us/Programs/AirPrograms/Monitoring/monitnetwork/index.asp).
Air monitoring for Hazardous Air Pollutants	Carbonyls, volatile organic chemicals, and heavy metals are measured at three sites between Baltimore and Washington (http://www.epa.gov/reg3artd/airquality/toxmon3.htm).	Since many carcinogens on EPA's HAPs list are bound to fine PM2.5, inhalation of PM2.5 particles may be a good surrogate measure of exposure to carcinogenic HAPs.
National-Scale Air Toxics Assessment (NATA) (http://www.epa.gov/ttn/atw/natamain)	Uses national emissions inventory data from outdoor sources for 180 of the 187 Clean Air Act HAPs plus diesel PM to model ambient concentrations of air toxics in the United States and population exposure at the census track level.	Results from this modeling have been used to calculate cancer risks associated with 80 known carcinogens within the 180 chemicals examined at national and regional levels (http://www.epa.gov/ttn/atw/nata2002/tables.html).

further investigation rather than demonstrating cause and effect because there is usually limited case information on other factors known to affect cancer, such as smoking, diet, family history, or previous environmental or occupational exposures.

Table 8.2 describes different data sources available for environmental and occupational factors.

Prevention of environmental and occupational cancer relies primarily on the identification and reduction of exposures to carcinogens. In the occupational setting this has been accomplished through regulations that reduce or eliminate exposures. In many cases environmental exposures cannot be completely eliminated, so the goal is to reduce them as much as possible.

Cluster Investigations

Evaluating small geographic areas (such as a neighborhood or a census tract) for increased cancer risk is difficult. Often a citizen is concerned about cancer cases in a neighborhood or worksite. For neighborhood evaluations, the cases diagnosed in the area may not yet have been reported, may not be completely reported, or may be inaccurately reported. Identifying the denominator or "population at risk" in a neighborhood

TABLE 8.2 CONT. Data Sources for Environmental and Occupational Factors

DATA SOURCE	CONTENTS	COMMENTS
WATER		
Drinking water data MDE	Local water quality reports.	
FOOD		
Food and Drug Administration http://www.fda.gov/downloads/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/UCM186204.pdf	The FDA collects several hundred samples of food from grocery stores and food distribution centers each year to test for pesticide residues, contaminants, and nutrients in foods.	http://www.fda.gov/downloads/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/UCM186204.pdf FDA may also conduct targeted sampling of food and animal feed (http://www.cfsan.fda.gov/).
US Department of Agriculture http://www.fsis.usda.gov and http://www.foodsafety.gov	The USDA's Food Safety and Inspection Service (FSIS) monitors and regulates domestically produced meat, farm-raised fish, eggs, and poultry.	USDA collects state/regional pesticide use data for all crops including food crops.
INDOOR ENVIRONMENTS		
No national or state data source for indoor environmental monitoring.		
HUMAN EXPOSURE		
EPA's Human Exposure Database System (HEDS)	Maryland data available.	HEDS is an integrated database system that contains chemical measurements, questionnaire responses, documents, and other information related to EPA-supported research studies of the exposure of people to environmental contaminants. These data are available to the public for exposure and risk assessment modeling.

relies on ten-year census information and intercensus estimates. Population data are often not available below the ZIP code or census tract level. ZIP codes also change with time. Identifying the "population at risk" at a worksite for rate calculation and comparison is very difficult, requiring a research study to obtain personnel records and to track individuals forward in time to assure complete denominator information and complete case identification on those who moved out of the surveillance area. Additionally, each of these evaluations requires having a population rate of the cancer of interest in a comparison group, which is often difficult to identify. Conveying these limitations of cancer concern investigation and cancer surveillance to individuals who seek the cause of a cancer diagnosis and to the media is challenging yet necessary.

Maryland has recently adopted a strategy to manage investigations where concerns are raised regarding possible relationships between cancer and some environmental factor. Annually, there are about a dozen cancer concerns reported to DHMH, MDE, or local jurisdictions. Cancer concerns are primarily reported to state and local health departments, but also can be directed to local and state environmental agencies, academic institutions, and healthcare facilities. Residents concerned about potential “clustering” of cancer cases reach out to public health professionals:

- For input into, consultation about, and clarification over the complex set of diseases known collectively as cancer.
- To report cases of cancer that appear unusual or atypical to the resident.
- To get a comprehensive analysis on observed patterns in number or type(s) of cancer.
- To learn plausible explanations for their own cancer diagnosis or diagnoses among neighbors, loved ones, colleagues, or other acquaintances.

Responsiveness to these concerns in a sensitive and timely manner with accurate information and appropriate level of detail is critical.

Adequate responses to reported cancer concerns involve coordination among local health departments as the lead contact to concerned communities, state cancer registries as the guardian of the most current and accurate cancer data, and overarching coordination by the state lead for cancer and environmental health as the agency with oversight. Most concerns are adequately addressed by providing timely information and directing the resident to additional resources for more information from trusted organizations; providing transparency in the process through which the concerns are addressed; recognizing the fear, anger, and frustration of anyone coping with a cancer diagnosis; assisting in navigating the individual through the multitude of information available to best enable him or her to better understand the complexity of the disease; and maintaining accessibility for follow-up and future assistance should it be needed. DHMH provides many resources to assist concerned residents with information, additional resources, and local contact information to further respond to cancer concerns in individual communities. Links to these resources can be found at http://fha.maryland.gov/pdf/cancer/mcr_combined_cancer_cluster.pdf.

Research

Research and data collection are essential for understanding and reducing cancer from exposure to carcinogens in the environment and workplace. Environmental and occupational cancer research has historically been very challenging for several reasons. First, the time between exposure to a carcinogen and the development of cancer (latency) can take years or decades, making it very difficult to determine what exposures occurred in the past and to measure them. Second, in order to understand what level of exposure poses a cancer risk, it is important to measure the amount of a carcinogen that enters the body when exposures occur. Because it is often difficult or impossible to eliminate all exposures, we need to determine what level of exposure can be considered acceptable or “safe.” The best way to measure the dose we receive from exposure to a carcinogen is with biological sampling (i.e., blood samples); however, this is labor intensive and expensive. Third, the biological process that occurs when someone is exposed to a carcinogen in the environment is often very complicated and may vary from individual to individual. In other words, two people exposed to the same amount of a carcinogen may not have the same response. And finally, because we are exposed to many different chemicals and agents in the environment and workplace simultaneously, it is often difficult to determine which exposure is causing cancer.

Research will help us answer many of the questions about the biological mechanisms that determine the ultimate health impact of carcinogens in our environment. Other important questions include:

- What carcinogens are we exposed to?
- How much is getting into our bodies?
- What dose will cause cancer?
- What exposure can be considered “safe” or acceptable?
- How can we reduce or eliminate our exposures to carcinogens?

In addition to research, data collection and cancer surveillance are critical pieces to reducing environmental and occupational cancer. We must collect data on exposure to carcinogens in the environment (air, water, soil, food) and workplace and conduct cancer surveillance in the workplace as well as within communities if we are going to understand what our cancer risks are and how to reduce them.

GOALS · OBJECTIVES · STRATEGIES

GOAL 1

Reduce cancer incidence in Maryland by minimizing exposures to known environmental and occupational carcinogens.

OBJECTIVE 1

By 2015, identify a limited set of up to five priority hazards to address during the course of the cancer plan.

STRATEGIES

1. **UTILIZE EXISTING DATA** on environmental hazards from multiple sources to identify the priority hazards based on the following criteria: known hazards, population potentially exposed, public health impact, vulnerability of the exposed populations, environmental justice considerations.
2. **DEVELOP A STRATEGY** to reduce exposures to these priority hazards by 2015.

OBJECTIVE 2

By 2015, develop and implement within state regulatory agencies a coordinated approach to reduce the priority hazards.

1. **INVENTORY STATUTES, REGULATIONS, AND NON-REGULATORY MECHANISMS** related to the priority hazards and examine them for regulatory gaps and non-regulatory opportunities available to Maryland.

OBJECTIVE 3

By 2015, create state policies that address levels of risk, disparities, community vulnerability, and the precautionary principle* when addressing environmental and occupational factors in cancer.

STRATEGIES

1. **COLLABORATE WITH APPROPRIATE AGENCIES** and councils to establish specific goals within existing state agencies to move the agencies to explore relationships between environment, occupation, and cancer.
2. **PUBLIC HEALTH AND ENVIRONMENTAL AGENCIES** will develop educational messages and outreach, in conjunction with academic partners, targeted towards improving public understanding of the complex relationship(s) between environmental/ occupational factors and cancer.

GOAL 2

Improve Maryland-specific data and strengthen research and education related to environmental and occupational factors and cancer.

OBJECTIVE 1

By 2015, create more integrated state systems for the surveillance and prevention of environmental and occupational carcinogen exposures and outcomes.

STRATEGIES

1. **COLLABORATE WITH APPROPRIATE AGENCIES** and councils to develop a strategy related to how healthcare reform and the institution of health information exchanges may affect current surveillance efforts.
2. **COLLABORATE WITH APPROPRIATE AGENCIES** and councils to identify priorities for data related to environmental and occupational factors and cancer in all of its surveillance systems including vital records, the Maryland Cancer Registry, death certificates, and the new occupational disease surveillance program at DHMH.

OBJECTIVE 2

By 2015, develop a state strategy on education and outreach associated with environmental and occupational factors and cancer.

STRATEGIES

1. **IMPROVE AND PROMOTE THE USE OF DATA PRESENTATION TOOLS** such as Environmental Public Health Tracking, the Maryland Assessment Tool for Community Health, and other systems that allow the public and decision-makers to better understand the complex relationship(s) between environmental and occupational factors and cancer.
2. **PROMOTE STATE AGENCY EDUCATION** and outreach aimed at improving public understanding of relationships between exposures and associated health outcomes.

** Precautionary Principle: When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. (1998 Wingspread Consensus Statement on the Precautionary Principle)*

REFERENCES

1 US Census Bureau. 2003 Public employment data, state and local governments, Maryland [Internet]. Washington (DC): US Census Bureau; 2003 [cited 2010 Apr 7]. Available from: http://ftp2.census.gov/govs/apes/03stlmd.txt

2 US Census Bureau. 2002 Economic census, Maryland [Internet]. Washington (DC): US Census Bureau; 2002 [cited 2010 Apr 7]. Available from: http://www.census.gov/econ/census02/data/md/MD000.HTM

3 US Environmental Protection Agency. The Clean Air Act Amendments of 1990 list of hazardous air pollutants [Internet]. Washington (DC): US Environmental Protection Agency; 1990 [cited 2010 Aug 3]. Available from: http://www.epa.gov/ttn/atw/orig189.html

4 US Environmental Protection Agency. 2002 National-scale air toxics assessment [Internet]. Washington (DC): US Environmental Protection Agency; 2002 [cited 2010 Aug 2]. Available from: http://www.epa.gov/ttn/atw/nata2002/

5 Ibid.

6 Woodruff TJ, Caldwell J, Cogliano VJ, Axelrad DA. Estimating cancer risk from outdoor concentrations of hazardous air pollutants in 1990. Environ Res. 2000 Mar;82(3):194-206.10702327.

7 Pope CA 3rd, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA. 2002 Mar 6;287(9):1132-41.

8 US Environmental Protection Agency. Toxic Release Inventory Program [Internet]. Washington (DC): US Environmental Protection Agency; 2009 [cited 2010 Apr 7]. Available from: http://www.epa.gov/tri/

9 Rosenbaum AS, Axelrad DA, Woodruff, TJ, Wei YH, Ligocki, MP, Cohen JP. National estimates of outdoor air toxics concentrations. J Air Waste Manage Assoc. 1999;49:1138-1152.

10 Ibid.

11 US Environmental Protection Agency. Food Quality Protection Act of 1996 [Internet]. Washington (DC): US Environmental Protection Agency; last updated 2008 Oct 29 [cited 2010 Apr 27]. Available from: http://www.epa.gov/opp00001/regulating/laws/fqpa/

12 Frumkin H, editor. Environmental health: from global to local. San Francisco (CA): Jossey-Bass; 2005.

13 US Enviornmental Protection Agency. EPA map of radon zones [Internet]. Washington (DC): US Environmental Protection Agency; last updated 2010 Mar 11 [cited 2010 Aug 3]. Available from: http://www.epa.gov/radon/zonemap.html

14 Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. N Engl J Med. 2007 Nov 29;357(22):2277-84.

15 US Food and Drug Administration. FDA unveils initiative to reduce unnecessary radiation exposure from medical imaging [Internet]. FDA press release. Washington (DC): US Food and Drug Administration; 2010 Feb 9 [cited 2010 Apr 27]. Available from: http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm200085.htm

16 Gallagher RP, Spinelli JJ, Lee TK. Tanning beds, sunlamps, and risk of cutaneous malignant melanoma. Cancer Epidemiol Biomarkers Prev. 2005 Mar;14(3):562-6.

17 US Environmental Protection Agency. An introduction to indoor air quality [Internet]. Washington (DC): US Environmental Protection Agency; last updated 2010 Apr 23 [cited 2010 Aug 3]. Available from: http://www.epa.gov/iaq/ia-intro.html