



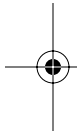
21 Environmental Laws and Exposure Analysis

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21.1 SYNOPSIS

This chapter analyzes how major federal laws address human exposure. The analysis provides a surprising conclusion. Our environmental regulations, designed to protect human health, offer scant protection against major sources of pollutant exposure that endanger human health. The largest of these sources — common consumer products and building materials — are virtually untouched by existing laws. One reason is that our regulatory approach focuses on outdoor emissions and effluents, rather than on exposures, even though exposures are how pollutants reach humans and affect health. Another reason is that no federal agency or law specifically regulates indoor environments, where most of our exposure currently occurs. For example, our primary exposure to many “hazardous air pollutants” (HAPs) occurs indoors. Yet existing regulations focus on HAPs outdoors, essentially ignoring the high levels of HAPs found indoors. Moreover, the laws contain exclusions and loopholes that enable significant exposures to occur. For instance, everyday household products can be exempt from testing and disclosure of their toxic chemical constituents. Finally, the laws



generally have not incorporated advances in the science of exposure analysis, such as use of personal exposure monitors to obtain exposure data, which would make the laws more effective.

21.2 INTRODUCTION

Earlier chapters examined different types of exposures and how they occur. A natural question is *why* these exposures occur, given that we have numerous regulations that aim to protect human health. This chapter investigates that question by conducting an in-depth analysis of 10 federal laws that have relationships to human exposure. For each law, we look at three main issues: What is the law and its goals? How does the letter of the law address human exposure? How effective is the law in actually reducing exposures? We also provide a content analysis of the laws (Table 21.1), which shows that “exposure” was mentioned 311 times total in these laws. Despite its frequent mention on paper, exposure is often treated only superficially in practice. For instance, many laws rely on vague estimates of exposure rather than actual exposure measurements. This chapter uncovers the gaps between the intent and implementation of the laws, and highlights the important yet unfulfilled role of exposure science in the laws. We conclude with a proposed Human Exposure Reduction Act (Table 21.2), designed to address current deficiencies and provide a more effective framework for environmental regulation and public health protection.

21.3 CLEAN AIR ACT (CAA)¹

Prior to the Clean Air Act of 1970, the nation’s air pollution laws contained many useful provisions, but they were coupled with cumbersome procedures that made controlling air pollution remarkably slow. The prior air pollution laws also relied primarily on state and regional actions to control air pollution, with scant federal enforcement. The 1970 CAA revamped air pollution controls in the United States, increased enforcement powers, and transferred regulatory authority for air pollution from the Department of Health, Education and Welfare to the newly created U.S. Environmental Protection Agency (USEPA).

The Clean Air Act authorizes the USEPA Administrator to establish nationally uniform air quality standards, called National Ambient Air Quality Standards (NAAQS), intended to protect public health and the environment. The NAAQS exist only for a class of pollutants called the “criteria” air pollutants: carbon monoxide (CO), ozone (O₃), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), particulate matter (PM_{2.5} and PM₁₀), and lead (Pb) (see Chapter 4 on Inhalation Exposure).

To establish a NAAQS, Section 108 of the Clean Air Act requires a judgment by the Administrator that the air pollutant under consideration (1) “has an adverse effect on public health and welfare,” (2) “results from numerous or diverse mobile or stationary sources,” and (3) is one for which the Administrator “plans to issue air quality criteria.”² Once these three conditions are met for a particular air pollutant, the USEPA publishes its intention to establish a NAAQS in a process called “listing,” which starts a time clock, and the Administrator must issue, within 12 months after listing, an “air quality criteria document.”³ This document compiles available data on the public health and environmental effects of the pollutant at various levels in ambient air and provides the scientific basis for determining the NAAQS values. The USEPA periodically updates the air quality criteria documents, which exist for all pollutants with NAAQS, to include recent scientific findings.

The 1990 Clean Air Act Amendments included a list of 189 hazardous air pollutants (HAPs), or air toxics, with authority for the USEPA to revise the list based on new data. HAPs are defined as substances “which present, or may present, through inhalation or other routes of exposure, a

¹ 42 U.S.C. §§ 7401-7671q (2002).

² 42 U.S.C. § 7408(a)(1) (2002).

³ 42 U.S.C. § 7408 (2002).



threat of adverse human health effects.”⁴ (See Table 21.3 for a current list of HAPs.) In contrast to the criteria air pollutants, the HAPs have no ambient standards, because HAPs are assumed to have no known safe levels of exposure, or health threshold. With no known health threshold, it has been difficult to adopt air quality standards for the HAPs, and attempts to create such standards before 1990 were largely unsuccessful. Instead, the 1990 amendments focused on mandatory reductions in emissions of HAPs using the maximum achievable control technology (MACT), rather than attaining ambient air standards. MACT standards for existing sources of pollution can be no less stringent than the average emission limitation achieved by the best performing 12% of existing sources in a similar source category or subcategory.⁵

The framers of the CAA intended to limit pollutant levels in air that people breathe by limiting pollutant levels in ambient air. Yet the original CAA does not define “ambient air,”⁶ and the USEPA has limited its interpretation of ambient air to the regulation of outdoor air, or “air external to buildings.”⁷ Thus the law has focused on pollutant levels in outdoor air, virtually neglecting indoor air, even though human exposure to all but a few pollutants is higher indoors than outdoors (Wallace 1991). (See Chapter 1 and the Introduction.) Further, nowhere does the law mention the term “indoor air” (see Table 21.1).

Because of this limited interpretation, the USEPA does not currently exercise authority over indoor air pollution under the CAA. However, the CAA does not restrict the USEPA’s authority to regulate indoor air, and the USEPA indeed regulates indoor air when it regulates ambient air, because outdoor air infiltrates indoors. Also, because the air quality criteria documents include exposure studies, the CAA considers, to some extent, the pollutant concentrations that people actually breathe, not ambient concentrations alone.

The USEPA has also used its authority under the National Emission Standards for Hazardous Air Pollutants (NESHAPS)⁸ program of the CAA to ban indoor activities that affect emissions into the atmosphere (such as the spraying of asbestos insulation). Thus, the USEPA may have reduced exposure to indoor pollutants as an inadvertent result of controlling emissions to the atmosphere.

In 1998, standards were passed under the CAA to regulate consumer products if they contribute to at least 80% of the volatile organic compound (VOC) emissions outdoors in areas that violate the NAAQS for ozone.⁹ However, these standards exempt some of the most significant sources of VOC exposures indoors, such as air fresheners, insecticides, adhesives, and moth-proofing products.¹⁰ Many of these exempted products also contain one or more of the HAPs, and many HAPs have been found at higher levels indoors than outdoors, because of indoor sources (Table 21.3).

The CAA relies on a national network of outdoor air monitoring stations, but no similar network exists for measuring exposure. Indeed, nearly all the existing exposure data collected on the U.S. population come from large-scale research studies such as TEAM and NHEXAS (See Chapters 1, 3, 7, 13, and 15). These research studies were conducted in a single time period, and in only a few cities; their aim was to develop new exposure methods, rather than to measure exposure routinely. Thus, we lack long-term data on trends in exposure to these same pollutants. The other major set of relevant exposure data is the national biomonitoring studies conducted by the Centers for Disease Control (CDC, 2001, 2003, 2005) (see Chapter 17 on Biomarkers).

Overall, the Clean Air Act’s regulation of criteria air pollutants has been effective in reducing ambient concentrations nationwide, and four of the six ambient air pollutants have shown a major decline throughout the United States over the last 20 years (USEPA 2005a). Nevertheless, because

⁴ 42 U.S.C. § 7412(b)(2) (2002).

⁵ 42 U.S.C. § 7412(d)(3) (2002).

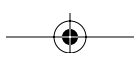
⁶ 42 U.S.C. § 7409 (2000).

⁷ 40 C.F.R. § 50.1(e) (2002).

⁸ 42 U.S.C. § 7412 (2000).

⁹ Clean Air Act § 183(e), 42 U.S.C. § 7511b(e); National Volatile Organic Compound Emission Standards for Consumer Products, Fed. Reg. 48819-48847 (1998), 40 C.F.R. §§ 59.201-59.214 (2003).

¹⁰ 40 C.F.R. §§ 59.201(c)(1)-(7) (2003).



CAA does not specifically address indoor air, major sources of exposure to VOCs, particles, and pesticides have received negligible attention under the CAA.

21.4 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)¹¹ AND SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA)¹²

Congress enacted CERCLA in 1980 to address releases of hazardous substances endangering public health. CERCLA established a “Superfund” from taxes on the chemical and petroleum industries to pay for cleanup of abandoned hazardous waste sites.¹³ Under CERCLA, the USEPA must maintain a National Priorities List (NPL), which is “the list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants...intended primarily to guide the EPA in determining which sites warrant further investigation” (USEPA 2004). Once a site is on the NPL, the USEPA conducts a remedial investigation to determine the nature and extent of the contamination at the site, and a feasibility study to identify and evaluate cleanup strategies.

The USEPA responds to hazardous substances at Superfund sites through “removal” and “remedial” actions. Removal actions are generally short-term (less than 1 year) and low-cost (under \$2 million), intended to address actual or potential releases of hazardous substances. Remedial actions are generally longer-term and more extensive, such as treating or containing contaminated soil, constructing underground walls to control the movement of groundwater, and incinerating hazardous wastes.

CERCLA set forth a new liability scheme, commonly referred to as the “polluter pays” program, for cleanup costs and other damages relating to releases of hazardous substances. Regardless of whether the USEPA or a private entity conducts a cleanup, CERCLA makes any owner or operator of contaminated property, or transporter or handler of a hazardous substance, a “potentially responsible party” with regard to the costs related to a release of such hazardous substance, essentially shifting the burden of proof to those entities to disprove their responsibility for any release.¹⁴

In 1986, Congress enacted SARA to reauthorize the Superfund tax and amend CERCLA and other statutes relating to hazardous substances. Among other changes, SARA established an emergency response and citizen right-to-know program involving state response authorities, encouraged greater citizen participation in cleanup decisions, and increased the funds for Superfund. In the first 5 years after CERCLA’s enactment, the federal government collected \$1.6 billion for cleaning up abandoned or uncontrolled hazardous waste sites. In 1986, SARA increased the size of the Superfund to \$8.5 billion. In 1990, Congress reauthorized the Superfund program through 1994, adding \$5.1 billion (USEPA 2005d). In 1995, the taxing authority of CERCLA/SARA expired, and has not been reauthorized by Congress.

CERCLA focuses on releases of hazardous substances into the environment. A “release” is defined broadly to include almost any discharge or leak into the environment.¹⁵ Thus, a release, the trigger for CERCLA coverage, is not tied directly to actual human exposure to contaminants. Also, CERCLA/SARA allows the USEPA to rely upon calculations of risk derived from estimates of exposure in its *Exposure Factors Handbook* (USEPA 2005e), rather than actual exposure data.

¹¹ 42 U.S.C. §§ 9601-9675 (2000).

¹² Pub. L. 99-499, 100 Stat. 1613, codified in scattered sections of the Internal Revenue Code and in amendments to CERCLA at 42 U.S.C. §§ 9601-9675 (2000).

¹³ Title II, § 221 of CERCLA, previously codified at 42 U.S.C. § 9631-9633, now codified at 26 U.S.C. § 9507 (2000); 42 U.S.C. § 9605 (2000).

¹⁴ 42 U.S.C. § 9607(a) (2000).

¹⁵ 42 U.S.C. § 9601(22) (2000).

CERCLA also created the Agency for Toxic Substances and Disease Registry (ATSDR) in the U.S. Department of Health and Human Services, and directed the administrators of the ATSDR and the USEPA to maintain registries and databases on toxic substances and their impact on human health. SARA broadened ATSDR's responsibilities with respect to environmental and public health by directing ATSDR and the USEPA to jointly prepare a list (ATSDR 2003), in order of priority, of at least initially 100 (and eventually over 250) hazardous substances that "pose the most significant potential threat to human health due to their known or suspected toxicity to humans and the potential for human exposure to such substances at facilities on the NPL."¹⁶

SARA also mandated ATSDR to perform a health assessment for each facility on the NPL and other contaminated sites. The ATSDR health assessments are intended to assist in determining whether actions should be taken to reduce human exposure to hazardous substances from a facility and whether additional information on human exposure and associated health risks is needed. Again, these assessments do not require actual measurements of human exposure.

Responding to increasing public concern about radon and other indoor air quality hazards, SARA also set forth the Radon Gas and Indoor Air Quality Research Act of 1986, which created a program within the USEPA to "(1) gather data and information on all aspects of indoor air quality in order to contribute to the understanding of health problems associated with the existence of air pollutants in the indoor environment, (2) coordinate federal, state, local, and private research and development efforts relating to the improvement of indoor air quality; and (3) assess appropriate federal government actions to mitigate the environmental and health risks associated with indoor air quality problems."¹⁷

This Act did not provide the USEPA with authority to promulgate standards for indoor air quality. Indeed, the Act explicitly states that "[n]othing in this title shall be construed to authorize the Administrator to carry out any regulatory program or any activity other than research, development, and related reporting, information dissemination, and coordination activities specified in this title."¹⁸ In 1989, as part of its responsibilities under SARA, the USEPA established the Federal Interagency Committee on Indoor Air Quality (CIAQ) to coordinate the activities of the federal government on issues relating to indoor air quality (USEPA 2005c). The CIAQ meets quarterly, generally for half a day. Given the lack of directive for CIAQ to recommend regulations for indoor air quality, and the highly scientific nature of the topics on its meeting agendas, it is not surprising that the CIAQ's activities have not attracted significant attention from the public or created any impetus for regulation in this field.

CERCLA/SARA has been critiqued from several perspectives, and one of them is lack of attention to exposure and health effects. For instance, CERCLA/SARA does not contain any requirement to study the link between contamination at a site and human exposure to the contaminants. Also, both ATSDR and the USEPA, in their approach to risk assessment, rely upon the *Exposure Factors Handbook*, which is subject to inaccuracies. In addition, CERCLA/SARA does not require medical monitoring or exposure data to determine actual health impacts from contaminated sites. Another critique is that CERCLA has been inefficient, with resources consumed by litigation rather than directed to cleanup of sites. The USEPA has "delisted" from the NPL only 308 sites (with 1,239 sites remaining on the list) in nearly 25 years (USEPA 2005f).

For CERCLA/SARA to provide meaningful protection of public health, scientific advances in exposure analysis should be incorporated into the laws. Nevertheless, a problem remains: many of the same pollutants of concern at Superfund sites, where negligible human exposure occurs, are already present as indoor air pollutants in homes and workplaces, where significant human exposure occurs.

¹⁶ Pub. L. No. 99-499, § 110, 42 U.S.C. § 9604(i)(2)(A) (2000).

¹⁷ Pub. L. No. 99-499 § 403(a).

¹⁸ Pub. L. No. 99-499 § 404.

21.5 CONSUMER PRODUCT SAFETY ACT (CPSA)¹⁹

Congress enacted the Consumer Product Safety Act (CPSA) in 1972 to address risks posed by consumer products. The CPSA is an “umbrella statute” that established the Consumer Product Safety Commission (CPSC), and provided the limits of its authority. When the CPSC finds an unreasonable risk of injury associated with a consumer product, it may develop a standard to reduce or eliminate the risk through notice and comment rulemaking.²⁰ If the CPSC determines that a consumer product poses an imminent danger, it can issue a mandatory recall of the product. It is this function of the CPSC with which consumers are probably most familiar.

The CPSA relies on voluntary consumer product safety standards.²¹ The CPSA provides for mandatory reporting of (1) known failures of consumer products to meet applicable standards, (2) information suggesting a product defect that could create a substantial risk of injury, and (3) information suggesting an inherent unreasonable risk of serious injury or death. The CPSC may impose labeling requirements only if there is substantial evidence that a warning is “reasonably necessary” to prevent or reduce unreasonable risks of injury.²²

Significantly, the CPSA does not require the listing of all ingredients in products. The CPSA requires the CPSC to maintain the confidentiality of trade secret or other confidential information (such as product formulation) provided to the CPSC.²³ The U.S. Supreme Court has concluded that the confidentiality provisions in the CPSA prohibit the CPSC from disclosing information deemed confidential under the CPSA, even in response to requests under the Freedom of Information Act.²⁴

The CPSA includes a finding by Congress that “existing federal authority to protect consumers from exposure to consumer products presenting unreasonable risks of injury is inadequate.”²⁵ The CPSA defines the term “risk of injury” to mean “a risk of death, personal injury, or serious or frequent illness.”²⁶ The CPSA contends with the risk of cancer posed by consumer products, but it requires a Chronic Hazard Advisory Panel to determine that the product is a carcinogen before the CPSC can initiate any rulemaking procedures.²⁷ Also, Congress excluded from the CPSA’s coverage many dangerous or potentially dangerous consumer products that are regulated by other statutes, some of which present significant potential for exposure to dangerous substances (including food, drugs, cosmetics, tobacco products, and pesticides).

In practice, the CPSA has regulated exposure by banning a few products that present exposure risks (such as lead-based paint products), specifying safety standards for a few exposure-related products (such as products using chlorofluorocarbons), and specifying label requirements for several chemicals and other dangerous substances (such as charcoal, fireworks, and art products).

However, the CPSA offers little protection to Americans from everyday exposures to hazardous chemicals in consumer products. An example is the prevalence of synthetic fragrances (toxic VOCs) found in air fresheners, laundry supplies, cleaners, and personal care products. Because of confidentiality provisions, a manufacturer need only list “fragrance” on the label, not the actual chemicals, even though more than 95% of chemicals used in fragrances are known toxics, sensitizers, and carcinogens (USHR 1986).

The CPSA has also had limited effect with regard to exposures because it, like many other agency-creating federal laws, requires the regulating agency to estimate the costs and benefits of proposed rules regulating or banning dangerous products.²⁸ Cost-benefit analyses pose particular

¹⁹ Pub. L. No. 92-573, 86 Stat. 1207 (1972), codified at 15 U.S.C. §§ 2051-2084 (2002).

²⁰ 15 U.S.C. § 2056(a) (2002).

²¹ 15 U.S.C. § 2056 (b)(1) (2002).

²² 15 U.S.C. § 2056(a) (2002); *see also* 58 Fed. Reg. 8013, 8015 (1993).

²³ 15 U.S.C. § 2055 (2002).

²⁴ *GTE Sylvania, Inc. v. Consumer Product Safety Commission*, 447 U.S. 102, 100 S. Ct. 2051 (1980).

²⁵ 15 U.S.C. § 2051 (2002).

²⁶ 15 U.S.C. § 2052(a)(3) (2002).

²⁷ 15 U.S.C. § 2080 (2002).

²⁸ 15 U.S.C. § 2058(f) (2002).

difficulties when trying to identify and monetize a range of possible health effects related to exposure, and when discounting future and uncertain outcomes into present value amounts. In sum, the CPSA is a significant statute in some consumer product areas, but does not close many important gaps in protecting people from hazardous exposures.

21.6 FEDERAL FOOD, DRUG, AND COSMETIC ACT (FFDCA)²⁹ AND FOOD QUALITY PROTECTION ACT (FQPA)³⁰

The Federal Food, Drug, and Cosmetic Act (FFDCA) of 1954 and the Food Quality Protection Act (FQPA) of 1996 are discussed together because a key focus of the FQPA was changing the FFDCA's framework for addressing pesticide residues in food. The breadth of these laws is far-reaching. Together they regulate the safety, effectiveness and labeling of drugs, cosmetics, and medical devices, while also dealing with food safety.

The federal government began regulating food and drug safety in 1906, but the FFDCA made several significant changes to weaker predecessor laws. Among these changes, the FFDCA extended federal control to cosmetics and therapeutic devices, required new drugs to undergo safety testing before marketing, and eliminated the requirement to prove intent to defraud in drug misbranding cases (USFDA 2005). To illustrate the extent to which these laws address exposure, this chapter will focus on two significant issues: pesticide residues in food, and cosmetic-drug distinctions.

Pesticide Residues in Food: In 1958, the Food Additives Amendment to the FFDCA was enacted, requiring manufacturers of new food additives (such as preservatives or colors) to establish the safety of the additives. The Delaney Clause, contained in Section 409, states that no additive can be considered safe if "it is found to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal."³¹

Pesticide residues in processed food products were considered food additives and, thus, subject to the zero-risk standard (i.e., no cancer risk allowed) of the Delaney Clause. Yet pesticide residues in raw foods were treated separately, under Section 408, and subject to a less restrictive standard of balancing risks and benefits. Also, under Section 402, "flow through" exemptions allowed pesticide residues on raw foods to remain in processed foods, at a tolerance specified for raw foods, notwithstanding the zero-risk language of the Delaney Clause. Thus, pesticide residues were regulated under different standards.

In 1987, a National Academy of Sciences (NAS) report concluded that the Delaney Clause, and its implementation by the Food and Drug Administration (FDA) and the USEPA, was an unworkable framework that could be creating higher risk of cancer by distinguishing between pesticide residues in raw and in processed foods (NRC 1987). The NAS explained that the Delaney Clause required the USEPA to prohibit new pesticides if they had any carcinogenic effect, even if they were considered safer overall than existing pesticides, illustrating the "Delaney Paradox" (NRC 1987).

In 1988, the USEPA promulgated a final rule, stating that it would permit carcinogenic pesticide residues in raw and processed foods if the risk of cancer was *de minimis*, which the USEPA defined as a 1 in 1 million risk of cancer over a lifetime. The courts struck down this interpretation as being inconsistent with the plain language of the Delaney Clause, which prohibited *any* carcinogenic risk in processed foods.³² In 1993, the NAS issued another report on the Delaney Clause, which concluded that current studies underestimated risks to infants and children from pesticide residues,

²⁹ Pub. L. No. 75-717, 52 Stat. 1040, codified at 21 U.S.C. §§ 321-397 (2000).

³⁰ Pub. L. No. 104-170.

³¹ 21 U.S.C. § 348(c)(3)(A) (2000).

³² *Les v. Reilly*, 968 F.2d 985 (9th Cir. 1992).

and suggested adding a safety margin to risk assessment of pesticide residues in foods consumed by infants and children (NRC 1993).

These battles over the Delaney Clause and pesticide residues ultimately led to a compromise, reflected in the unanimous passage of the Food Quality Protection Act (FQPA) by Congress in 1996. The FQPA amended the FFDCA and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) to remove pesticide residues in food products from the scope of the Delaney Clause (i.e., pesticide residues were no longer considered “food additives”), and to establish a single health-based safety standard, “reasonable certainty of no harm,” for regulation of risks to human health from pesticide residues in food.

Specifically, the FQPA provides that levels of pesticide residues in food products are acceptable if “there is a reasonable certainty that no harm will result from the aggregate exposure to the pesticide chemical residue.”³³ The FQPA does not define “reasonable certainty,” but a 1-in-1 million lifetime risk of cancer (which the USEPA had tried to implement through regulation previously) is the standard that Congress expected the USEPA Administrator to apply.³⁴ The FQPA also requires that a safety factor 10 times lower than for adults be applied to tolerances for infants and children, unless data show that children are not more susceptible to the health risks from pesticide residues.

The FQPA moves beyond the idea that cancer is the only health risk for regulatory purposes; the new law requires the USEPA to consider not only carcinogenicity but also estrogenic and other hormone disruptor effects from pesticide residues.³⁵ Also, the FQPA requires the USEPA to consider information on “cumulative effects” of pesticide residues on consumers, and aggregate exposure levels of consumers to pesticide residues in food and other media (including drinking water and home lawn care products) from non-occupational sources.³⁶ The USEPA must also consider the special consumption patterns of infants and children, and the cumulative effects of exposure to pesticide residues in infants and children. If the USEPA determines that total risk from all currently registered uses of a pesticide and other substances with a “common mechanism of toxicity” exceeds the safety standard, the USEPA must cancel one or more uses of the pesticide or reduce the tolerance levels for those uses, and the USEPA is prohibited from registering new uses of the pesticide (USDA 1997). Thus, in concept, the FQPA represents an important advance in considering total exposure.

Cosmetic–Drug Distinctions: According to the FFDCA, the term “cosmetic” means “(1) articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness, or altering the appearance, and (2) articles intended for use as a component of any such articles; except that such term shall not include soap.”³⁷

This definition in the FFDCA is significant because (a) cosmetics, unlike drugs (but like most consumer products), are not subject to pre-market review, and (b) cosmetic manufacturers, unlike drug manufacturers, are not required to register with the FDA. Just as the Delaney Clause came to be perceived as unworkable, the cosmetic–drug distinction in the FFDCA has come under criticism for ignoring that many cosmetic products have drug-like effects. In addition, cosmetics often contain toxic chemicals that are regulated under other laws, but unregulated in consumer products. Further, the FDA cannot require companies to conduct safety studies of their cosmetics before marketing. For instance, only 11% of the 10,500 ingredients that the FDA documented in products have been assessed for safety by the cosmetic industry’s review panel (EWG 2005).

The FFDCA drug testing and medical device provisions are some of the more science-based federal laws, relying upon years of studies with control groups. In contrast, cosmetic provisions

³³ 21 U.S.C. § 346a(b)(2)(A) (2000).

³⁴ H.R. Rep. No. 104-669, pt. 2 at 41 (1996).

³⁵ 21 U.S.C. § 346a (2000).

³⁶ 21 U.S.C. § 346a(b)(2)(D)(vi) (2000).

³⁷ 21 U.S.C. § 321(i) (2000).

contain an outdated framework that largely ignores risks and levels of exposures to hazardous substances in cosmetic products.

Although the FQPA has made the FFDCAs food safety components more exposure-oriented, there is no indication in the short history of the FQPA that it has reduced exposures to pesticides. When passed, it was estimated that the FQPA would significantly reduce pesticide use. However, total use of pesticides in the United States continues to grow (USEPA 2002a), and the FQPA's focus on pesticide effects on infants and children appears not to have affected USEPA considerations of tolerances (Cross 1997). A difficulty in implementing the FQPA is the EPA's lack of comprehensive exposure data, which makes it nearly impossible to accurately assess the impacts that the FQPA assumes can be assessed, such as consideration of cumulative exposure levels from pesticides and other toxic substances.

Since 1961, the FDA has conducted a "Total Diet Study" (also known as "Market Basket Study") to determine the levels of toxic chemicals, such as pesticide residues, and nutrients in approximately 280 core foods in the U.S. food supply. The market baskets are generally collected four times each year, once in each of four geographic regions of the United States each year. In the 2003 Total Diet Study, pesticide residues were found in 37.3% of the domestic samples, the most common being DDT (12%), malathion (7%), endosulfan (7%), dieldrin (6%), and chlorpyrifos-methyl (6%) (CFSAN 2005). Although both DDT and dieldrin were banned in the 1970s, their residues persist in our food supply. Moreover, many of the pesticides found in the Total Diet Study were also found in indoor air (see Chapter 15 on Pesticide Exposure), such as chlorpyrifos, dieldrin, malathion, and diazinon, although these pesticides did not make it on the list of HAPs (Table 21.2).

The FQPA required the USEPA to report to Congress within four years on the USEPA's progress in implementing the law. The USEPA report states that out of 612 pesticides eligible for re-registration between 1996 and 1999, 231 cases were voluntarily canceled, while the USEPA "canceled, deleted or declared not eligible for re-registration" only 21 pesticide products. The USEPA re-registered 189 pesticides, with the remainder subject to decision (USEPA 1999). These numbers indicate that the FQPA may have weeded out some of the most dangerous pesticides, but it does not demonstrate that existing pesticides or exposure levels are safe.

21.7 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)³⁸

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947 has evolved from a law designed to protect farmers from damaged feed to a system of regulating pesticide use on food and in the environment. FIFRA defines "pesticide" broadly to include substances used to control mold and mildew in water or on stored grains, as well as fumigants, mothballs, rat poison, and other substances used to control pests. Under FIFRA, the USEPA is responsible for "registering," or licensing pesticide products for use in the United States.

Pesticide registration decisions are based on an assessment of the potential effects of a product on human health and the environment, when used according to label directions. For a pesticide to be registered, the applicant must submit data to the USEPA on its use and effects, but the EPA does not routinely measure exposure to pesticides or conduct its own health effect studies of pesticides. Also, the emphasis is on protecting pesticide applicators rather than members of the general public. If the USEPA registers a pesticide, it specifies the approved uses and conditions of use of the pesticide.³⁹

The USEPA attempts to make a judgment whether a pesticide chemical residue is safe by considering whether there is "a reasonable certainty that no harm will result from aggregate exposure

³⁸ Pub. L. No. 80-104, and including the FIFRA amendments of 1988, Pub. L. No. 100-532 and amendments to FIFRA and the Food Quality Protection Act in Pub. L. No. 104-170. FIFRA is codified at 7 U.S.C. §§ 136-136y (2000).

³⁹ 7 U.S.C. § 136a(d)(1) (2000).

to the pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information.”⁴⁰ FIFRA provides that, with limited exceptions, “any pesticide chemical residue in or on a food shall be deemed unsafe” unless “a tolerance for such pesticide chemical residue in or on such food is in effect under this section and the quantity of the residue is within the limits of the tolerance.”⁴¹ Two of the factors the USEPA must use in establishing a tolerance for a pesticide are “available information concerning the cumulative effects of such residues and other substances that have a common mechanism of toxicity” and “available information concerning the aggregate exposure levels of consumers (and major identifiable subgroups of consumers) to the pesticide chemical residue and to other related substances, including dietary exposure...and exposure from other non-occupational sources.”⁴²

The modern version of FIFRA mentions exposure but does not require direct measurements of exposure, and often there are no data available on the actual exposure of the public. The Non-Occupational Pesticide Exposure Study (NOPES) of 1985–1986 was the first study to measure the public’s everyday exposure to pesticides (See Chapter 15 on Pesticide Exposure). In addition, despite FIFRA’s attention to exposure, total pesticide use continues to grow (USEPA 2002a).

Further, a significant weakness of FIFRA is its lack of clear regulation on inert ingredients. Although FIFRA requires manufacturers to disclose each active ingredient of a pesticide on the consumer label with the percentage of that active ingredient by weight, they need not specify the “inert ingredients” in the pesticides. Yet inert ingredients often predominate in pesticide products and can be more toxic than the active ingredients (USEPA 2005g). For example, a study of 85 consumer pesticide products found that 72% contained over 95% inert ingredients, and more than 200 of these “inerts” were classified as hazardous pollutants in other federal environmental statutes (NY 1996). In September 1997, the USEPA issued a regulation (Pesticide Regulation 97-6) encouraging, but not requiring, manufacturers of pesticides to stop using the term “inert ingredients” and to use the term “other ingredients” as a substitute, because the USEPA surveys showed that consumers erroneously believed “inert ingredients” were harmless. Thus, while FIFRA addresses hazardous exposure to pesticides, it does not address all hazardous ingredients in pesticide products or require exposure measurements.

21.8 OCCUPATIONAL SAFETY AND HEALTH ACT (OSH ACT)⁴³

Congress enacted the Occupational Safety and Health Act (OSH Act) in 1970 to assure “safe and healthful working conditions” for private sector American workers.⁴⁴ The OSH Act contains a general duty provision requiring employers to provide working conditions “free from recognized hazards that are likely to cause death or serious physical harm” to employees.⁴⁵ In 1971, the Act established, under the Department of Labor, the Occupational Safety and Health Administration (OSHA), which administers the Act.

The OSH Act also authorized OSHA to adopt certain national consensus health and safety standards and established federal standards (called “interim standards” in the OSH Act) soon after the effective date of the OSH Act, without the notice-and-comment procedure applicable to most federal regulations.⁴⁶ In 1971, OSHA acted pursuant to this authority to promulgate a rule setting 425 permissible exposure limits (PELs) for air contaminants.⁴⁷ Most of the PELs were consensus standards that had been recommended in 1968 by the American Conference of Governmental

⁴⁰ 21 U.S.C. § 346a(b)(2)(A)(ii) (2000).

⁴¹ 7 U.S.C. § 346a(a)(1) (2000).

⁴² 21 U.S.C. § 346a(b)(2)(D)(v)(vi) (2000).

⁴³ 29 U.S.C. §§ 651 et seq. (1970).

⁴⁴ 29 U.S.C. § 651(b) (2000).

⁴⁵ 29 U.S.C. § 654(a) (2000).

⁴⁶ 29 U.S.C. § 655(a) (2000).

⁴⁷ 29 C.F.R. § 1910.1000 (2000).

Industrial Hygienists (ACGIH) and were applicable to many government contractors under the Walsh-Healey Act prior to the enactment of the OSH Act.⁴⁸

The OSH Act created a notice-and-comment procedure whereby OSHA could amend, delete, or modify the interim standards with permanent health and safety standards “reasonably necessary or appropriate to provide safe or healthful employment and places of employment.”⁴⁹ However, OSHA has been largely unsuccessful in its efforts to adopt new standards. Over 30 years after OSHA promulgated its “interim standards,” they continue to constitute the bulk of OSHA’s health standards relating to exposure to contaminants.

Air quality standards that have been adopted under the OSH Act are much less protective of health than the national ambient air quality standards adopted under the CAA. For example, the outdoor ambient NAAQS for carbon monoxide is a 9 parts per million (ppm) average for 8 hours, not to be exceeded in a community more than once per year, while the similar personal exposure standard adopted under the OSH Act is 50 ppm average for 8 hours (see Chapter 4 on inhalation exposure).

The OSH Act leaves several regulatory gaps with respect to exposure to pollutants. Most fundamentally, it only protects employees, and only in certain workplaces. In 2000, 41% of the U.S. population was employed (CQC 1994), and, based on national diary studies of the U.S. population’s activities, Klepeis et al. (2001) found that Americans, on average, spent only 5.4% of their time in an office or factory. The OSH Act provides no coverage to persons outside the workplace, or to persons who work in their homes. Even in the workplace, the OSH Act does not cover all employers, and can exclude state and local government employees (unless the state has a plan approved by OSHA), private sector employees (if excluded by the state plan), and federal employees (except by executive order).

The courts have given OSHA little leeway in pursuing its statutory missions. In 1980, the U.S. Supreme Court reviewed OSHA’s standard for benzene exposure and interpreted the OSH Act’s requirements with respect to promulgation of permanent health and safety standards on toxic substances.⁵⁰ The Court held that OSHA must first demonstrate that a significant risk of material health impairment exists at the current levels of exposure to the toxic substance.⁵¹ The Court implied that OSHA must quantify the risk by showing how many employees would become ill or die from the current exposure level. The Court further explained that OSHA must demonstrate that the proposed new standard prevents material impairment of health of employees to the extent feasible.⁵² Thus, even if a proposed standard would improve worker health, it may be invalidated for not going far enough to prevent material impairment of health.

In 1989, after several unsuccessful attempts to adopt or revise rules on specific toxic substances, OSHA issued an Air Contaminants Standard that updated 212 of the 1971 interim standards and added 164 new health standards for toxic substances.⁵³ In *AFL-CIO v. OSHA*,⁵⁴ the U.S. Court of Appeals for the Eleventh Circuit vacated OSHA’s order establishing the Air Contaminants Standard. The Court found that OSHA had conducted a “generic” analysis of the toxic substances and had not explained the significant risk posed by the existing level of exposure for each toxic substance and how the new standard protected workers from material impairments of health relating to each toxic substance.⁵⁵ The Court also held that OSHA had failed to explain the feasibility of the Air Contaminants Standard with respect to each toxic substance with regard to each industry affected.⁵⁶

⁴⁸ 41 U.S.C. § 35 (2000); 53 Fed. Reg. 20960, 20966 (1988).

⁴⁹ 29 U.S.C. § 652(8) (2000).

⁵⁰ *Industrial Union Dept., AFL-CIO v. American Petroleum Inst.*, 448 U.S. 607 (1980) (plurality opinion).

⁵¹ *Id.* at 614-615.

⁵² *American Textile Mfrs. Inst., Inc. v. Donovan*, 452 U.S. 490, 512 (1981).

⁵³ 54 Fed. Reg. 2332 (1989).

⁵⁴ 965 F.2d 962 (1992).

⁵⁵ *Id.* at 975-79.

⁵⁶ *Id.* at 980-82.

OSHA acknowledged in the rulemaking process that it had taken a generic approach to estimate risks and feasibility posed by the toxic substances in the Air Contaminants Standard, explaining that “it would take decades to review currently used chemicals and OSHA would never be able to keep up with the many chemicals which will be newly introduced in the future.”⁵⁷

OSHA’s efforts to establish exposure limits to toxic substances have generally not been successful because it is difficult for OSHA to develop the administrative record to demonstrate a significant risk of material health impairment. OSHA is also hamstrung by a small budget to use for scientific research (OSHA 2002), and weak penalty provisions in the OSH Act such that violations must result in an employee’s death in order for the employer to be subject to criminal sanctions.⁵⁸ Given these constraints, OSHA relies upon self-monitoring and other regulatory schemes that are unlikely to be effective. For instance, the studies and data used to set permissible exposure limits are often generated by the employers who can have a conflict of interest.

The OSH Act established the National Institute for Occupational Safety and Health (NIOSH), under the Department of Human Health and Services, to research occupational health and safety conditions and provide information and training. Notably, NIOSH conducts a Health Hazard Evaluation (HHE) program that responds to requests by an employee, employee representative, or employer to investigate workplace health and safety issues. NIOSH has responded to hundreds of requests for HHE studies, which have been important in documenting indoor air quality problems such as VOCs from off-gassing materials, mold and fungal growth, improper ventilation systems, and pesticides.

In 1994, OSHA published a proposed comprehensive indoor air quality rule. According to OSHA, “The proposal would require employers to write and implement indoor air quality compliance plans that would include inspection and maintenance of current building ventilation systems to ensure they are functioning as designed...” (OSHA 2005). The proposed indoor air quality rule went through a notice-and-comment period, but OSHA never promulgated a final (enforceable) version due to changes in the U.S. Congress in 1994. The Indoor Air Quality rule remains an inactive item on OSHA’s long-term agenda.

Overall, the OSH Act has improved worker safety standards in certain workplaces, but provides little protection outside those venues. The OSH Act provides no coverage for homes and other non-industrial environments, where many people work. In addition, OSHA has tended to focus on single hazards within industrial workplaces (such as large machinery), rather than multiple and often invisible hazards within typical office buildings (such as indoor air pollutants).

21.9 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)⁵⁹

The Resource Conservation and Recovery Act (RCRA) of 1976 had two components: (1) “cradle-to-grave” regulation of hazardous waste, governing generation, transport, treatment, storage, and disposal; and (2) management of the growing volume of non-hazardous solid waste generated in the United States. The goals of RCRA include protecting human health and conserving energy. In 1984, Congress added regulation of underground storage tanks to RCRA’s purview.

RCRA focuses on active and proposed waste sites, whereas CERCLA governs abandoned and inactive waste sites. RCRA defines “hazardous wastes” as wastes that may “cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness” or “pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.”⁶⁰

⁵⁷ 53 Fed. Reg. at 20963.

⁵⁸ 29 U.S.C. § 666(e) (2000).

⁵⁹ Pub. L. No. 94-580, 90 Stat. 2806 (1976), codified at 42 U.S.C. §§ 6901-6992k (2002).

⁶⁰ 42 U.S.C. § 6903(5) (2002).

RCRA exempts household hazardous waste, such as pesticides, motor oil, and certain cleaners. Also, the federal courts have held that RCRA does not require the USEPA to list as hazardous all wastes that might satisfy the criteria for hazardous wastes, so its coverage is not comprehensive.⁶¹

RCRA's hazardous waste program requires applicants for landfill permits to provide information on "the potential for the public to be exposed to hazardous wastes or hazardous constituents through releases related to the [hazardous waste facility]" including "the potential magnitude and nature of the human exposure resulting from such releases."⁶² RCRA also provides authority for the USEPA or state officials to require a health assessment of landfill activities by ATSDR whenever the landfill poses a substantial potential risk to human health, although this assessment is based usually on estimates instead of measurements.

RCRA does not limit the creation or use of hazardous wastes directly, although it makes it very expensive to transport and control hazardous wastes. Indeed, at least in its first few decades, RCRA created strong financial incentives to dispose of those wastes illegally. From a global and environmental justice perspective, RCRA has been criticized because it allows the export of hazardous wastes.

RCRA has significantly changed how most companies in the United States deal with hazardous wastes. The USEPA estimates that since RCRA was enacted, the annual generation of hazardous wastes in the United States has been reduced from 300 million tons to 40 million tons (USEPA 2002b). Although RCRA and its regulations provide a detailed scheme for addressing hazardous and other solid wastes, they have not eliminated, or regularly assessed, the exposure from such wastes.

21.10 TOXIC SUBSTANCES CONTROL ACT (TSCA)⁶³

The Toxic Substances Control Act (TSCA) of 1976 authorizes the USEPA to secure information on all new and existing chemicals (or mixtures) sold in interstate commerce, and to control those chemicals that cause "unreasonable risk to public health or the environment."⁶⁴ Earlier laws did not require the screening of new chemicals or the control of existing substances until damage occurred.

In Title I of TSCA, Congress gave the USEPA authority to require by rule that chemical manufacturers test existing chemicals after the USEPA finds that (1) a chemical may present an unreasonable risk of injury to human health or the environment, or the chemical is produced in substantial quantities that could result in significant human or environmental exposure, (2) the available data to evaluate the chemical are not adequate, and (3) testing is necessary to develop such data.⁶⁵

Title II (Asbestos Hazard Emergency Response) was added in 1986 to regulate asbestos abatement in schools. Title III (Indoor Radon Abatement) was added in 1988 and provides assistance to states in dealing with public health risks from radon. Title IV (Lead Exposure Reduction) was added in 1992 and provides assistance to states in reducing environmental lead contamination and lead exposure, especially in children. (See Chapter 14 on house dust exposure.)

Before manufacturing any new chemical or putting an existing chemical to a significant new use, the manufacturer must notify the USEPA. In deciding whether a chemical is "new," a manufacturer consults the TSCA Chemical Substance Inventory, which the USEPA maintains. If the substance is not on the Inventory, it is considered new. For an "existing" chemical, the Inventory can help to determine restrictions on its manufacture and use under TSCA. The Chemical Substance

⁶¹ E.g., *Natural Res. Def. Council v. EPA*, 25 F.3d 1063 (D.C. Cir. 1994).

⁶² 42 U.S.C. § 6939a (2002).

⁶³ Pub. L. No. 94-469, 90 Stat. 2003 (1976), codified at 15 U.S.C. §§ 2601-2692 (2002).

⁶⁴ 15 U.S.C. §2605(a) (2000).

⁶⁵ 15 U.S.C. § 2603(a) (2002).

Inventory currently contains over 82,000 chemicals (GAO 2005). Though the Chemical Substance Inventory is public information, significant portions of the Inventory are confidential.

If the USEPA determines that a chemical presents “an unreasonable risk of injury to health or the environment,” then the USEPA may limit, or prohibit outright, the production of the chemical, or regulate its disposal, use, or marketing.⁶⁶ But TSCA does not define “unreasonable risk,” and the USEPA has faced difficulties in proving this and other standards in order to take action. Further, the USEPA may impose limitations only “to the extent necessary to protect adequately against such risk using the least burdensome requirements.”⁶⁷ For instance, if unreasonable risk could be managed by placing a warning label on the chemical, then the EPA could not ban or otherwise restrict use of that chemical (GAO 2005).

TSCA also contains several provisions that hinder the USEPA’s ability to exercise such control. For instance, *Corrosion Proof Fittings v. Environmental Protection Agency*,⁶⁸ a landmark case decided by the Fifth Circuit Court of Appeals, shows how TSCA’s restrictive language has hindered the USEPA’s implementation of TSCA. In *Corrosion Proof Fittings*, the court vacated a rule the USEPA had issued under TSCA banning all use of asbestos in products. The court noted that the normal “arbitrary and capricious” standard of review for administrative agencies did not apply to rules promulgated by the USEPA pursuant to Section 2605(a) of TSCA. Congress had specified in TSCA a stricter “substantial evidence” standard of review for such rules. Applying that standard of review, the court concluded that the USEPA had not shown that human exposure to asbestos was substantial, or that less-restrictive limitations than a total ban on asbestos could prevent an unreasonable risk of injury to health or the environment. The court held that TSCA requires a balancing of costs and benefits in promulgating a new rule under Section 2605(a). The record in the *Corrosion Proof Fittings* case showed that the asbestos rule would cost the industry up to \$74 million per life saved. Meanwhile, the USEPA could not show that adequate substitutes existed for many asbestos products. The court determined that, given such costs to industry, the USEPA could not show that asbestos presented such an unreasonable risk of injury to health or environment that a total ban was required. Given these strict legal standards, it has been very difficult and expensive for the USEPA to prove that a chemical in use presents an unreasonable risk to health.

In theory, TSCA offers an important advance in the assessment and control of chemicals, and gives the USEPA significant authority to reduce exposure. Yet TSCA’s impact has been much narrower than the Act’s words would suggest. Since the enactment of TSCA, the USEPA has promulgated rules under TSCA to place restrictions on only five existing chemicals/chemical classes and only four new chemicals (GAO 2005).

TSCA’s effectiveness is also constrained by lack of data. There are few test data on short-term health effects and far fewer data on long-term chronic health effects. The USEPA does not have the funds to adequately test new products and does not require the producers to provide such data. Instead, the USEPA uses a method known as structural activity relationship analysis to compare new chemicals with chemicals of like molecular structure that have been tested to predict health effects. This method, while a useful screening tool, is subject to inaccuracies in predicting toxicity. The USEPA takes action on approximately 10% of the premanufacture notices (PMNs) submitted; only 2–3% of the total number of PMNs submitted undergo a detailed review by the USEPA, while the remaining 7–8% of PMNs are analyzed through the structural activity relationship analysis (USEPA 2005b).

The USEPA reviewed the risks of only 2% of the 62,000 chemicals already in use when the agency began to review new chemicals (GAO 1994). At the current rate of testing of existing chemicals, it could require hundreds of years to fully test chemicals in use. Once a chemical is approved and production begins, there is little monitoring of changes in production, use, and

⁶⁶ 15 U.S.C. § 2605(a) (2002).

⁶⁷ 15 U.S.C. § 2605(a) (2002).

⁶⁸ 947 F.2d 1201 (5th Cir. 1991).

exposure. Although the USEPA has taken action on about 3,500 new chemicals (out of about 32,000) submitted for review under TSCA, the “EPA’s reviews of new chemicals provides limited assurance that health and environmental risks are identified before the chemicals enter commerce” (GAO 2005). Thus, tens of thousands of chemicals have not been evaluated for acute or chronic exposure; further, for those already evaluated, the process may have assessed risks inadequately.

Another factor limiting TSCA’s effectiveness is the Act’s confidentiality requirements. The USEPA must treat as confidential much of the information that manufacturers submit under TSCA, which also prevents the USEPA from sending this information to officials who have a responsibility to protect the public. For instance, about 95% of the PMNs for new chemicals submitted by chemical companies contain some information that is claimed as confidential (GAO 2005). Many of these claims to confidentiality may be unjustifiable, but the USEPA lacks the resources to challenge a significant portion of these claims.

Further, the USEPA lacks exposure data that it can use to justify regulation of chemicals in use. The USEPA can request test data from industry only when the USEPA can prove that the chemical may present an unreasonable risk of injury to health or the environment, or may lead to significant or substantial human exposure,⁶⁹ which the USEPA generally cannot prove without that additional data from industry.

As part of the implementation of TSCA, an Interagency Testing Committee (ITC) has been formed to make recommendations to the USEPA Administrator for testing existing chemicals. ITC knows which chemicals it would like to test but there is a lack of test data. When these data do exist, they are usually confidential, which greatly reduces their value in reducing human exposure (GAO 1994).

Finally, certain types and amounts of chemicals are excluded from TSCA’s coverage. Pesticides, tobacco, and tobacco products, radioactive material, foods, food additives, drugs, and cosmetics are excluded from TSCA regulations.

In summary, TSCA has limited impact due to strict legal tests in the Act and USEPA’s lack of the resources and administrative support to use its authority under TSCA to review, measure, and control exposures to the majority of chemicals in commercial use. Without increases in exposure data, resources, administrative support, and changes in the laws, the potential effectiveness of TSCA may remain unfulfilled.

21.11 CONCLUSIONS

We have found that federal environmental regulations, which seek to protect human health, are missing major pollutant exposures that imperil human health. Exposures from sources indoors are currently far greater than exposures from sources outdoors. Yet these indoor environments, such as homes, offices, schools, and vehicles, are largely unregulated and unmonitored.

Fortunately, because many significant exposures are within our control, we can reduce health risks through relatively simple and cost-effective actions, such as using less toxic consumer products and building materials. Unfortunately, many people are unaware of the major sources of pollutant exposures, their health effects, and ways to reduce those exposures. Thus, a gap exists between regulation and risk, and between science and public awareness.

We can use the science of human exposure to bridge that gap by understanding what, where, and when pollutants come in contact with humans. We have successfully reduced outdoor pollutant levels, thanks to our environmental laws. But our regulatory lens needs to focus on *total* exposures to pollutants in order to reduce some major health risks that remain.

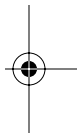
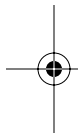
To this end, a group of scientists has proposed a Human Exposure Reduction Act (HERA), which is presented in Table 21.2. The HERA seeks to more efficiently and cost-effectively protect health by incorporating exposure into environmental laws.

⁶⁹ 15 U.S.C. § 2603(a) (2002).



21.12 QUESTIONS FOR REVIEW

1. Most of our exposure to pollutants occurs within indoor environments, such as homes, offices, and schools. Certain laws address some aspects of indoor air quality, yet no law provides comprehensive coverage.
 - a. Select a law, and discuss how it covers an aspect of indoor air quality.
 - b. Now discuss how the law does not cover indoor air exposures, even though it would seem within the scope of the law to do so.
 - c. Finally, for this law, suggest revisions to address exposure more effectively.
2. Regulation often relies on a cost-benefit analysis as a prerequisite to action, such as banning a product or a hazardous chemical. What are some limitations of this cost-benefit approach? Respond with particular attention to benefits and costs related to exposure and human health. What would you suggest as an alternative regulatory approach or criterion?
3. In these laws, the health outcomes considered are usually cancer mortalities, even though exposures are linked to a range of other mortality and morbidity effects. Why do you think the laws focus on cancer as a basis for risk assessment and regulation? What other types of exposure-related health effects are overlooked?
4. Superfund (CERCLA/SARA) has been criticized for spending relatively large amounts of money to address sites that pose relatively little exposure risk to humans. Why do you think this has occurred? How might results from exposure studies be used to allocate resources?
5. You are working inside a state government building, which is being renovated. Employees are becoming sick due to exposures to materials and products used in the renovation. Which law(s) might apply in this case to reduce exposure, and how? Which law(s), if they were stronger, might have prevented this “sick building” incident from happening?
6. Most of the environmental laws are “source oriented” rather than “receptor oriented” in that they focus on emissions/effluents instead of exposures. Why do you think this is the case?
7. Fragrances (synthetic compounds) in products represent significant sources of human exposure to toxic VOCs, and are linked to a range of adverse health effects such as seizures, headaches, and breathing difficulties. Consumers often believe that if a product is sold in a store, then it must be “safe.” Why, then, are these products allowed to be sold, and why do you think consumers continue to buy them, given the health risks?



21.13 ACKNOWLEDGMENTS

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TABLE 21.1
Content Analysis of Major Environmental Laws

Name of Law	"Exposure"	"Ambient Air"	"Indoor Air"	"Outdoor Air"
Clean Air Act (CAA)	29	175	0	0
Clean Air Act Amendments	10	13	0	0
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	41	2	0	0
Superfund Amendments and Reauthorization Act (SARA)	14	0	18	0
Consumer Product Safety Act (CPSA)	4	0	0	0
Federal Food, Drug, and Cosmetic Act (FFDCA)	35	0	0	0
Food Quality Protection Act (FQPA)	33	0	0	0
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	35	0	0	0
Occupational Safety and Health Act (OSH Act)	20	0	0	0
Resource Conservation and Recovery Act (RCRA)	27	2	0	0
Toxic Substances Control Act (TSCA)	63	2	0	0

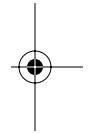




TABLE 21.2
Human Exposure Reduction Act (HERA)

Intent:

The purpose of a proposed Human Exposure Reduction Act (HERA) is to assess and reduce human exposure to pollutants in all carrier media, and to more efficiently and effectively reduce health costs. A major objective is to reduce exposures to children because of their increased susceptibility to health effects caused by environmental pollutants.

Findings:

- (1) Americans are regularly exposed to a range of pollutants that enter their bodies and can harm health
- (2) Existing laws do not adequately address many of the major sources of pollutant exposures and health risks
- (3) Pollutant exposures are not measured routinely among the American population in exposure field studies, even though these measurements provide critical information and can be made with high accuracy with today's science of exposure analysis
- (4) The American public is generally unaware of their personal exposures to toxic pollutants through daily activities and would benefit from increased education on this issue
- (5) A more effective regulatory approach would address the sources that contribute most to human exposures and health risks, without abandoning existing protection

Objectives:

- (1) Identify and measure sources of human exposure to pollutants from all environmental media (air, water, soil, food, dust, dermal) in a single balanced approach
- (2) Reduce pollutant exposure, with priorities based on relative contributions of each source to cumulative exposure
- (3) Conduct regular monitoring and exposure studies of the general population, and quantify changes in human exposure to pollutants over time
- (4) Assess and compare the exposure reduction effects of different environmental regulations and initiatives affecting all environmental media and exposure routes
- (5) Require testing and labeling of consumer products, building materials, and other significant sources of pollutant exposures
- (6) Perform independent studies of toxicity and health effects of chemicals, chemical mixtures, and other pollutants found in everyday life
- (7) Conduct research to develop new exposure measurement methods, including personal monitoring systems and exposure models that will facilitate routine, less expensive exposure monitoring studies
- (8) Conduct health studies that combine epidemiology with actual exposure measurements
- (9) Support programs that provide training, information, and public outreach about pollutant exposures and reduction strategies in homes, workplaces, schools, and other environments
- (10) Support academic institutions in their education of a new generation of human exposure scientists
- (11) Support research to develop new technologies and products that reduce pollutant exposures, such as new building materials, new consumer product formulations, and easy-to-employ control systems

Principles:

- (1) To effectively protect health and reduce health costs of the American public, we need to understand accurately the causes of human exposures to environmental pollutants, the ways in which these exposures can be altered, and the trends in population exposures over time
- (2) To understand trends in population exposures over time, routine exposure monitoring programs are needed, much like the nationwide ambient air and water monitoring networks now operating, but instead focused on routinely measuring the status and changes in personal exposures
- (3) Environmental epidemiology should include, wherever possible, as an integral part of its methodology, the direct measurement of physical, chemical, and biological indicators of actual exposure, in addition to surrogate indicators of exposure such as questionnaires
- (4) Research should be conducted to improve our understanding of the individual variation in the susceptibility of different persons to environmental chemicals, as well as the nature, extent, and variability of the population exposure to these pollutants

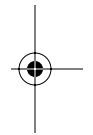
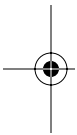




TABLE 21.2 (CONTINUED)
Human Exposure Reduction Act (HERA)

- (5) Regulations adopted under existing environmental laws should be evaluated comparatively across all media (air, water, soil, food, dust, dermal) for their effectiveness in reducing population exposure, especially the exposure of susceptible persons and children
- (6) Accurate information should be available to the user of a consumer product about whether the product contains an appreciable concentration of certain listed chemicals, the specific concentrations of those listed chemicals, the likely exposure that might result from using the product, and the ways that the product should be used safely to reduce or eliminate these exposures
- (7) Educational programs should be developed and experts should be trained in the emerging science of exposure analysis and exposure assessment, including outreach programs to demonstrate new methods for reducing exposure in the everyday lives of our citizens
- (8) Government should require testing, labeling, and evaluation of the toxic pollutants emitted by consumer products and building materials, just as they require for food and drugs. At a minimum, the manufacturer should submit accurate and complete information about the toxic pollutants their products contain and the levels of exposure that might result from typical use

Source: Ott, W.R., Roberts, J.W., Steinemann, A.C., Repace, J., Gilbert, S.G., Moschandreas, D.J., and Corsi, R.L. (2002), and adapted in Moschandreas, D. (2003).

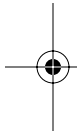


TABLE 21.3
List of Hazardous Air Pollutants (HAPs) Established in the Clean Air Act, as Amended in 1990

CAS Number	Chemical Name	Found in TEAM Studies ¹	Found in Household Products ²	Found in Indoor Air in Other Studies
75070	Acetaldehyde			√4,5,6
60355	Acetamide			
75058	Acetonitrile			
98862	Acetophenone			
53963	2-Acetylaminofluorene			
107028	Acrolein			√4,7
79061	Acrylamide			
79107	Acrylic Acid			
107131	Acrylonitrile			√4,5,7
107051	Allyl Chloride	√		
92671	4-Aminobiphenyl			√4
65233	Aniline			√8
90040	o-Anisidine			
0	Antimony Compounds			√9,10
0	Arsenic Compounds (inorganic including arsine)			√4,5
1332214	Asbestos			
71432	Benzene (including benzene from gasoline)	√	√	√4,5,7,11,12,13,14,15,16,17,18,19,20
92875	Benzidine			
98077	Benzotrichloride			
100447	Benzyl chloride	√		
0	Beryllium Compounds			
92524	Biphenyl			
117817	Bis(2-ethylhexyl)phthalate (DEHP)	√		
542881	Bis(chloromethyl)ether	√		
75252	Bromoform	√		
106990	1,3-Butadiene	√		√5,7,8,15,17,18
0	Cadmium Compounds			√4,5,21
156627	Calcium cyanamide			
133062	Captan	√		
63252	Carbaryl	√		
75150	Carbon disulfide			√22
56235	Carbon tetrachloride	√	√	√7,18,19
463581	Carbonyl sulfide			
120809	Catechol			√4,5
133904	Chloramben			
57749	Chlordane	√		
7782505	Chlorine			
79118	Chloroacetic acid			
532274	2-Chloroacetophenone			
108907	Chlorobenzene	√		√7
510156	Chlorobenzilate			
67663	Chloroform	√	√	√12,13,14,17,18
107302	Chloromethyl methyl ether			
126998	Chloroprene	√		

TABLE 21.3 (CONTINUED)**List of Hazardous Air Pollutants (HAPs) Established in the Clean Air Act, as Amended in 1990**

CAS Number	Chemical Name	Found in TEAM Studies ¹	Found in Household Products ²	Found in Indoor Air in Other Studies
0	Chromium Compounds			√4,5,21
0	Cobalt Compounds			
0	Coke Oven Emissions			
1319773	Cresols/cresylic acid (isomers and mixture)			
95487	o-Cresol			√10
108394	m-Cresol			√10
106445	p-Cresol			√10
98828	Cumene			√16,17
0	Cyanide Compounds			
94757	2,4-D, salts and esters			
3547044	DDE	√		
334883	Diazomethane			
132649	Dibenzofurans			
96128	1,2-Dibromo-3-chloropropane			
84742	Dibutylphthalate	√		
106467	1,4-Dichlorobenzene(p)	√		√7,12,16,17,18,20
91941	3,3-Dichlorobenzidene			
111444	Dichloroethyl ether (Bis(2-chloroethyl)ether)			
542756	1,3-Dichloropropene			
62737	Dichlorvos	√		
111422	Diethanolamine			
121697	N,N-Diethyl aniline (N,N-Dimethylaniline)			
64675	Dimethyl Sulfate			
119904	3,3'-Dimethoxybenzidine			
60117	Dimethyl aminoazobenzene			
119937	3,3'-Dimethyl benzidine			
79447	Dimethyl carbamoyl chloride			
68122	Dimethyl formamide			
57147	1,1-Dimethyl hydrazine			√4,5
131113	Dimethyl phthalate	√		
77781	Dimethyl sulfate			
534521	4,6-Dinitro-o-cresol, and salts			
51285	2,4-Dinitrophenol			
121142	2,4-Dinitrotoluene			
123911	1,4-Dioxane(1,4-Diethyleneoxide)	√	√	√7
122667	1,2-Diphenylhydrazine			
106898	Epichlorohydrin (1-Chloro-2,3-epoxypropane)			
106887	1,2-Epoxybutane			
140885	Ethyl acrylate			
100414	Ethyl benzene	√	√	√11,16,17,18
51796	Ethyl carbamate (Urethane)			√4,5
75003	Ethyl chloride (Chloroethane)			
106934	Ethyl dibromide (Dibromoethane)	√		

TABLE 21.3 (CONTINUED)
List of Hazardous Air Pollutants (HAPs) Established in the Clean Air Act, as Amended in 1990

CAS Number	Chemical Name	Found in TEAM Studies ¹	Found in Household Products ²	Found in Indoor Air in Other Studies
107062	Ethylene dichloride (1,2-Dichloroethane)	√	√	
107211	Ethylene glycol			√20
151564	Ethylene imine (Aziridine)			
75218	Ethylene oxide	√		
96457	Ethylene thiourea			
75343	Ethylidene dichloride (1,1,- Dichloroethane)			
0	Fine mineral fibers			
50000	Formaldehyde			√11,20,23
76448	Heptachlor			
118741	Hexachlorobenzene	√		
87683	Hexachlorobutadiene			
77474	Hexachlorocyclopentadiene			
66721	Hexachloroethane			
822060	Hexamethylene-1,6-diisocyanate			
680319	Hexamethylphosphoramide			
110543	Hexane	√	√	
302012	Hydrazine			√4
7647010	Hydrochloric Acid			
7664393	Hydrogen fluoride (Hydrofluoric acid)			
123319	Hydroquinone			√9,10
78591	Isophorone			
0	Lead Compounds	√		√5,10,21
58899	Lindane (all isomers)	√		
108316	Maleic anhydride			
0	Manganese Compounds			√9,10
0	Mercury Compounds			√9,10
67561	Methanol			√8,11
72435	Methoxychlor			
74839	Methyl bromide (Bromomethane)	√		
74873	Methyl chloride (Chloromethane)	√	√	
71556	Methyl chloroform (1,1,1- Trichloroethane)	√	√	
78933	Methyl ethyl ketone (2-Butanone)	√	√	√20,23
60344	Methyl hydrazine			
74884	Methyl iodide (Iodomethane)			
108101	Methyl isobutyl ketone (Hexone)		√	
624839	Methyl isocyanate			
80626	Methyl methacrylate			
1634044	Methyl tert butyl ether			
101144	4,4'-Methylene bis(2-chloroaniline)			
75092	Methylene chloride (Dichloromethane)		√	
101688	Methylene diphenyl diisocyanate (MDI)			
101779	4,4-Methylenedianiline			
91203	Naphthalene	√		√8,18
0	Nickel Compounds			√4,5
98953	Nitrobenzene			

TABLE 21.3 (CONTINUED)**List of Hazardous Air Pollutants (HAPs) Established in the Clean Air Act, as Amended in 1990**

CAS Number	Chemical Name	Found in TEAM Studies ¹	Found in Household Products ²	Found in Indoor Air in Other Studies
92933	4-Nitrobiphenyl			
100027	4-Nitrophenol			
79469	2-Nitropropane			
684935	N-Nitroso-N-methylurea			
62759	N-Nitrosodimethylamine			√4,5
59892	N-Nitrosomorpholine			√4
56382	Parathion	√		
82688	Pentachloronitrobenzene (Quintobenzene)			
87865	Pentachlorophenol	√		
108952	Phenol	√		√9,20,24
106503	p-Phenylenediamine			
75445	Phosgene			
7803512	Phosphine			
7723140	Phosphorus			
85449	Phthalic anhydride			
1336363	Polychlorinated biphenyls (Aroclors)			√24
0	Polycyclic Organic Matter	√		
1120714	1,3-Propane sultone			
57578	Beta-Propiolactone			
123386	Propionaldehyde			
114261	Propoxur (Baygon)	√		
78875	Propylene dichloride (1,2-Dichloropropane)	√		
75569	Propylene oxide	√	√	
75558	1,2-Propylenimine (2-Methyl aziridine)			
91225	Quinoline			
106514	Quinone			
0	Radionuclides (including radon)			
0	Selenium Compounds			
100425	Styrene	√		√5, 8,11,12,16,17
96093	Styrene oxide	√		
1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin			
79345	1,1,2,2-Tetrachloroethane	√		
127184	Tetrachloroethylene (Perchloroethylene)	√	√	
7550450	Titanium tetrachloride			
108883	Toluene		√	√8,11,12,15,16,23
95807	2,4-Toluene diamine			
584849	2,4-Toluene diisocyanate			
95534	o-Toluidine			
8001352	Toxaphene (chlorinated camphene)			
120821	1,2,4-Trichlorobenzene			√22
79005	1,1,2-Trichloroethane	√		
79016	Trichloroethylene	√	√	
95954	2,4,5-Trichlorophenol			
88062	2,4,6-Trichlorophenol			
121448	Triethylamine			

TABLE 21.3 (CONTINUED)
List of Hazardous Air Pollutants (HAPs) Established in the Clean Air Act, as Amended in 1990

CAS Number	Chemical Name	Found in TEAM Studies ¹	Found in Household Products ²	Found in Indoor Air in Other Studies
1582098	Trifluralin			
540841	2,2,4-Trimethylpentane			
108054	Vinyl acetate			
593602	Vinyl bromide			
75014	Vinyl chloride			√4,5,14,25
75354	Vinylidene chloride (1,1-Dichloroethylene)	√		
1330207	Xylenes (isomers and mixture)	√		
95476	o-Xylenes	√	√	√11,26
108383	m-Xylenes	√	√	√11,22,26,27
106423	p-Xylenes	√	√	√11,22,26,27

References:

¹ 42 U.S.C. § 7412(b)(2) (2002); hydrogen sulfide, caprolactam, and glycol ethers delisted from the original list of HAPs.

² Includes the TEAM studies of volatile organic compounds, pesticides (NOPES), and particulate matter (PTEAM). See Chapters 1, 3, 7, 8, and 15 in text.

³ Sack, T.M., Steele, D.H., Hammerstrom, K., and Remmers J. (1992) A Survey of Household Products for Volatile Organic Compounds, *Atmospheric Environment*, 26A(6): 1063–1070.

⁴ USDHHS (1989) Reducing the Health Consequences of Smoking, 25 Years of Progress, A Report of the Surgeon General, U.S. Department of Health and Human Services, Rockville, MD.

⁵ Hoffmann, D. and Hoffmann, I. (1990) Cigars — Health Effects and Trends, in *Smoking and Tobacco Control Monograph*, Table 15, Carcinogens in tobacco smoke, NIH Publication No. 98-4302, February, National Cancer Institute, National Institutes of Health.

⁶ Zhang, J., He, Q., and Liyo, P.J. (1994) Characteristics of Aldehydes: Concentrations, Sources and Exposures for Indoor and Outdoor Residential Microenvironments, *Environmental Science and Technology*, 28: 146–152.

⁷ Sheldon, L.S., Clayton, A., Jones, B., Keever, J., Perritt, R., Smith, D., Whitaker, D., and Whitmore, R. (1991) Indoor Pollutant Concentrations and Exposures, Final report, California Air Resources Board, Sacramento, CA.

⁸ National Institute of Occupational Safety and Health (NIOSH) (1994) *Pocket Guide to Chemical Hazards*, Centers for Disease Control & Prevention, U.S. Department of Health and Human Services, June.

⁹ Sax, N.I. (1984) *Dangerous Properties of Industrial Materials*, 6th ed., Van Nostrand Reinhold, NY.

¹⁰ USDHEW (1979) Smoking and Health, A Report of the Surgeon General, U.S. Department of Health, Education, and Welfare, Washington, DC.

¹¹ Brown, S.K. (2002) Volatile Organic Pollutants in New and Established Buildings in Melbourne, Australia, *Indoor Air*, 12(1): 55–63.

¹² Adgate, J.L., Bollenbeck, M., Eberly, L.E., Stroebel, C., Pellizzari, E.D., and Sexton, K. (2002) Residential VOC Concentrations in a Probability-Based Sample of Households with Children, Levin, H., Ed., in *Indoor Air, Proceedings of the 9th International Conference on Indoor Air Quality and Climate*, Santa Cruz, CA, 1: 203–208.

¹³ Clayton, C.A., Pellizzari, E.D., Whitmore, R.W., Perritt, R.L., and Quackenboss, J.J. (1999) National Human Exposure Assessment Survey (NHEXAS): Distributions and Associations of Lead, Arsenic and Volatile Organic Compounds in EPA Region 5, *Journal of Exposure Analysis and Environmental Epidemiology*, 9: 381–392.

¹⁴ Foster, S.J., Kurtz, J.P., and Woodland, A.K. (2002) Background Indoor Air Risks in Selected Residences in Denver, Colorado. Levin, H., Ed., in *Indoor Air, Proceedings of the 9th International Conference on Indoor Air Quality and Climate*, Santa Cruz, CA, 1: 932–937.

TABLE 21.3 (CONTINUED)**List of Hazardous Air Pollutants (HAPs) Established in the Clean Air Act, as Amended in 1990**

- ¹⁵ Gordon, S.M., Callahan, P.J., Nishioka, M.G., Brinkman, M.C., O'Rourke, M.K., and Lebowitz, M.D. (1999) Residential Environmental Measurements in the National Human Exposure Assessment Survey (NHEXAS) Pilot Study in Arizona: Preliminary Results for Pesticides and VOCs, *Journal of Exposure Analysis and Environmental Epidemiology*, 9: 456–470.
- ¹⁶ Heavner, D.L., Morgan, W.T., and Ogden, M.W. (1995) Determination of Volatile Organic Compounds and ETS Apportionment in 49 Homes, *Environment International*, 21: 3–21.
- ¹⁷ Heavner, D.L., Morgan, W.T., and Ogden, M.W. (1996) Determination of Volatile Organic Compounds and Respirable Suspended Particulate Matter in New Jersey and Pennsylvania Homes and Workplaces, *Environment International*, 22: 159–183.
- ¹⁸ Van Winkle, M.R. and Scheff, P.A. (2001) Volatile Organic Compounds, Polycyclic Aromatic Hydrocarbons and Elements in the Air of Ten Urban Homes, *Indoor Air*, 11: 49–64.
- ¹⁹ Mukerjee, S., Ellenson, W.D., Lewis, R.G., Stevens, R.K., Somerville, M.C., Shadwick, D.S., Willis, R.D. (1997) An environmental scoping study in the lower Rio Grande Valley of Texas, III, Residential Microenvironmental Monitoring for Air, House Dust, and Soil, *Environment International*, 23(5): 657–673.
- ²⁰ Otson, R., Fellin, P., and Tran, Q. (1994) VOCs in Representative Canadian Residences, *Atmospheric Environment*, 28: 3563–3569.
- ²¹ Lioy, P.J., Freeman, N.J., and Millette, J.R. (2002) Dust: A Metric for Use in Residential and Building Exposure Assessment and Source Characterization, *Environmental Health Perspectives*, 110(10): 969–973.
- ²² Girman, J.R., Hadwen, G.E., Burton, L.E., Womble, S.E., and McCarthy, J.F. (1999) Individual Volatile Organic Compound Prevalence and Concentrations in 56 Buildings of the Building Assessment Survey and Evaluation (BASE) study, in *Indoor Air 99, Proceedings of the 8th International Conference on Indoor Air Quality and Climate*, Vol. 2, Raw, G., Aizlewood, C., and Warren, P., Eds., Construction Research Communications Ltd., London, 460–465.
- ²³ Lindstrom, A.B., Proffitt, D., and Fortune, C.R. (1995) Effects of Modified Residential Construction on Indoor Air Quality, *Indoor Air*, 5: 258–269.
- ²⁴ Rudel, R.A., Camann, D.E., Spengler, J.D., Korn, L.R., and Brody, J.G. (2003) Phthalates, Alkylphenols, Polybrominated Diphenyl Ethers, and Other Endocrine-Disrupting Compounds in Indoor Air and Dust, *Environmental Science and Technology*, 37(20): 4543–4553.
- ²⁵ Kurtz, J.P. and Folkes, D.J. (2002) Background Concentrations of Selected Chlorinated Hydrocarbons in Residential Indoor Air, in *Indoor Air 2002, Proceedings of the 9th International Conference on Indoor Air Quality and Climate*, Vol. 1, Levin, H., Ed., Santa Cruz, CA, 920–925.
- ²⁶ Daisey, J.M., Hodgson, A.T., Fisk, W.J., Mendell, M.J., and Ten Brinke, J. (1994) Volatile Organic Compounds in Twelve California Office Buildings: Classes, Concentrations and Sources, *Atmospheric Environment*, 28: 3557–3562.
- ²⁷ Sheilds, H.C., Fleischer, D.M., and Weschler, C.J. (1996) Comparisons among VOCs Measured in Three Types of U.S. Commercial Buildings with Different Occupant Densities, *Indoor Air*, 6: 2–17.

REFERENCES

- ATSDR (2003) Agency for Toxic Substances and Disease Registry, <http://www.atsdr.cdc.gov/clist.html> (accessed December 6, 2005).
- CDC (2001) *First National Report on Human Exposure to Environmental Chemicals*, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA, <http://www.cdc.gov/exposurereport/> (accessed December 6, 2005).
- CDC (2003) *Second National Report on Human Exposure to Environmental Chemicals*, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA, <http://www.cdc.gov/exposurereport/> (accessed December 6, 2005).
- CDC (2005) *Third National Report on Human Exposure to Environmental Chemicals*, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA, <http://www.cdc.gov/exposurereport/> (accessed December 6, 2005).
- CFSAN (2005) Center for Food Safety and Applied Nutrition, <http://www.cfsan.fda.gov/~dms/pes03rep.html#summary> (accessed December 6, 2005).
- CQC (1994) Census Questionnaire Content, Bureau of the Census, <http://www.census.gov/aprd/cqc/cqc20.pdf> (accessed December 6, 2005).
- Cross, F.B. (1997) The Consequences of Consensus: Dangerous Compromises of the Food Quality Protection Act, *Washington University Law Quarterly*, **75**: 1157.
- EWG (2005) Environmental Working Group, <http://www.ewg.org/reports/skindeep/index.php> (accessed December 6, 2005).
- GAO (1994) Toxic Substances Control Act: Legislative Changes Could Make the Act More Effective, Chapter Report, 09/26/94, GAO/RCED-94-103, U.S. General Accounting Office, Washington, DC, www.mapcruzin.com/scrutztri/docs/gao94103.htm (accessed December 6, 2005).
- GAO (2005) Chemical Regulation: Options Exist to Improve EPA's Ability to Assess Health Risks and Manage Its Chemical Review Program, GAO-05-458, U.S. General Accounting Office, Washington, DC, <http://www.gao.gov/docsearch/abstract.php?rptno=GAO-05-458> (accessed December 6, 2005).
- Klepeis, N.E., Nelson, W.C., Ott, W.R., Robinson, J.P., Tsang, A.M., Switzer, P., Behar, J.V., Hern, S.C., and Engelmann, W.H. (2001) The National Human Activity Pattern Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants, *Journal of Exposure Analysis and Environmental Epidemiology*, **11**: 231–252.
- Moschandreas, D. (2003) The Whence, Wherefore and Whither of the New Scientific Discipline of Environmental Inquiry: Exposure Analysis, The 2002 Wesolowski Lecture, *Journal of Exposure Analysis and Environmental Epidemiology*, **13**(4): 247–255.
- NRC (1987) *Regulating Pesticides in Food: the Delaney Paradox*, Committee on Scientific and Regulatory Issues Underlying Pesticide Use Patterns and Agricultural Innovation, National Research Council.
- NRC (1993) *Pesticides in the Diets of Infants and Children*, Committee on Pesticides in the Diets of Infants and Children, National Research Council.
- OSHA (2002) OSHA Trade News Release, http://www.osha.gov/pls/oshaweb/owadisp.showdocument?ptable=NEWS_RELEASES&pid=1182 (accessed December 6, 2005).
- OSHA (2005) Indoor Air Quality in the Workplace, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=UNIFIED_AGENDA&p_id=5042 (accessed December 6, 2005).
- Ott, W.R., Roberts J.W., Steinemann A.C., Repace J., Gilbert S.G., Moschandreas D.J., and Corsi R.L. (2005) The Proposed Human Exposure Reduction Act. (Full text available from lead author, and reprinted in Moschandreas, D., 2003.)
- State of New York (1996) *The Secret Hazards of Pesticides: Inert Ingredients*, Office of the Attorney General, Environmental Protection Bureau, New York State, February, <http://www.oag.state.ny.us/environment/inerts96.html> (accessed on December 6, 2005).
- USEPA (1999) *Implementing FQPA: Progress Report*, U.S. Environmental Protection Agency, August.
- USEPA (2002a) *Pesticide Industry Sales and Usage: 1998 and 1999 Market Estimates*, U.S. Environmental Protection Agency.
- USEPA (2002b) 25 Years of RCRA: Building on Our Past to Protect Our Future, <http://www.epa.gov/epaoswer/general/k02027.pdf> (accessed December 6, 2005).
- USEPA (2004) National Priorities List, <http://www.epa.gov/superfund/sites/npl/> (accessed December 6, 2005).
- USEPA (2005a) Air Trends, <http://www.epa.gov/airtrends/> (accessed December 6, 2005).



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- USEPA (2005b) Chemical Categories Report, New Chemicals Program, <http://www.epa.gov/oppt/newchemicals/pubs/chemcat.htm> (accessed December 6, 2005).
- USEPA (2005c) Interagency Committee on Indoor Air Quality, <http://www.epa.gov/iaq/ciaq/index.html> (accessed December 6, 2005).
- USEPA (2005d) Key Dates in Superfund, <http://www.epa.gov/superfund/action/law/keydates.htm> (accessed December 6, 2005).
- USEPA (2005e) National Center for Environmental Assessment, <http://cfpub.epa.gov/ncea> (accessed December 6, 2005).
- USEPA (2005f) National Priorities List, <http://www.epa.gov/superfund/sites/query/queryhtm/npldel.htm> (accessed December 6, 2005).
- USEPA (2005g) Pesticides: Regulating Pesticides, <http://www.epa.gov/opprd001/inerts/lists.html> (accessed December 6, 2005).
- USFDA (2005) U.S. Food and Drug Administration, <http://www.fda.gov/opacom/backgrounders/miles.html> (accessed December 6, 2005).
- USHR (1986) *Neurotoxins: At Home and the Workplace*, Report 99-827, Report by the Committee on Science and Technology, U.S. House of Representatives, September 16.
- Wallace, L.A. (1991) Comparison of Risks from Outdoor and Indoor Exposure to Toxic Chemicals. *Environmental Health Perspectives*, **95**: 7–13.

