Industry Challenges to the Principle of Prevention in Public Health: The Precautionary Principle in Historical Perspective

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Historically, prevention of disease has been a cornerstone of public health practice. In the 19th century, the provision of pure water, the engineering efforts to remove sewage, and sanitation were hallmarks of urban reform. In the 20th century, vaccination and early treatment of communicable disease, such as syphilis and gonorrhea, and well baby services, for example, emerged as central activities of health departments around the nation. Yet, in recent decades, as public health has expanded its scope to address issues of environmental and industrial health, the apparently clear-cut public health mandate to prevent disease has often come into conflict with private industries' self-interest in avoiding public health or state interventions in its practices.

In recent years, the stakes have been dramatically raised as nation states have sought to address issues affecting the health of the global community. For the most part, until the late 1990s, environmental disputes have been local or national in scope, such as those at Love Canal, New York; Times Beach, Missouri; or Convent, Louisiana. But lately, the arguments have taken on international dimensions especially during and after the debates over the Kyoto Protocol on Global Warming. Issues, which were once of interest only to particular companies and local communities, are now of concern to multinational corporations and the world. For example, the Business Roundtable—founded in 1972 as an association, representing 200 of the nation's largest corporations, to

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counter the government's growing regulatory role—has now taken an active role in debates concerning environmental pollution, vigorously opposing the Kyoto Protocol. This influential body has argued that "because climate change is a complex issue which will evolve over many decades . . . no policy commitments should be made until the environmental benefits and economic consequences of global climate change proposals are thoroughly analyzed and reviewed."[1] Like others in the industrial community, they argue that economic interests should not be challenged until science has proven danger. Precaution is equated with economic and social stagnancy, and is viewed as an unnecessary interference with the scientific advances essential to progress. Progress, as defined by the industrial community, trumps precaution.

The precautionary principle, despite industry's general suspicion, has become central to the new, evolving definition of public health's responsibilities to protect the health and environment for future generations. Public health officials and many policy makers see in precaution the only means of averting new global dangers posed by the chemical industry and, more broadly, the industrial environment. These uncertain threats, with the potential for extraordinary global damage, have led to a revisiting of the public health principles that have been largely trumped during much of the last century.

Here we will outline the century of struggle preceding the modern arguments over the principle of precaution, and look at the tension between public health principles and industrial interests during the 20th century by focusing on three critical substances: lead, silica and vinyl chloride. In the case of lead, we will focus on the first third of the century when lead became ubiquitous in the industrial and environmental landscape and was acknowledged to be a danger to consumers, children and adults alike. In regard to silica, we will examine how a disease that the industrial hygiene community identified as "this King of Occupational Diseases" in the 1930s and 1940s, and which public health officials, industry, and labor agreed was totally preventable, was redefined to make it appear less threatening even though it continued to kill and disable workers many decades later. Finally, we will explore the case of vinyl chloride during the last third of the 20th century, when the traditional struggle between prevention and economic advancement evolved into a basic conflict between the public health community and industry over whose science and scientists should determine policy.

EARLY WARNINGS FROM THE PUBLIC HEALTH COMMUNITY

During the first third of the 20th century, public health officials confronted a new and troubling issue: toxins. Once considered a threat only to the workforce, toxins were being introduced in large quantities into the broader environment. Lead, particularly in the form of an additive to gasoline (tetraethyl lead), was now being marketed throughout the nation and dispersed through automobile tailpipes onto the streets of growing cities, and breathed in by people everywhere. In the wake of blaring headlines announcing the deaths of 11 workers and the poisoning of dozens more from tetraethyl lead at Standard Oil, General Motors, and DuPont facilities in the early 1920s, public health leaders such as Alice Hamilton, C-E.A. Winslow, and Yandell Henderson warned of the potential for damage to broad swaths of the population posed by the introduction of this well established toxin into the daily lives of millions of people. Yet despite these warnings, millions of children, workers, and the general public were harmed by its effects over the subsequent 80 years, and this entirely preventable poisoning still occurs today. Early public health warnings were not heeded because the industry assured the scientific community and the public that there was no danger.[2]

The industry argued that the amount of lead being emitted into the atmosphere was too small to impair people's health and that, at any rate, there was no proof that lead in the environment put people at risk. Corporate leaders and their scientific advisors maintained that public health officials did not have the right to interfere in the private activities of the increasingly important automotive, gasoline, and petrochemical industries without definitive scientific proof of danger to the public. Industry spokespersons argued that it was not possible to abstract the questions of public health from the real economic issues confronting businessmen, and the nation at large, every day. Industry attempted to put the public health community on the defensive by making them appear to be reactionaries whose limited vision of the country's future could permanently retard progress and harm future generations.[3]

Those who opposed the introduction of leaded gasoline disagreed with every fundamental position of industry representatives. First, they believed it was wrong to accept that progress entails inevitable risks; rather, the federal government had to assume responsibility for protecting the health of the nation. Second, opponents pointed out that what we now call inorganic

lead compounds were already known to be a slow, cumulative poison that should not be introduced into the general environment. Third, and most important, because they believed public health should take precedence over the needs of industry, they argued that the burden of proof should be on the companies to prove that tetraethyl lead would not cause harm to the general population rather than on opponents to prove that tetraethyl lead was dangerous. Dr. Yandell Henderson, a Yale physiologist, emerged as one of the strongest critics of the industry. He held that lead was a public menace, as serious as the infectious diseases that mobilized the public health community to action in the 19th and early 20th centuries. He was horrified at the thought that hundreds of thousands of pounds of lead would be deposited every year in the streets of every major city of America and that "the conditions would grow worse so gradually and the development of lead poisoning will come on so insidiously . . . that leaded gasoline will be in nearly universal use and large numbers of cars will have been sold . . . before the public and the government awaken to the situation."[4–6]

Unlike industry spokespeople, Henderson believed leaded gasoline was a public and environmental health issue requiring federal action. Opponents were extremely concerned by the industrial equation of the use of lead with industrial progress. Reacting to the Ethyl Corporation representative's statement that tetraethyl lead was a "gift of God," Grace Burnham of the Workers' Health Bureau said it "was not a gift of God when those 11 men were killed or those 149 were poisoned." She angrily questioned the priorities of "this age of speed and rush and efficiency and mechanics" and said, "the thing we are interested in the long run is not mechanics or machinery, but men." A.L. Berres, Secretary of the Metal Trades Department of the American Federation of Labor, also rejected the notion prevalent in the 1920s, that "the business of America was business." He said the American Federation of Labor opposed the use of tetraethyl lead. "We feel that where the health and general welfare of humanity is concerned, we ought to step slowly."[7]

The country's foremost authority on lead, Dr. Alice Hamilton (often considered the founder of modern industrial medicine) agreed with those who believed there was no way to know how to regulate leaded gasoline so that it would be safe. Only a ban would suffice. "You may control conditions within a factory," she said, "but how are you going to control the whole country?"[8] Hamilton stated, "I am not one of those who believe that the use of this leaded gasoline can ever be made safe. No lead industry has ever, even under the strictest control, lost all its dangers. Where there is lead some case of lead poisoning sooner or later develops, even under the strictest supervision."[9]

Most public health professionals did not agree with Henderson and Hamilton. For the vast majority of public health experts, the problem was how to reconcile the opposed views of advocates of industrial progress and those alarmed by the potential for disaster. Although everyone hoped science itself would provide a definitive answer to this imponderable dilemma, the reality was that all evidence about lead toxicity through environmental exposures was ambiguous. Convinced by industry that oil supplies were limited and there was an extraordinary need to conserve fuel by making combustion more efficient, most public health workers believed there must be overwhelming evidence that leaded gasoline actually harmed people before it should be banned. Dr. Henry F. Vaughan, president of the American Public Health Association, said, "Certainly in a study of the statistics in our large cities there is nothing which would warrant a health commissioner in saying that you could not sell ethyl gasoline." He agreed there should be further tests and studies of the problem, but that "so far as the present situation is concerned, as a health administrator I feel that it is entirely negative." Emery Hayhurst, the eminent industrial hygienist from Ohio, argued that the widespread use of leaded gasoline for 27 months "should have sufficed to bring out some mishaps and poisonings, suspected to have been caused by tetraethyl lead."[10–12] Given that it didn't, he was prepared to declare leaded gas safe.

In private, however, Hayhurst and others admitted their private doubts. One investigator from Columbia University, Frederick Flinn, expressed his concerns in a personal communication to R.R. Sayers of the United States Public Health Service and the Bureau of Mines: "The more I work with the material [tetraethyl lead] the more I am confused as to whether it is a real public health hazard," he began. He felt that much depended upon the special conditions of exposure in industry and on the street, but in the end stated he was "convinced that there is some hazard—the extent of which must be studied around garages and filling stations over a period of time and by unprejudiced persons." As Flinn had performed studies for the Ethyl Corporation, it is not surprising he ended his letter by saying that "of course, you must understand that my remarks are confidential."[13]

Emery Hayhurst was even more candid in his private correspondence to Sayers. He told Sayers that he had just received a letter from Dr. Thompson, from

the Public Health Service saying that "lead has no business in the human body. . . . That everyone agrees lead is an undesirable hazard and the only way to control it is to stop its use by the general public." Hayhurst, however, acknowledged to Sayers that political and economic considerations influenced his scientific judgment. "Personally I can quite agree with Dr. Thompson's wholesome point of view, but still I am afraid human progress cannot go on under such restrictions and that where things can be handled safely by proper supervision and regulation they must be allowed to proceed if we are to survive among the nations. Dr. Thompson's arguments might also be applied to gasoline and to the thousand and one other poisons and hazards which characterize our modern civilization."[14]

During the same period of time that the petrochemical and automobile industries were touting the value of tetraethyl lead, another lead-based product, lead pigment for paint, was being promoted as essential to the modern consumer economy. Beginning in 1904 in Australia, and in 1914 in the United States, physicians documented numerous cases of lead poisoning among children who had ingested lead paint by sucking and chewing on cribs, toys, windowsills, woodwork, and other objects in their homes. In response to the growing sense in the medical community that lead was an environmental toxin (and actions in several countries to restrict lead in paint) and a threat to children, the industry began a concerted campaign to counteract the negative publicity regarding lead and to reassure the medical and public health professions that it was on top of the issue and in control of the danger. The industry undercut the ability of public health practitioners to educate, ameliorate, and confront the broad public health danger that lead paint presented. It sponsored research at prestigious universities, conducted a massive advertising campaign aimed at projecting a benign and even healthful image for lead, and organized a specific campaign focused on children themselves.[2,15–18]

In ads throughout much of the first half of the century, the lead industry continually marketed not only their paint and gasoline products, but lead in general. A series of advertisements in *National Geographic*, *Saturday Evening Post*, and other mass-circulation magazines in the early 1920s extolled lead's critical place in modern American life.[19] In all of these ads, the objective was to praise the benefits of lead in general, and to convince the public that they would really feel the loss, especially if lead in paint were eliminated. No mention was made of the dangers of lead—that workers were poisoned, children died, women miscarried, and people were affected by convulsions or palsies.

National Lead was perhaps the most aggressive of the pigment manufacturers in promoting of the use of lead in children's toys and games, continually reminding customers of the qualities of lead that made it most useful. Its marketing of toys and sporting goods was not incidental, but part of an intentional campaign to make palatable the buying of lead products for children and to influence the next generation of consumers. In a promotion to paint distributors, the company advised storeowners to "Not Forget The Children—Someday They May Be Customers."[20] It urged dealers to hand out "children's paint books," which carry "a message to the grown-ups, while its jingles and pictures amuse the little ones."[21,22]

By the Depression, so much information about lead paint's danger to children had accumulated that even the industry's trade group, the Lead Industries Association (LIA), would acknowledge the inappropriateness of using lead paint on children's toys and furniture. Still, the National Lead Company continued in its Dutch Boy campaign to promote lead's use[23–25] and in 1949, *Modern Packaging* noted: "The appeal [of their advertising] was particularly strong to children and the company has never overlooked the opportunity to plant the trademark image in young and receptive minds."[26]

In addition to appealing to children, National Lead sought to co-opt the growing public health movement by identifying lead with modernity and health, and portraying the clutter of older Victorian styles as a haven for germs and disease. The themes of order, cleanliness, and purity that were hallmarks of the efforts to reform and sanitize American life were quickly incorporated into the promotional materials developed by the industry. In an advertisement entitled "How Paint Promotes Public Health," the *Dutch Boy Painter* advised readers that "the easiest way to get rid of germs that have nested in your house and around your premises is: Clean-up and Paint-up."[27] It was emphasized that unlike wallpaper, felt, and other common wall coverings of Victorian America, lead paint could be washed, making it both sanitary and attractive.[28]

At the same time that studies were documenting lead as a potent poison, National Lead ran an ad in *National Geographic* magazine promoting the idea that "lead helps to guard your health." "Lead," the ad proclaimed, "concealed in the walls and under the floors of many modern buildings, helps to give the best sanitation." "Lead pipe" was "centuries old" and was as important now as it was for making Rome "a center of civilization."[29]

Throughout the '20s and '30s, National Lead linked lead to the most modern and efficient symbols of medicine and public health. It promoted the use of lead-based paints for hospital interiors in *The Modern Hospital*, calling their tinted paint "the doctor's assistant because of its cheerful coloring and its ability to be washed with soap and water." They assured customers that lead paint was "an ideal paint for hospital walls" because it did "not chip, peel or scale."[30] Their Department of Color Research and Decoration had "already served more than 600 hospitals, recommending color treatments, supplying color samples, sketches and formulas."[31,32]

Yet the use of lead paint in hospitals was not without its dissenters. Even some within the paint industry worried about its health effects. George B. Heckel, a former publicist for the New Jersey Zinc Company[33] and the long-time editor of *Drugs, Paints and Oils*, a trade journal of the industry, wrote as early as 1921 that "I stake my life and my reputation in hand by stating at the outset, that I think that lead, in any form, except for plumbing, has no place inside the doors of a hospital. . . . The proper white pigments for interior hospital painting are zinc oxide, lithopone . . . and very probably newly introduced titanox. . . . All of these are white, permanent, and innocuous."[34]

It is no surprise that the sole purpose of advertising is to promote a product and thereby increase revenues for a company. But the marketing of lead paint was particularly insidious in that it sought to turn the truth on its head. Lead was a toxin, but promoted as healthful. Though its reputation was soiled, it was touted for its white purity; though children were being poisoned by lead, Dutch Boy was marketed to suggest that lead paint was benign for children, even fun. The legacy of this corporate behavior in undermining the principle of precaution is that over the course of the past century, tens of thousands of children have been lead poisoned, and as the Centers for Disease Control and Prevention estimated in 1997, one in every 20 children in the United States now suffers from sub-clinical lead poisoning.[35] During the first half of the 20th century, the principle of precaution slowly eroded as industry representatives pressed the public health community to downplay prevention in favor of economic development. The costs of not heeding precaution later turned out to be very great.

REDEFINING DISEASE

While the example of lead shows the ways that industry was able to delay public health regulation and to stifle attempts of reform, the story of silicosis illustrates another manner in which public health principles of precaution were undermined. By the 1930s, it was widely accepted that silicosis—a lung disease that developed slowly in workers exposed to finely ground sand and rock in mining, sandblasting, construction, foundry work, potteries, granite quarries, and other basic American industries—was not only the most important occupational disease, but also a totally preventable one. Yet, powerful economic forces and arguments about the economic feasibility of instituting proper engineering practices into plants, mines, and other facilities undercut the ability of public health officials to reduce or eliminate silicosis as a threat to workers. Even as we enter the new millennium, workers continue to develop silicosis as a result of exposure to silica dust.[36]

During the Depression, the disease had a devastating impact on workers and their families. It was considered the "King of Occupational Disease," one that potentially affected more than half a million workers.[36] Industry, labor, and government alike agreed that the means of preventing silicosis were readily at hand—installation of new ventilation equipment, substitution for dangerous silica-based abrasives, and reorganization of shop floor practices. But industry questioned whether there was, in fact, a crisis at all and sought to redefine the disease in ways that made prevention a less pressing issue. Alfred Hirth, a corporate lawyer working for Owens-Illinois Glass Company, argued that in large measure the entire crisis was overblown. It was "ignorance and sensational journalism" that had produced "the popular belief . . . that to inhale silica is to have Silicosis."[37] Hirth, representing industry, maintained that exposure to small amounts of silica would cause only small amounts of silica dust to be retained in the lungs. This minimal exposure, he argued, was not disabling and would not adversely affect a person during his working life.

Asserting a position that today remains a key argument in many regulatory debates (particularly during the recent debates about the ergonomics standard), Hirth sought to establish a medical definition of silicosis that would protect industry from lawsuits and from governmental pressure to reform. He suggested that silicosis was only a problem when workers were incapable of working, not when they had evidence of silica dust in their lungs. "The question of disability seems to be ignored entirely, whereas it is really the meat of the question. . . ." He held that even if workers had fibrosis, they had to be considered "healthy," so long as their work was not impaired. "If we talk more about disability and less about silicosis, we would be more accurately expressing our ideas." Why, he asked, was

everyone talking about silicosis? It was because of the "shyster lawyer and quack doctor, who have been with the United States always, but whom we hope we may someday exterminate." He maintained that their influence had been so pervasive that "the great majority of cases which have come to my attention have been without merit. . . . The silicotic is rare as compared to the legion of men who have been driven from their jobs by shysters."[38]

A labor representative, John Frey of the American Federation of Labor, however, saw the issue differently. He argued that silicosis was a problem for workers even before they became disabled. Workers should not come into contact with any silica because any silica in the lungs was pathological. In contrast to Hirth's analysis charging that public concern with silicosis had been artificially created by unsavory professionals and the economic conditions of the Depression, Frey saw the "rapidly increasing public interest" as a rational response to "the knowledge that silicosis is frequently fatal." He maintained that Hirth's emphasis on disability and impairment led management to rely on preemployment physicals and periodic screening as a means of denying employment or firing diseased workers (an early precursor to genetic screening of workers). Such workers "have been discharged to learn immediately after that other employers, for that reason were unwilling to place them on the payroll. They have been barred from the opportunity of earning a livelihood." The real issue was not to eliminate diseased workers from the workplace, but to "eliminate the silica from the air, and prevent additional infections."[39]

Unlike industry spokespeople who sought to reduce the problem of silicosis to an engineering and cost-benefit issue that balanced the health of the workforce with the cost to industry, Frey's argument rested upon older public health reformers' analyses that emphasized protecting communities rather than individuals. "Silicosis is an industrial disease which can be eliminated as effectively as typhoid germs can be removed from the city's drinking water." He noted that "when pollution of drinking water leads to typhus and typhoid, the citizens are not removed from their homes by the authorities." The cost of protecting the workforce was a public obligation, not a cost-benefit balancing. But Frey argued that health should not be limited by what industry or public health officials thought was economically feasible. Just as modern city administrations had decided that the very high cost of purifying the water supply was justified by the improvements in health of the population, so too the cost of purifying the work environment was justified by the need to protect all workers from risk of contracting a preventable condition.[40]

The contrasting views of labor and management—reflecting the enormous political and economic stake that these two groups had in the definition of the silicosis hazard—help us understand the historical development of the concept of the Threshold Limit Value (TLV) that began to dominate the field of industrial hygiene in the 1930s and beyond. In the case of silica standard setting, the participants in the debate over TLVs in the 1940s saw the setting of standards for exposure to dangerous materials as a political compromise, which had to balance the interests of employers, employees, and equipment manufacturers, not solely as a public health principle. In 1948, the Chair of the Threshold Limits Committee of the American Conference of Governmental Industrial Hygienists (ACGIH), Lawrence Fairhall, reported that "it has been the purpose of the Conference to seek [threshold limit] values which, on the one hand, protect the individual workman, and on the other hand, impose no impossible burden on the manufacturer."[41]

We now think of standards as being a result of scientific study and analysis. But it is clear this was not the case for silica (or for many other substances). This standard was developed retrospectively and as part of a political compromise that traded on workers' health.[42] Philip Drinker and Theodore Hatch, two of the leading engineers concerned with the problem of silicosis, and both associated with the Air Hygiene Foundation, stated in their 1936 textbook, *Industrial Dust, Hygienic Significance, Measurement and Control*, that the 5 million parts per cubic foot that ultimately emerged as the standard "lacks entirely any published data in its support."[43] Earlier, Drinker traced the origins of the TLV to Donald E. Cummings, a research scientist at Saranac Laboratory in upstate New York, but believed that Cummings "must have arrived at it by a process of 'intuitive correlation'" based on "his own seasoned opinion."[44] In their text, Drinker and Hatch concluded that "adopting standards of permissible dustiness for each harmful dust has a medicolegal appeal that is not at all justified by the data available today."[45] Nearly 20 years later, in their 1954 edition, their statement is even more telling. The standard had been developed because it was "about as low as modern engineering methods can achieve."[46,47] Others who helped to develop standards recognized that they were designed not only to protect the workers and to provide governments with a basis for protective legislation, but also to "protect industrial concerns from racketeering in liability cases."[48]

Despite the early acknowledgement among some professionals that the silica TLV was based upon practical engineering rather than health criteria, its long-term use served to promote a sometimes false sense of safety and security among workers exposed to silica dust. In publications aimed at explaining criteria for the development of respiratory protection devices such as respirators, exhaust hoods, and filters, the distinction between reducing dust levels to what was practical and what was safe was lost.[49]

In 1966, Hervey Elkins, who also served on the ACGIH's Threshold Limits Committee, identified three competing positions in the establishment of the TLVs. First, equipment manufacturers generally pushed for a standard that would not, in Elkins' words, "adversely affect the value of his product in the market place." Hence, this group generally argued for standards that would allow them to build equipment capable of meeting less stringent criteria. Second, the employer "would prefer a limit which will protect most workers, but he would rather not undergo the extra expense for providing for the most susceptible." Finally, workers themselves preferred "to have the limit set at a concentration where no one at all will be affected."[50] In the best of circumstances, scientific evidence would determine the standard. But in reality, the differing relative power of participants in the process was critical.

Standards historically represented the perspectives of the first two participants identified by Elkins. During the New Deal, when the Air Hygiene Foundation (later the Industrial Hygiene Foundation), an industry-sponsored organization founded during the silicosis crisis of the 1930s, and other industry-sponsored groups talked among themselves and among other professionals, this process was sometimes made explicit. H.B. Meller, Managing Director of the Air Hygiene Foundation, (AHF) and F.S. Mallette, also of the AHF, pointed out the tendency among even industrial hygienists to be lulled "into false security by reliance on the protection given by strict adherence to these permissible limits." But, rather than inform workers of the potential dangers they faced, the authors suggested that companies conduct "periodic physical evaluations" as a "biological check" for "concentrations of hazardous substances, which had been sanctioned as being safe." They maintained that the very hazards of the job were effective devices for screening out workers whose physique left them susceptible to illness. Calling this process "industrial selection," they endorsed the idea that standards "are based on experience with workmen who are best fitted to withstand industrial hazards, those who are vulnerable to the exposure being weeded out by natural selection."[51] In the Darwinian world of the factory, standards were set that protected the "average" worker from occupational illnesses. Those who became sick were de facto defined as "unfit." Standard setting often represented a negotiation based upon politics, power, and economics; in this mix, precaution and health were often submerged.[52]

Until the 1970s, there were few opportunities for those trained in industrial hygiene to find employment outside of industries themselves. Even university programs in industrial hygiene, largely without access to federal funding for their studies, generally turned to industry for grants. In silicosis, the impact of this synergy between the industrial hygiene community and the industries themselves led to a general acceptance in the profession that, while giving lip-service to the ideal of prevention, resulted in privileging industry's economic needs over workers' health.

WHAT SHOULD CONSTITUTE PROOF OF DANGER?

The development of the concept of thresholds provided a tool for industry and public health to find common ground. But even this tool was inadequate as new chemicals and compounds, whose sometimes subtle effects would be unseen for decades, began to flood the workplace. Further, the thousands of new chemicals, which were introduced into the broader environment in the post-war era, presented unique and troubling new problems for the society, since only a minority of the new substances were tested for their toxicity and the vast majority were tested by private industry that alone had access to data. The case of vinyl chloride in the early 1970s, which we will briefly trace below, illustrates that industry understood the importance of principles of precaution. But, in the face of data that could prove damaging to the future of the industry, corporations actually sought to deny access to information that public authorities needed to adopt prudent policies.

During the 1950s and 1960s, plastics replaced a host of other building materials and created an enormous increase in the amount of new synthetic materials in the American environment. When vinyl chloride monomer (VCM), the building block of one of the most widely used plastics, polyvinyl chloride, was discovered in 1970 to be a carcinogen in laboratory animals at very high doses, the chemical industry became extremely concerned. European petrochemical companies contracted with Italian researcher Cesare Maltoni to conduct a rigorous program of animal experi-

ments to determine the potential threat to humans. In 1972, Maltoni's experiments revealed that VCM caused angiosarcoma of the liver—a rare liver cancer—in animals at half the exposure levels that workers were told were safe.[53]

In the privacy of the industry's own councils, the vinyl manufacturers clearly understood the potential danger, revealed in Maltoni's animal studies, that vinyl chloride represented to humans. They even quietly removed VCM from aerosols used in hairsprays, spray paints, pesticide spray cans, and other consumer products because of potential liability claims.[53] The industry's acknowledgement that animal studies were a legitimate form of scientific evidence in establishing human danger meant that the industry faced a dilemma: if the industry acted in adherence with traditional public health principles of prevention and precaution, they would reduce exposures until they could be assured that safe work practices were in place and that environmental exposures did not pose a risk to the public. But rather than take this approach, the European and American polyvinyl chloride producers engaged in an elaborate effort that one of their representatives said could be "used as evidence of an illegal conspiracy by industry."[54] They met over the course of several months to plan how to provide partial information (or no information at all) about their secret research to the National Institute of Occupational Safety and Health (NIOSH) officials, who were seeking information about VCM and PVC's possible dangers.[55]

The industry understood that government regulators would have had no choice but to use this information to protect the workforce. The following year, 1974, when workers in a number of plastics plants were found to have died of angiosarcoma of the liver, the very same rare cancer that the rats in Maltoni's studies had died of, the industry finally publicly acknowledged that there was a problem. Even so, the industry fought strict standards for exposure to VCM, and sought to develop a rationale for continuing the use of its valued product and to undermine the growing pressure from environmental, labor, and other groups that urged government agencies to limit the use of potentially dangerous substances. Later, industry would argue that information derived from animal experiments, which had so alarmed them when the information was secret, did not justify regulatory action, i.e., that precaution was not justified until danger to human beings was proven. The industry determined, on its own, that the economic harm to their industry outweighed the potential danger to the society.

The chemical industry came under enormous pressure in the mid-1970s as the public learned of the "plastic coffins" to which workers had been consigned and as information about the widespread exposure to toxic chemicals in the workplace and in the environment was published in the popular press.[56] But ultimately, the industry was able to contain the specific crisis around vinyl. In fact, the crisis represented a launching point for a long-term assault on the public health community's gold standard of using animal studies as indicators of potential impacts in humans and on precaution as a legitimate principle of public health policy and practice under uncertainty. The frontal assault on the public health ideals of prevention accelerated as industry embraced public relations agencies as well as a variety of scientific experts and "independent" third-party organizations who systematically attacked environmentalists and labor activists as luddites determined to stifle our economy.[2]

Industry spokespeople and a number of academics and university researchers pressed for new principles upon which public health should depend, namely that it was the responsibility of environmentalists to have indisputable proof of danger before government should interfere in private industry activities. They challenged environmentalists' assumptions that there was a causal connection between chemical exposures and the rising epidemic of cancers. For example, Edith Efron, whose research was funded by the conservative Olin and Pepsico Foundations, wrote in her 1984 book, *The Apocalyptics: Cancer and the Big Lie,* that elite scientists had perpetuated a tremendous hoax on the American people by claiming that cancer was a product of industrial production.[57] She claimed that science itself had demonstrated exactly the opposite, that there was no scientific proof of a link between cancer and exposure to a variety of chemicals, but that ideologically driven, radical scientists from elite universities had intimidated other scientists and thus kept them from proclaiming this truth. Conservative intellectuals even argued that there was no reason for government to act because technological innovation combined with a resilient earth would easily absorb any man made insult.[57]

Another author, Elizabeth Whelan, the president of the American Council on Science and Health, an organization founded in 1978, published *Toxic Terror* in 1985 (and again in 1993), which made virtually the same argument.[58,59] Whelan found "an astounding gap between the consensus in the scientific and medical community on environmental issues versus what was being presented in popular publications, on television and radio, and in books" for the layman. She argued that far from being long standing public health principles, such arguments represented the views of the "extreme environmentalist movement" and had need-

lessly terrorized the public into believing that chemicals were unduly hazardous. She called for "Americans to recognize the severity of the gap between science and popular public thought, and the dramatically unpleasant side effects that a continued embracing of environmental alarmism will have for our country." Why, she asked, "are the media so gullible when it comes to swallowing whole the utterances of the doomsayers" and "why haven't the vast majority of American scientists and physicians come forth publicly in defense of the truth?"

The American Council on Science and Health (ACSH), distinguishing itself from "so-called consumer-advocacy organizations that misrepresent science and distort health priorities," claims to represent "mainstream science, defending the achievements and benefits of responsible technology within America's free-enterprise system."[60] Many have argued that the organization, which receives financial support from major chemical industries and conservative foundations, is a front for industry.[61] In 1994, *Consumer Reports* published a critique of the ACSH, titled "Forefront of Science, or Just a Front?," noting that the organization received "40 percent of its money from industry, particularly manufacturers in the food processing, beverage, chemical, and pharmaceutical industries, and much of the remainder from industry-sponsored foundations." Major contributors included American Cyanamid, Dow, Exxon, Union Carbide, Monsanto, and Uniroyal Chemical Company, the very companies that had fought against the vinyl chloride standard. *Consumer Reports* argued that "sometimes, the council appears more interested in fighting regulation than in promoting good science or health."[62,63] As Sheldon Rampton and John Stauber noted, the organization has denied the relationship between asbestos, agent orange, DDT, lead, and chemical food additives and environmental disease.[61,64]

Some argue that the government should not concentrate on the elusive, ambiguous relationship between chronic illness and long-term exposures to environmental pollution, but should devote its attention and resources to widely accepted links between disease and tobacco, alcohol, poor diet, and personal behavior, not industrial activities or policies. They, like industry's advocates during the tetraethyl lead crisis in the 1920s, maintain that it is facile to minimize the question of economic development. Christopher Foreman, in his recent book, *The Promise and Peril of Environmental Justice*, faults environmental activists for failing "to confront the inevitable trade-offs between economic opportunity and environmental risks." In Foreman's view, "these risks are, in the grand scheme of things, mostly relatively low and manageable." The most important issue should be economic development, which, if halted by calls for environmental justice, will only "produce its own victimization of minorities."[65]

In recent years the historical debate, which was first articulated in the 1920s lead crisis and developed in the later discussions over silica and vinyl, has been refined in hands of academics sympathetic to industry's point of view. Citing studies that call into question the validity of the fear of cancer due to environmental exposures, Aaron Wildavsky, Julian Morris, and others have argued that there is a danger in being too cautious. While there are certain technologies that have "serious negative effects and few beneficial effects (the plague and nuclear war are examples), imposing a general prohibition on the use of new technologies until solutions have been found to all their potential harmful side-effects is a recipe for stasis."[66] For many of these authors the recent concerns of environmentalists about the potential impact of chemicals and new technologies on health and the environment are exaggerated and have potential for undermining American industry's long standing commitment to innovation and progress.

CONCLUSION

The three cases we outline above illustrate the evolving strategies of corporate leaders whose self interests and corporate needs led to efforts to undermine ideas of prevention and precaution in public health. As the tetraethyl lead controversy illustrates, control over ideas and public opinion were prime battlegrounds. The lead and automobile industries' assertion that definitive proof of danger was essential before private industries were restricted gained a legitimacy that overcame the public health community's call for preventive action. Through the use of public relations firms and advertising, the lead pigment manufacturers were able to redirect Americans' attention away from the dangers of lead paint to children. The silica-using industries developed another strategy to reassure the workforce about industrial dangers through the control of standard setting and the establishment of technical measures that gave the patina of safety to sandblasters, miners, construction workers, foundry workers, and others who came in contact with silica dust. Beginning with the tetraethyl lead controversy in the late 1920s and continuing through the 1960s, government became more of a presence in discussions of environmental and occupational dangers, but often at the behest of industry and without the resources or power to do independent investigations or arrive at indepen-

dent judgment. Until the 1970s, government was still largely dependent on industry and its scientists for information upon which to base standards and decisions about risk. It was not until the last third of the 20th century that independent government agencies, often supported by environmental activists and organized labor, were capable and legally empowered to enforce occupational and environmental health standards. Faced with real government authority that answered to others besides the business community, the chemical industry, in general, and the plastics industry, in particular, engaged in outright deception, hiding information that they understood would lead to greater government regulation. It became more important to industry to assert its control over both the regulatory and the public relations arenas. It is in this context that we see social scientists become instrumental in attempts to forestall a growing environmental movement's pressures for precaution.

Historically, public health has defined its mission as precaution and prevention. At its base, these ideas depend upon an openness rooted in public participation and involvement in decision-making. Without open information and without a public scrutiny of industry activities, there is little way to scrutinize the introduction of the thousands of synthetic substances and products into the environment. Ultimately, the principles of precaution conflict with the rapacity of competition in the stark economic world we live in and, under the rhetoric of progress being our most important product, numerous assaults on the principles of precaution ensued.

Throughout its history, the public health community has sought to find ways of preventing diseases before they take a substantial toll. As we face increasing uncertainty about the health hazards of the thousands of new and old toxins being introduced into the environment, it is especially important to reassert the principles that have been at the profession's core. The precautionary principle is a new iteration of this age-old value in the profession and arises in the face of growing industry-led efforts to undermine the profession's values. While many environmentalists and public health professionals have called for a concerted effort to develop better data on the relationship between industrial pollution and disease, some also argue that, in the absence of final proof, the government must step in to protect people and a fragile environment from a host of man-made insults. As the signers of the Wingspread Statement on the Precautionary Principle stated in January 1998, the principle of precaution should be the overriding policy in environmental and health matters.[67] Rather than await definitive proof that may never come, society must require a certain degree of confidence in a material's safety before allowing it into the human environment and must continuously seek the safest means to achieve particular goals. We argue that perhaps we should consider the admonition of the National Research Council in 1991: "Until better evidence is developed prudent public policy demands that a margin of safety be provided regarding potential health risks. . . . We do no less in designing bridges and buildings. We do no less in establishing criteria for scientific credibility. We must surely do no less when the health and quality of life of Americans are at stake."[68]

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