The Work Environment Impact Assessment:
A Methodologic Framework for Evaluating Health-based Interventions

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Abstract

Backgound A new conceptual framework is needed to evaluate health-based interventions based on the premise that like the environment, workplaces are complex ecologies. The proposed Work Environment Impact Assessment (WEIA) is analogous to Environmental Impact Assessment (EIA), a concept and method developed 30 years ago in the environmental policy arena to evaluate potential consequences of human activity for the natural environment. WEIA entails identifying and evaluating both intended and unintended consequences, or outcomes, associated with a particular intervention. Because the workplace is an ecology, changes in one aspect may lead to changes in other aspects. WEIA calls for a systematic and comprehensive approach to the total work environment.

Methods To illustrate its utility, we use WEIA to evaluate an intervention to reduce the public's exposure to the pesticide Alar, which had been used on apples until it was withdrawn from the market in 1989.

Results While this intervention did indeed reduce the public's exposure to Alar, it also led to other unintended consequences, namely new ergonomic hazards for apple pickers, increased stress levels in the orchards for both pickers and growers, as well as new worker, and perhaps public, exposure to potent neurotoxins.

Conclusions The goal of using WEIA is not to engage in a risk-risk debate that stalls worthwhile interventions. Rather, we propose that by conducting a Work Environment Impact Assessment, all possible positive and negative "ripple" effects stemming from an intervention can be considered, so that the intervention can be designed to achieve maximum benefit.

Key words: work environment, impact assessment, intervention, intervention research

Introduction: The Need for a Work Environment Impact Assessment

Thirty years ago, the growing environmental movement demanded that the impact of humans on the natural environment be taken into account in planning decisions. This concern yielded a method, called Environmental Impact Assessment, which was mandated in 1970 under the National Environmental Protection Act. When, for instance, construction projects are proposed, an Environmental Impact Assessment is conducted to determine the impact of the project on water, soil, and air. Yet, the analog for the Work Environment is lacking. The proposed Work Environment Impact Assessment can raise the work environment to the status of the natural environment. Recently, the National Institute for Occupational Safety and Health (NIOSH) dedicated funds to research aimed at evaluating the effectiveness of workplace interventions. We propose in this paper a conceptual framework for evaluating such interventions, based on the premise that, like the environment, workplaces are complex ecologies. Methods to evaluate interventions must, therefore, be both systematic and comprehensive, capable of capturing both intended and unintended outcomes of interventions.

Several existing methods can be used to evaluate interventions, including cost-benefit and cost-effectiveness analyses and risk assessment. The first two methods are motivated by concern for financial implications of interventions, rather than health effects *per se*. Health is measured in these models, but only to the extent that health effects can be monetized. Risk assessment and other epidemiologic methods aim to assess health risks or events associated with exposures to hazards. They can assess risk before and after interventions, but they do not generally examine unintended ("ripple") effects, or effects other than the outcome under study.

Evaluating intervention effectiveness in a narrow context without considering any "ripple" effects can lead to erroneous conclusions. There have been numerous examples of negative consequences of well-intended interventions, particularly for workers, because the ecology of the workplace has been ignored. For example, worthwhile efforts by OSHA and other agencies to regulate asbestos helped to reduce worker exposure, but it also resulted in the introduction of other hazardous fibrous materials that subsequently raised new, albeit less serious, concerns for worker health (IARC, 1997). Regulating asbestos was appropriate, but it produced the negative and unintended consequence of a new and different hazardous exposure. An epidemiologic study of this intervention's effectiveness would likely be limited to assessing how workers' reduced exposure to asbestos affected their risk or actual experience of asbestos-related disease. The evaluation would have been too narrowly framed to have captured the important consequence of a substitute hazard. Of course, interventions can also lead to positive unintended consequences. The banning of the pesticide DBCP, for example, spurred the Agricultural Extension Service to find non-chemical and less costly ways to control nematodes that attack crops (Rosenberg, 1995).

The Work Environment Impact Assessment (WEIA) tracks the implications of substitutes, bans or other process changes. As part of formal rule-making, EPA and OSHA consider the economic effects of regulation on industry, but do not consider unemployment or displacement of workers and other potential consequences. WEIA goes further by examining whether interventions achieve not only their intended aim, but also whether they lead to introduction of more hazardous substitutes, changes in work organization, introduction of ergonomic hazards, changes in job skill requirements, reductions or gains in number of jobs, financial gains or losses for all affected parties, and environmental and public health effects for communities.

The purpose of this paper is to demonstrate the need for and to introduce WEIA, not to discuss the methodology in detail or to present a "how to" guide. In fact, we acknowledge that WEIA is a rudimentary method at this point, much as its predecessor EIA was thirty years ago. We urge others concerned with worker health and safety to further develop WEIA. It is important to mention, however, that WEIA has some distinctive features that allow for rich and in-depth examination of interventions. First, WEIA combines qualitative and quantitative research methods. Whereas quantitative approaches are able to show patterns of distribution and association, qualitative data are useful for elucidating process and meaning behind distributions (Goldenhar and Schulte, 1996). For example, suppose one is evaluating an intervention to reduce injuries. Quantitative data reveal that injury rates have decreased. This observation could reflect fewer accidents or decreased reporting. Injury data alone cannot reveal the reason for reduced injury rates, while qualitative approaches, such as in-depth interviews, can. A second important feature, in keeping with the aim of a broad view of interventions, is, in policy parlance, stakeholder involvement. Inadequate involvement of stakeholders, particularly labor, can lead to interventions that neglect workers' concerns, perceptions and valuable knowledge, and in some cases may inadvertently create new hazards for them (Rosenberg, 1996; Barbeau, 1998). There is a need to include labor, management (Goldenhar and Schulte, 1996), environmental health and safety professionals, government regulators, insurers, academicians, and policymakers in research and evaluation efforts to avoid the tunnel vision that has characterized some past interventions and policies. Third, WEIA does not entail complicated quantitative formulae for weighing various risks, as do other models that deal with unintended consequences. Rather, WEIA is designed to be a transparent, open, and user-friendly method that can be readily interpreted by all concerned with the work environment. The goal of WEIA is to promote sound decision-making based on as much information as possible. It identifies unintended consequences not so that they may be excuses for inaction, but rather so that interventions can be crafted to achieve maximum benefit.

To illustrate its utility, WEIA will be used to evaluate the effectiveness of the withdrawal of the agrochemical Alar. This particular intervention was designed to protect consumer rather than worker health, but it had consequences for workers and so lends itself to an evaluation using WEIA.

Using the Work Environment Impact Assessment to Evaluate the Withdrawal of Alar

Background

Alar® (daminozide) is a plant growth regulator. The common proportion of Alar used in the United States was 85% daminozide and 15% inert ingredients. Uniroyal Chemical Company registered Alar for use as a pesticide under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) in 1963 and then in 1968 as a plant growth regulator on apples and later on other crops (Federal Register, 1989). It was used on orchard crops such as apples, cherries, nectarines, peaches and pears, as well as on tomatoes, grapes and peanuts. Under a different trade name, B-Nine, the same chemical formulation is registered for use on non-food items such cut flowers and a variety of bedding plants (Federal Register, 1989). This WEIA case study focuses on the effect of the withdrawal of Alar's use on apples.

Alar was used by apple growers for many reasons. It decreased fruit cracking and splitting, delayed watercore development (an internal core rot), enhanced color, increased fruit firmness and, most importantly, prevented pre-harvest fruit drop and extended harvest time (Lord, 1969). The harvest is a vulnerable time for growers, because during these rushed few weeks, growers must depend on workers to pick apples quickly and carefully before the apples are lost to "drop." (Dropped apples bruise and are used for cider, which commands a much lower price than whole fruit). Labor problems or shortages can be disastrous at this time. With Alar, growers' vulnerability was somewhat mitigated, because Alar kept the apples "glued" to the trees (Lord, 1969). Growers no longer feared losing their crop to drop, so the harvest time could be extended from the usual three weeks, in the case of McIntosh apples, to five. Longer time on the tree also allowed apples to get bigger and redder, attributes necessary to fetch premium prices at market.

Beginning in 1973 and throughout the 1970s, scientific studies demonstrated the carcinogenicity of unsymmetrical dimethyl-hydrazine (UDMH), which Alar contains both as a contaminant and as a breakdown product. (Toth, 1973; Toth, 1977a; Toth, 1977b, NCI, 1978; Haun, 1984). Some UDMH was present in daminozide products, and additional UDMH formed through hydrolysis, i.e. when water was added to the Alar crystals for mixing during crop application or during cooking of the treated fruit. While daminozide was shown to be oncogenic, UDMH is both oncogenic and mutagenic. (Toth, 1973; Toth, 1977a; Toth, 1977b, NCI, 1978; Haun, 1984; Brusick and Matheson, 1976; Rogers and Back, 1981, U.S. EPA, 1986) Increased incidence of blood vessel, kidney, uterus and lung tumors were reported in rodents. These studies prompted the Environmental Protection Agency to meet with Uniroyal and begin a Special Review process, but no regulatory action was taken.

On February 26, 1989, the Natural Resources Defense Council (NRDC) released a report, the findings of which were aired the previous night on the television news magazine, 60 Minutes. The report justly criticized the U.S. Environmental Protection Agency for gearing standards for pesticide residues on food to adult biology and eating patterns, rather than to the more vulnerable population of young children. Because Alar, which had been shown to be a carcinogen, was used on apples, and because children drink more apple juice and eat more apple sauce than other consumer groups, Alar became a target for the NRDC and later the public. In response to mounting public pressure, led by movie star and mother Meryl Streep, Uniroyal voluntarily withdrew its registration for Alar in November 1989. The remaining stocks of Alar were recalled and relabelled B-Nine and B-Nine SP for non-food uses.

Analysis of Alar's withdrawal by WEIA. Analysis of the removal of Alar by WEIA requires identification and evaluation of a specific set of parameters (Figure I).

Insert Figure 1

Function and purpose of the toxic substance in a specific process What were Alar's purpose and function? Anthropologists make a useful distinction between *purpose* and *function* that is often blurred in the normal course of life. For example, the purpose of a rain dance is to make rain, while the function is to gather the community, to affirm common goals, to have fun, and so on. When removing or changing a toxic substance in a specific process, it is important to be cognizant of its purpose and function.

Alar's *purpose*, as stated previously, was to decrease fruit cracking and splitting, delay watercore development, enhance color, increase fruit firmness and, most importantly, prevent pre-harvest fruit drop and extend harvest time (Farm Chemicals Handbook, 1985; US EPA, 1989). One of Alar's key *functions* was to make apple trees more tolerant of mite infestations. Mites cause "early drop," which, in turn, leads to bruised apples that can only be sold for cider. When Alar is used, mites can still infest apple trees, but Alar keeps the apples glued to the tree. As one grower explains, "Spider mites suck nutrients from the leaves, and if you don't control them, they cause early drop. With Alar, even with a heavy mite infestation, you could get by" (Chick, unpublished communication, 1993).[1] Alar was not developed or marketed to allow trees to be more tolerant of mite infestations, although the loss of this function subsequent to the withdrawal turns out to be consequential.

<u>Availability of substitutes and alternatives</u> This item calls for enumeration of all available substitutes and alternatives to using Alar. Environmental scientist James Goldstein points out that in Environmental Impact Assessments of proposed highway or incinerator projects, alternatives are usually given short shrift, because the writers of the proposal are proponents of the project (Goldstein, unpublished communication,1995).[2] Similarly, when the U.S. Environmental Protection Agency and the U.S. Department of Agriculture consider the impact of a ban of an agrochemical, the claim that there are no chemical alternatives is often used to justify the continued use or some other form of inaction (Rosenberg, 1995). To seek only "drop-in" substitutes is myopic. Alternative technologies need to be considered, as they

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1 In-depth interview with grower Joe Chick took place at his orchard in Worthington, Massachusetts in October, 1993. The interview was an open-ended survey and lasted about 2 hours.
2 Goldstein J. Environmental Scientist, Tellus Institute, Boston, Massachusetts. telephone interview, March 1, 1995.

were when the pesticide DBCP was banned. Rather than using a chemical "drop-in" substitute, a new strategy was developed to serve the same function and purpose of the pesticide. DBCP protected crops by killing nematodes that attack roots. In the case of peach trees, planting coastal Bermuda grass, which nematodes find aversive, between trees is a safer alternative to the very toxic DBCP. One doesn't need to kill nematodes to protect peach trees; one simply needs to keep nematodes away from the trees (Rosenberg et al, 1998).

There was no chemical substitute for Alar. That is, there was no other agrochemical that served Alar's purpose and function. Rather, growers searched for other ways to accomplish these aims. First, they had to protect against mite infestations that, in the absence of Alar, now posed a serious threat. They began using agrochemicals to kill mites (miticides), which present health risks of their own. Second, they diversified the crop to include different varieties of apples so that harvest times were staggered. Growers added more dwarf and semi-dwarf tree varieties which make apple picking easier and allowed for staggered harvests (Rosenberg, 1996).

<u>Health Effects of Substitutes and Alternatives</u> Knowledge of health and environmental effects of hazardous substances or processes is necessary in order to avoid trading one bad risk for an even worse one.

Hazardous properties. Do the substitutes or alternatives to Alar pose carcinogenic, mutagenic, teratogenic, or reproductive threats? Are they harmful to respiratory, renal, cardiac, hepatic, dermal systems, etc.?

Physical hazards. Do the substitutes and alternatives to Alar introduce new physical hazards to the work environment, including excessive heat, cold, noise, vibration, or radiation?

Ergonomic and psychosocial hazards. Do the substitutes and alternatives to Alar introduce ergonomic hazards, including heavy lifting, repetitive motions, awkward posture, stress, limits on social interaction?

Before discussing the health effects of miticide use, it is important to acknowledge there was some disagreement among apple growers interviewed for this case study about whether growers use more miticides since Alar's withdrawal (Smith, 1993; Wood, 1993; Chick, 1993; Clark, 1993; Syncook, 1993, unpublished communications)[3] According to USDA entomologist Ron Prokopy, the overwhelming majority of growers are using more insecticides due to Alar's withdrawal (Prokopy, unpublished communication,1995)[4]. He explains that growers are "definitely using more Vydate for leaf miners" and Omite for mites. While it is uncertain whether mites induce fruit drop, it is what growers believe, Prokopy said, and the belief prompts them to spray more.

At least one grower takes exception, however. Stephen Wood, apple grower and President of the New England Fruit Growers' Council on the Environment, claims that other growers are still angry about Alar's withdrawal and being labeled "baby killers" for having used it. Growers may say out of spite that they are using more miticides when, in fact, they are not (Wood, unpublished communication, 1995). He attributed any increase in miticide use to the loss of another miticide whose registration was withdrawn two years before Alar's. Indeed, a

3 In-depth interviews with growers Smith, Chick and Clark took place at their orchards in Massachusetts in October, 1993. The interviews were open-ended surveys and lasted about 2 hours. Communication with USDA personnel, Syncook and Prokopy, and New Hampshire grower Wood, were lengthy, numerous telephone interviews.

4 Prokopy R. 1995. Entomologist, U.S. Department of Agriculture, Belchertown Extension Service. Personal communication, March 31

Uniroyal official revealed that miticide sales started increasing when Cyhextin was banned in 1987 and were not influenced by Alar's withdrawal two years later (Moore, unpublished communication, 1995)[5].

It is reasonable to assume based on interviews with growers and entomologists that some portion of growers are using more miticides on apples trees since Alar's withdrawal. Therefore, we turn to evaluating the health effects associated with exposure to two commonly used miticides listed under the trade names Vydate and Omite. Data from a range of sources points to the health hazards posed by miticides. It is important to note in evaluating the health effects of these and other substances that absence of data should not be interpreted to mean that these substances are not harmful. Rather, it most likely indicates that the substances have not been carefully studied.Miticides are neurotoxic to mites and humans. Systemic poisonings, characterized by headaches, weakness, and nausea, among field workers and pesticide applicators exposed to Vydate, in California have been reported in the medical literature (Berberian, 1987). Anecdotal evidence provided by an official with the USDA Agricultural Extension Service indicates that Vydate, is "a particularly hot material" that causes "numb lips" but he admitted that if there had been poisonings, he would not hear about them. (Syncook, unpublished communication,1993)6. Illnesses and injuries on farms are well-known to be significantly underreported (Fenske and Simcox, 2000) so the absence of reported poisonings amongst farmworkers, who, in this case, are generally off-shore, Jamaican labor who are unlikely to complain, cannot be interpreted as an absence of poisonings. Vydate, a carbamate, is

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5 Moore R., Uniroyal Agrochemical Division. Telephone interview, March 30, 1995

6 Syncook J. Apple grower and Farm Superintendent, Horticultural Research Center, Belchertown, Massachusetts. telephone interview, November 16, 1993

a cholinesterase inhibitor. The Material Safety Data Sheet, from chemical manufacturer Du Pont, states that "oxamyl [main ingredient of Vydate] poisoning produces effects associated with anticholinesterase activity which may include weakness, blurred vision, headache, nausea, abdominal cramps, discomfort in the chest, constriction of pupils, sweating, slow pulse, muscle tremors" and that it contains over 2% methylene chloride, a known carcinogen (Du Pont, 1990). Omite, whose active ingredient is propargite, is less hazardous systemically, but can cause severe dermatitis and eye irritation (Saunders et al., 1987).

Toxicologic data for these miticides and for Alar are listed in Table I (Farm Chemicals Handbook, 1985; DuPont, 1990). The Environmental Protection Agency rates the acute toxicity of chemicals on a scale from I to IV, with decreasing severity. Vydate and Omite are class I: Alar is classified as class III and IV, depending on the source. As indicated by lethal oral and acute inhalation doses and toxicity classifications, Vydate and Omite are more acutely toxic than Alar. Rats can ingest and breathe more of Alar than either Vydate or Omite and still survive. Acute toxicologic data, however, are of limited value in that they reveal nothing about chronic health effects, or any effects that may harm the test animals but do not kill them, such as arthritis, cognitive disorders, etc.

Alar's main ingredient, daminozide, is currently classified by the U.S. Environmental Protection Agency as a Class B2 carcinogen, which means it is a proven animal carcinogen and a probable human carcinogen (US EPA, 1993). Vydate and Omite have not undergone complete evaluation and determination of human carcinogenicity (US EPA, 1990; US EPA, 1986).

Insert table I (p.24)

According to the manager of the agrochemical division at Uniroyal, Omite is so severely irritating that manufacturing workers sometimes have to leave the plant. (Ames, unpublished communication, 1994)[7]. Workers who apply miticides to apple trees are also at risk. Alar was applied twice per season, in early spring and then two weeks before harvest. By comparison, miticides can be applied to crops four to six times per year, depending on the severity of infestation, so workers are now being exposed to miticides more often and consumers are exposed to more neurotoxic residue.

The bottom line is that using miticides to replace one of Alar's functions introduced new chemical health risks. That is not to say that Alar's withdrawal was unwarranted. Rather, these data on the hazards of the additional chemicals point to the need to be cognizant of the ecology of the workplace, and that removing a chemical or changing a process may introduce new hazards to workers, consumers and the environment.

While there appear to be no new noise, heat, vibration hazards or other presented by Alar's withdrawal, harvesting apples in the absence of Alar created some new ergonomic hazards, both physical and psycho-social, for workers. Apple picking must be done more gingerly without Alar because apples could be knocked off trees and bruise more easily, substantially reducing their market value. According to one picker, "You set your ladder up more times and go up without hardly breathing" (Anonymous picker, unpublished communication, 1993). More ladder moving is required because when Alar was used, a picker

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7 Ames R. Manager of plant growth regulators, Uniroyal Chemical Company. Telephone interview, January 12, 1994.

could pull a branch close to himself, pick the apples and then release the branch. Now, since apples fall off easily, grabbing branches this way causes "drops." The heavy wooden ladders, with stakes to prevent slippage, must be uprooted and replanted three to four times more frequently now that Alar is not used. Pickers also must go up and down the ladders, three to four times more often, with their bushel bags swung over their shoulders. Grower and picker Rick Smith says, "The rungs hurt your arches, you get a stiff neck from the bag and your hands freeze because the apples are cold" (Smith, unpublished communication, 1993).

Because pickers are paid by the bushel, rather than by the hour, there is incentive to move quickly to pick as much as possible. In this case, haste really makes waste because haste causes bruising. One grower, whose pickers are Jamaican, complained of the difficulties of trying to get them to slow down, and sometimes resorts to putting them on an hourly rate for a day or two (Clark, unpublished communication, 1993). A day's work on the hourly wage yields about half that of a day's work on piece-rate.

The increased pace of the harvest is felt by everyone in the orchard. Through numerous interviews with Massachusetts apple growers, ergonomist Nicholas Warren found that "the time pressure often results in pickers working much longer hours at a frantic pace, in an attempt to harvest the crop before too much is lost to drop..." (Warren, 1992). The hectic pace is carried over into storage facilities, where the increased load of apples needs to be packed quickly for cooling (Warren, 1992). The pickers and the packers must be more careful with Alar-free fruit that readily bruises. The shorter picking window requires a 40 percent increase in the equipment needed to move apples into storage (Warren, 1992). Since smaller orchards can ill afford to buy new equipment, overused and possibly dangerous equipment stay in use much longer (Warren, 1992). Although there are no data available to measure changes in injury rates under conditions of increased pace of work, longer work hours, and increased use of older and overused equipment, it is reasonable to assume that these hazardous conditions would increase risk if not actual rates of injury.

The loss of Alar also influenced the work organization. Level of supervision, flexibility, control, and pace all affect stress levels. Ultimately it is the growers who care most about the condition of the harvest, so they must keep anxious vigil on their employees. "I have to watch them closer," according to one grower (Clark, unpublished communication, 1993). Closer supervision is also a stressor for workers. The level of anxiety caused by the loss of control over the harvest is expressed by a Massachusetts apple broker, "There were times you would be lying in bed, miles away from an orchard, and you'd think you could hear them dropping" (Manning, 1989).

Employment effects. Changing substances or processes may produce changed staffing or job skill requirements. Did particular jobs expand, contract, or become more or less mentally challenging as a result of Alar's withdrawal? Did the number of jobs change? The answers have implications for all employees.

Employment effects were evaluated at the manufacturing level and in the apple orchard. There were no employment effects of the Alar withdrawal for chemical manufacturing workers, neither plant closings, nor lay-offs (Ames, unpublished communication, 1994). This is not surprising given that daminozide (Alar's active ingredient) is manufactured, part-time, in just one plant in the United States; it is still used on ornamentals in the form of B-Nine and is exported (Chemical Marketing Reporter, 1989).

At the orchard level, the distribution of labor over the harvest period changed. The farm superintendent at the University of Massachusetts Horticultural Research Center in Belchertown, Massachusetts, described the changes in harvesting which were echoed by all growers interviewed. He said, "With Alar, you picked 2000 bushels the first week, 2000 bushels the second week and 2000 bushels the third week" (Syncook, unpublished communication, 1993). Without Alar, he (and all the other growers) concentrate labor in the first week, hiring more pickers to pick more bushels early on, but retaining them over a shortened harvest period.

Community and public health effects**.** As a result of changing substances or processes, new hazards to the community and the public health may be introduced. Did Alar's withdrawal result in new pesticide residue concerns for the public?

Because public scrutiny and pressure to protect consumers, particularly children, from this pesticide's residue on apples is what brought about Alar's withdrawal, a central question is whether removing this pesticide was beneficial to the public's health. As stated previously, daminozide is a probable human carcinogen, and so its removal protected consumers from this exposure (US EPA 1989, US EPA 1992). When it was withdrawn, however, some growers began to use neurotoxic miticides. In essence, consumers traded a low-level carcinogen for a potent neurotoxin. The stability of substances over time affects their hazardousness. Vydate is acutely toxic, but it disintegrates quickly (Prokopy, unpublished communication, 1995). Therefore, consumers are unlikely to be affected by it, although workers are obviously at increased risk. The miticide, Omite, leaves residue on apples (Prokopy, unpublished communication, 1995). The public health effects of these residues remain unstudied.

International effects. The WEIA examines international effects associated with bans on manufacturing and use. Alar is no longer manufactured or used in the United States, although its active ingredient, daminozide, is. This chemical is still exported to 71 other countries (Chemical Marketing Reporter, 1989).

Economic effects. Economic effects at the manufacturing level and in the orchard were evaluated. Uniroyal suffered no adverse economic consequences. Alar accounted for less than 1% of the company's total sales, or $2.04 billion in 1983; the company continues to manufacture daminozide for non-food uses and for export (Chemical Marketing Reporter, 1984).

The economic effect of Alar's withdrawal on the Massachusetts apple industry is unclear. USDA data for the state reveal a 19% decline in average crop size, and a 7.5% reduction in average crop value for the four years before Alar's withdrawal in 1989 compared to the four years after 1989 (USDA, 1993). The average masks a wide range of effects for individual growers. One grower estimated that he lost fully a third of his crop because Alar was unavailable (Clark, unpublished communication, 1993.) The deficits in crop size and value, however, were offset by increases in the price per bushel over the same time period. Grower Clark laments that "losing Alar had a big impact on the bottom line. It's one more nail in the coffin of the family farm" (Clark, unpublished communication,1993).

Some growers reported that Alar allowed orchards to get bigger (Wood, 1993; Clark, 1993; Smith, 1993, unpublished communications). With longer harvest times, growers could manage more trees without fearing early drop. Now, large orchards are more difficult to manage in a shortened harvest period, so some growers are not harvesting part of their orchards or are selling off part of their land. (Britton, 1989)

Other effects. McIntosh apples were the most Alar-dependent crop. The ban induced growers to plant more varieties of apples in order to stagger the harvest. The practice of diversifying the crop has the added benefit of reducing the crop's vulnerability to pests. In addition to the increased use of miticides, there is another important change in the way growers think about chemicals since the Alar ban. It made them more wary of their dependency on chemicals for fear that the government will take one away or consumers would suddenly decide not to buy fruit treated with one. So, there is renewed interest in reducing the use of chemicals through Integrated Pest Management (IPM).

Discussion and Conclusions

Given the way that the Alar problem was framed, that is, as a problem of carcinogenic residue on apples consumed by American children, the withdrawal was a success. However, Alar's removal engendered a series of unintended outcomes, most importantly it resulted in new and unanticipated chemical and ergonomic health threats for growers and workers, and possibly for the public. Although Alar is no longer used on food crops in the United States, there is no evidence that daminozide production has decreased since 1989, and it is still exported. In the United States, consumers are no longer ingesting daminozide on domestically grown fruit; farmers and pesticide applicators in orchards no longer use it, but manufacturers and greenhouse workers continue to be exposed from use on non-food plants. Consumers and all orchard workers are potentially being exposed to more miticides.

Using the Work Environment Impact Assessment to retrospectively evaluate Alar's withdrawal, we observe that there were unintended negative consequences for workers, and perhaps the public. What might have been different had a WEIA been conducted at the outset of this controversy? Would the decisionmaking *process* and the actual *outcome* be changed? This case study revealed that not all voices were heard in the decisionmaking process. The occupational hazards introduced by Alar's withdrawal for farm workers were ignored. Not only was their input into the process not solicited, it is safe to assume that had they even been asked to voice their concerns, these workers, who traditionally lack political clout, would have been ignored. The opinions of farmers arguing for Alar's role in reducing the overall use of pesticides (as part of an Integrated Pest Management program) were also never factored into policymaking. According to the President of the New England Fruit Growers' Council on the Environment, apple growers were well aware of Alar's role in "preventing late season applications of environmentally harsh insecticides and miticides" and ensuring "that a larger proportion of the fruit would be harvested and removed from the orchard, thus removing hosts (apples) for the following season's pests. These benefits of Alar were well known to us, but we never heard about them in the regulatory benefits . . . we had information that we thought was critical to the regulatory decision, but we couldn't find the door in." (Wood, 1990) All too often, the information known by workers remains untapped, leading to inadequate and ill-informed policy. WEIA seeks to redress this.

Would a more open and inclusive process have led to a different outcome? Had farmers and growers "found the door in," might not the public have become informed that

Alar's withdrawal would likely lead to increased use of other toxic chemicals and, further, raised questions in the public's mind about an agricultural system dependent on toxics? Had consumers led by movie star Meryl Streep known that the tradeoff for Alar-free apples involved substituting a potent neurotoxin for a low level carcinogen, would they have pressed only for Alar's removal, or would they have insisted on safer ways to produce apples?

The debate around its removal was offpoint. The problem, as it was framed, was that there was a toxic chemical in the food supply, and the debate completely ignored the web of agricultural chemical use. The ban falsely reassured the public because the issue of an agricultural system based on the use of toxics was never raised. Ideally, a WEIA on Alar's proposed withdrawal would have raised the issue of substituting neurotoxins for a weak carcinogen. As a tool to assess policy interventions, WEIA could help to create a more ecologically informed citizenry. Whether or not the outcome would have been different, the use of a WEIA would have forced a broader, more democratic, debate.

Currently in the US, under the regulations of the Administrative Procedures Act, stakeholders provide formal input into regulations after the regulation has been written and published in the Federal Register. Prior to publication, special interests, such as industry groups, labor unions and environmental groups, conduct intense informal campaigns to influence the regulations as they are being developed. (see for example, Gibson, 1994) This informal process gives an edge to those with more resources and power. Although many stakeholders are presently included, workers usually are not. We envision a process whereby broad stakeholder involvement happens early in the process, to counteract the power imbalance in influence.

Not only could this result in better policy, that is, policy that benefits the most people and does the least harm, but it might result in a further internationalization of democratic values into planning and decisionmaking processes. A wider range of voices at the table may strike some as complicating or bogging down the planning process. Democracy moves slowly already; it took over ten years to lower the benzene standard. In this mired system, a broader involvement of stakeholders during the writing of a standard may decrease resistance at the later stages and even streamline the process. Our priority is a fair and democratic decision making process that would yield the best available alternatives. We recognize that this approach is not a panacea, but it does provide a checklist for critical analysis of interventions in which all voices, including those of workers, are heard.

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Figure I Work Environment Impact Assessment (WEIA) of a ban, phase-out or process change

I. Function and purpose of the chemical or process

II. Identification of available substitutes or alternatives
   - A. Chemical ("Drop-in" or other)
   - B. Process Changes
   - C. Other

III. Health effects for workers of substitutes and alternatives
   - A. Hazardous properties: carcinogenic, mutagenic, teratogenic, reproductive, neurotoxic, respiratory, cardiac, hepatic, dermal, etc.
   - B. Physical hazards: heat, noise, vibration, etc.
   - C. Ergonomic and psychosocial hazards: lifting, repetitive motion, awkward posture, stress, limits on interaction
   - D. Other

IV. Other ripple effects
   - A. Employment
     1. Staffing requirements
     2. Skill requirements (stimulating or "stupidifying")
   - B. Community effects/public health effects
   - C. International effects/export of hazards
   - D. Economic effects

Table I. Toxicity data for Alar, Vydate, and Omite

	Toxicologic Measure			
Trade name (Main ingredient)	**Oral LD50 mg/kg (rat)[a]**	**Acute dermal LD50 mg/kg (rabbit)[a]**	**Acute inhalation LC50 mg/l (rat)[a]**	**Toxicity Class**
Alar (Daminozide)	8450[b]	>1600[b]	>147[b]	III[b], IV[c]
Vydate (Oxamyl)	5.4 (pure)[d,e] 37 (24%)[e]	2960 (pure)[e]	0.14 (24%)[f]	I[e]
Omite (Propargite)	4029[e]	2940 "severely irritating"[e]	0.05[e]	I[e]

a LD50 and LC50 are lethal dose and lethal concentration, respectively. They represent the dose at which 50% of test animals die.
b Farm Chemicals Handbook, 1985.
c US EPA, 1993.
d Vydate is formulated in a 24% liquid solution, so some toxicological information is for the pure compound, and other information is for the 24% solution.
e Farm Chemicals Handbook, 1993.
f MSDS #M0000057 DuPont Chemical Co.