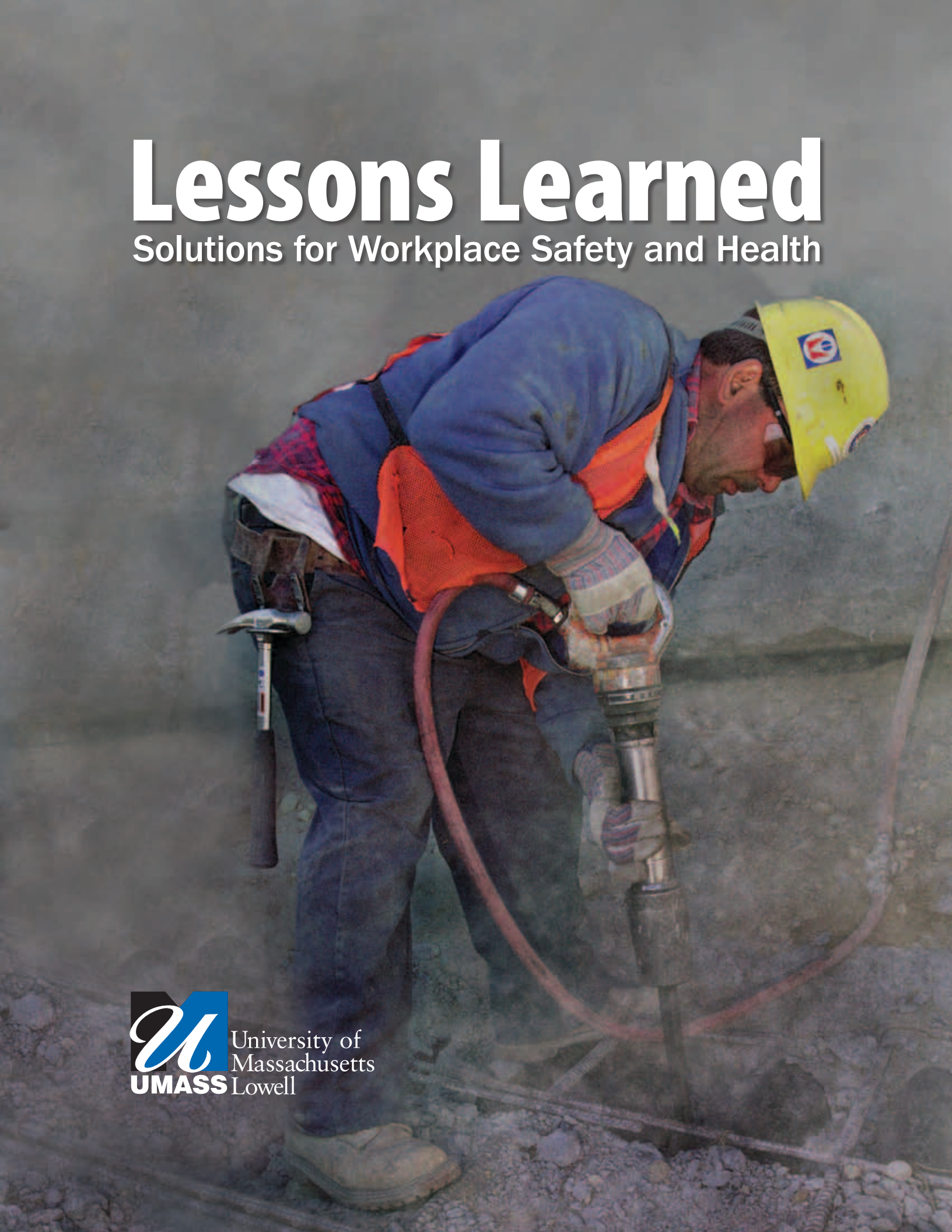
Lessons Learned

Solutions for Workplace Safety and Health



UMASS University of Massachusetts Lowell

Lessons Learned

Solutions for Workplace Safety and Health

David Kriebel, Molly M. Jacobs, Pia Markkanen, Joel Tickner

with editorial assistance by Nancy Irwin Maxwell

Lowell Center for Sustainable Production
University of Massachusetts Lowell

JANUARY 2011

About the Lowell Center

The Lowell Center for Sustainable Production is a research center of the University of Massachusetts Lowell working to build healthy work environments, thriving communities, and viable businesses that support a more sustainable world. We do this by working collaboratively with citizens' groups, workers, businesses, and government agencies.

Acknowledgments

We are deeply grateful to Earl Dotter (shown here at Ground Zero) for permitting us to use his breathtaking photographs of workers. Earl "seeks out those who are taking steps to improve their lives at work, and uses the camera to engage them—giving visual testimony to their achievements. The images that result tell of the satisfactions of their work as well as its many challenges to their safety and health." Please visit Earl's website to view additional images and to learn how to purchase his photos at *www.earldotter.com.*

We are also grateful to the Public Welfare Foundation for its generous support of this project and the dozens of occupational health experts (too many to mention) that we consulted with as we selected and developed the individual case studies.

Contents

Going to work should not be a choice between feeding your family and protecting your health and safety.

INTRODUCTION

Healthy Workplaces Support Healthy Communities

MOST PEOPLE WORK. MANY people do work that is highly hazardous, such as mining, construction, and some manufacturing jobs. Many others work in service industries such as retail or house-keeping, which are not typically thought of as "hazardous" but can still cause serious injuries. More than four thousand workers in the United States died on the job in 2009 and more than 3.3 million workers were injured or made ill by their work.[1,2]

We also know that the *reported* injuries, illnesses and fatalities represent only a small fraction of the total work related illnesses and diseases in the United States because of serious under-reporting. For example, the 4,000 deaths/year counted above don't include the nearly 10,000 asbestos-related deaths in the U.S. per year—a number about which we have a high degree of confidence even though it doesn't come from the official workplace fatality statistics.[3] Failures to protect the health and safety of workers have tremendous costs for those who are harmed, their families and their communities. Ignoring the pain and suffering, the simple economic costs run to the tens of billions of dollars per year (workers compensation payments alone accounted for $57.6 billion in 2008).[4,5]

Despite these sobering statistics, improving occupational safety and health has received little public or political attention in this country. While Upton Sinclair highlighted horrific working conditions in the meatpacking industry in the early 1900s, and visionary scientists like Alice Hamilton and Irving Selikoff identified occupational health hazards of lead and asbestos, we continue to expose workers to a wide range of dangerous, yet wholly preventable, hazards. Going to work should not be a choice between feeding one's family and protecting one's health and safety.

This report, *Lessons Learned: Solutions for Workplace Safety and Health* documents case studies of systemic failures in protecting workers from injury and illness and outlines some paths forward that can more effectively protect workers, the communities in which they live, consumers, and the environment while stimulating innovation in safer forms of production.

A failed regulatory approach to worker health

In 1970, Congress passed the Occupational Safety and Health Act (OSHAct) to "assure so far as possible every working man and woman in the Nation safe and healthful working conditions." The OSHAct was enacted at a time of unprecedented passage of laws for protection of workers and the environment. It promised new protections for worker safety and health including a general duty on employers to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees." Particularly in its first decade, the Occupational Safety and Health Administration (OSHA) made important contributions to workplace health and safety, but from the Reagan

administration onwards, the agency and the policies it implements have been significantly weakened.

OSHA has suffered severe reductions of its funding and effectiveness in implementing and enforcing workplace health and safety. Early court decisions supported OSHA's ability to implement strict prevention-oriented standards even when the scientific evidence about a particular hazard was limited. For example in a case challenging OSHA's occupational standard for vinyl chloride (The Society of the Plastics Industry, Inc., v. Occupational Safety and Health Administration, 1975), the Second Circuit Court noted: "the ultimate facts here in dispute are on the frontiers of scientific knowledge and though the factual finger points, it does not conclude. Under the command of OSHA, it remains the duty of the Secretary to protect the working-man, and to act even in circumstances where existing methodology or research is deficient." The court further stated that regulations can establish standards that require technologies that may be only "looming on the horizon."

The early recognition of limits in science but the need to act in a precautionary, preventive manner changed with the 1980 Supreme Court decision striking down OSHA's proposed standard for benzene. The court noted that OSHA had not demonstrated significant risk with substantial evidence. The case ushered in a requirement for agencies to quantitatively demonstrate that a hazard represented a significant risk before establishing an occupational health standard, that the job of OSHA was not "absolute safety but the elimination of significant harm."

Today, few health and safety experts believe that OSHA's rulemaking and enforcement activities are effectively living up to the goals of the original act. A short list of failures includes:

- Chronic under-reporting of occupational injury and illness rates in national surveillance systems;
- An enforcement system based heavily on small penalties and inspections that never reach the vast majority of establishments covered by the OSHAct;

The current rules and structure of occupational safety and health work against preventive and precautionary measures.

- A slow, reactive hazard-by-hazard rule-making system that has failed to adopt or update standards for preventing injuries from widespread ergonomic and chemical hazards including known carcinogens; accepts risks to workers that are magnitudes greater than are considered acceptable for the general population; and cannot keep pace with rapid technological change in the American workplace; and
- Constant legal challenges by industry that have resulted in OSHA rule-making requirements that place greater emphasis on reducing economic impacts than on reducing illness and injury.

The current rules and structure of occupational safety and health work against preventive and precautionary measures. These shortcomings cannot simply be explained by the gross under-funding of OSHA or problematic court decisions. For example, the agency's location in the Department of Labor has sometimes worked against comprehensive approaches to chemical regulation which could benefit workers, the environment and consumers with less burdensome rules for industry. At the same time, attempts at voluntary compliance under several administrations have also not been effective. Globalization, outsourcing, and the weakening of labor unions have fundamentally altered the workplace and challenged OSHA's ability to protect workers as originally conceived by the OSHAct.

While the majority of employers have a genuine concern about the health and safety of workers, most feel intimidated by OSHA. Injured workers and families of those who have been killed are deeply angered that OSHA levies a mere slap on the hand with its extremely low fines for non-compliance—fines that by no means serve to deter as intended. The general public continues to barely know what OSHA is or what it does and continues to be ill-informed about the magnitude of harm in today's workplaces—harms that not only hurt the lives of workers and their families, but also cause enormous economic and social costs for the rest of society.

Learning from late lessons

There is a sad history of knowing about occupational health hazards and the programs and policies that could fix them, but not taking the action that's required. By researching the lessons learned from our occupational safety and health history, we learn that the failure to act to protect workers is not only caused by weak OSHA regulations or enforcement. Failure to act is often the result of multiple factors, such as: the practices of numerous federal agencies whose decisions impact worker health yet do not include worker health considerations in their decision processes; the politicization of science; or the inherent conflicts between economic and social interests. In essence, harm to workers from occupational health hazards is a system failure. Hence, systems solutions are needed.

Learning from past failures

This report is inspired by the European Environment Agency's (EEA) *Late Lessons from Early Warnings: the Precautionary Principle 1896–2000* (*http://www.eea.europa.eu/publications/environmental_issue_report_2001_22*). EEA's report outlined 14 environmental and occupational health cases where early evidence existed of potential harms but no action was taken. The report reveals the economic and human costs of inaction as well as lessons learned to improve environmental and occupational health decision-making. EEA's report and the Lowell Center's work as ¡one of the leading U.S. advocates of the precautionary principle have strongly influenced environmental and health policy debates in the U.S. and in Europe. This report, *Lessons Learned: Solutions for Workplace Safety and Health* builds on these earlier efforts, making the case for precautionary and preventive action to improve workplace health and safety in the U.S.

There is a sad history of knowing about occupational health hazards and the programs and policies that could fix them, but not taking the action that's required.

Reforms are desperately needed, and effective reforms can be identified by studying and revealing lessons learned from our failures in a range of occupational safety and health settings. Effective workplace health and safety programs need to be integrated with other aspects of the design of production systems and community health. By learning more about limits of government and industry to protect workers from occupational injury and disease we can advance recommendations that would co-optimize goals of worker health, community health and economic prosperity.

Six case studies of health and safety problems and solutions

This report includes six case studies of occupational health and safety failures across sectors, populations and hazards. The Lowell Center for Sustainable Production (Lowell Center) of the University of Massachusetts Lowell has produced this report to provide evidence and recommendations for systemic national policy reforms that will lead to stronger, more effective prevention-focused worker health and safety protections. The case studies document the history of selected workplace health and safety policies and practices and draw lessons from these to inform and stimulate new policy initiatives.

Case studies were chosen based primarily on three factors: (1) addressing a large population of workers or vulnerable populations; (2) timely or relevant to current events; (3) teaching lessons with important policy implications. A list of over a dozen potential case studies was developed. These were presented to a large group of advisors drawn from labor unions, government and academia.

This input was used to narrow the list to the final six case studies from which our "stories within the stories" were extracted:

- Floor finishers, lacquer sealers, and fires: safer product alternatives are the solution
- When my job breaks my back: shouldering the burden of work-related musculoskeletal disorders
- The poison that smells like butter: diacetyl and popcorn workers' lung disease
- Injuries are not accidents: construction will be safe when it's designed to be safe
- Regulating methylene chloride: a cautionary tale about setting health standards one chemical at a time
- Safe food from safe workplaces: protecting meat and poultry processing workers

Based on initial research and input from advisors, key lessons to explore were identified for each case study. The research approach for each case study varied though all included: (1) literature reviews, including government, academic and non-profit organization reports; newspaper articles; and peer reviewed journal articles and (2) key informant interviews with experts on each case. Each case study was developed and refined by the Lowell Center research team and peer reviewed by one or more experts in the field. Based on the case studies, the research team extracted key lessons and developed recommendations for future systemic reforms in the final chapter of this report.

This report is guided by a fundamental perspective of the Lowell Center: healthy workplaces are inextricably linked to healthy communities, local and global ecosystems and economic vitality. Our experience as scientists, policy analysts and technologists has taught us that the most effective way to ensure that workers, communities and the environment are protected from hazards is through the redesign of production and consumption systems so that they are inherently more sustainable. We understand the challenges involved in such systematic changes but believe that a big vision, combined with small successful examples, is the way to infuse hope and opportunity into a system that may appear severely broken.

References

1. Bureau of Labor Statistics. *Economic News Release: Census of Fatal Occupational Injuries Summary, 2009* 2010. Available at: *http://www.bls.gov/news.release/cfoi.nr0.htm*. Accessed: October 29, 2010.
2. Bureau of Labor Statistics. *News Release: Workplace Injuries and Illnesses – 2009*. 2010. Available at: *http://www.bls.gov/news.release/archives/osh_10212010.pdf*. Accessed: October 29, 2010.
3. Environmental Working Group. *Asbestos: Think Again. Section 1: The Asbestos Epidemic in America*. 2010. Available at: *http://www.ewg.org/sites/asbestos/facts/fact1.php*. Accessed: October 29, 2010.
4. Leigh JP, Markowitz SB, Fahs M, et al. *Costs of Occupational Injuries and Illnesses*. Ann Arbor, MI: University of Michigan Press. 2000.
5. Sengupta I, Reno V, Burton Jr JF. *Worker's Compensation: Benefits, Coverage, and Costs, 2008*. National Academy of Social Insurance. September 2010. Available at: *http://www.nasi.org/research/2010/report-workers-compensation-benefits-coverage-costs-2008*. Accessed: October 29, 2010.

What's the best way to prevent fires from quick-drying floor finishes? Substitute a safer product.

CASE STUDY 1

Floor Finishers, Lacquer Sealers, and Fires:
Safer Product Alternatives Are the Solution

Pia Markkanen, David Kriebel, Joel Tickner, Molly M. Jacobs

In 2004, two 35-year-old Vietnamese immigrants, Toan Bui and Ha Vu, were refinishing hardwood floors in a three-family house in Somerville, a city on Boston's northern periphery. This was not at all an unusual scene. The older cities of New England feature tens of thousands of nineteenth- and early twentieth-century houses with fine old wood floors, which periodically need to be refinished. From an environmental and health perspective, there's a lot that's good about wood floors: they're easy to keep clean, they're comfortable and warm underfoot, and when they eventually get scuffed and dirty, they can be sanded and refinished several times before they need to be replaced.

Floor finishing is heavy, noisy, and dusty work, but it also requires attention to detail and a commitment to quality workmanship. In Massachusetts, the industry is now dominated by Vietnamese immigrants. An estimated 80 percent of all floor sanders/finishers in Boston are ethnic Vietnamese. In 2006, 127 of 144 registered Boston hardwood floor contractors had Vietnamese workers, and there are undoubtedly many more contractors who are not registered with the city.

Toan Bui and Ha Vu were typical workers in a typical trade—until 2004, when they died on the job in a fiery and entirely preventable disaster in which two co-workers were also badly burned. They had finished sanding the old floors and were coating them with a lacquer sealer that is typically 80 percent flammable solvent, with the remainder a mixture of resins that serve to coat and protect the wood. The entire house caught fire in a matter of seconds after the lacquer sealer was ignited by a pilot light in a gas stove.[1,2]

SADLY, OTHER DEATHS HAVE occurred under circumstances nearly identical to those described above. Between 1995 and 2005, more than 25 fires directly attributed to hardwood floor installation and refinishing occurred in Boston alone, resulting in a property loss valued at over $1.5 million.[2] In 2005, in the nearby town of Hull, Massachusetts, a floor sander died from burns and another received minor burns while finishing wood floors that they had installed in a single-family home. A recent survey of 109 floor sanders/finishers in central and eastern Massachusetts found that 43 percent of respondents knew of fires that had broken out on hardwood floor-finishing jobs done by their company.[3]

In Toronto, two floor finishers died in 1991 as they were applying a lacquer finish to a new, unfinished hardwood floor, a fire broke out and an explosion followed. Ching Chan died of a suspected heart attack after helping his friend Chung Chow out of the burning building. Chung Chow died later from third-degree burns over 95 percent of his body. "The force of the explosion was

so great it blew most of the brick off the back of the house and gutted it from basement to roof," Sergeant Miles of York Region Police told reporters.[4] Ten years later, another Toronto floor finisher died: 62-year-old Albert Ernst was burned to death as he was applying a lacquer sealer to a basement parquet floor.[5] Both Ernst's helper and the building's owner missed fiery deaths by seconds because the helper had gone upstairs to bring the owner to see the first coat being applied.

Between 1995 and 2005, more than 25 fires directly attributed to hardwood floor installation and refinishing occurred in Boston alone.

During 1992-2002, 52 fatal injuries among workers in the occupational group of carpet, floor, and tile installers and finishers in the United States were reported to the Bureau of Labor Statistics.[4] This is undoubtedly an underestimate: reporting of occupational fatalities is incomplete in the United States, and the data for small independent contractors are particularly inadequate. Of the known deaths, 21 percent (11/52) resulted from fires and explosions.[4,5]

ABOUT THIS CASE STUDY

This case study highlights two major themes: (1) hazards of highly flammable wood floor-finishing products, in particular a number of serious fires these chemicals have caused in many communities; and (2) unprotected immigrant workers who need safer chemical alternatives to use at work. We start by describing the general nature of the floor-finishing work. The majority of the case study focuses on causes and aftermath of the two fatal fires in Massachusetts during 2004–2005 including the landmark State 2010 legislation that now prohibits the commercial use and sale of lacquer sealers in floor finishing.[1,6,7,8] The case demonstrates the necessity of toxics use reduction (TUR) strategies—through government legislation, economic incentives, outreach, and training—as an essential element to promote public safety and fair business competition while making operations safer. Legislation is needed to ban hazardous products when less hazardous alternatives are clearly on the market.

The floor-finishing industry

Floor sanders and finishers belong to the broad occupational group of carpet, floor, and tile installers and finishers. In 2008, this set of occupations accounted for about 160,500 jobs in the United States, and 35 percent of these workers were self-employed.[9] The US Bureau of Labor Statistics (BLS) predicts 11 percent employment growth during 2008-2018 for floor sanders and finishers due to the increasing use of hardwood as a flooring material as well as the growing demand for residential renovations. Although earnings vary by geographic location and by union membership status, median hourly wages for floor sanders and finishers—at about $15 per hour—are the lowest in the broad occupational group.[9]

Most carpet, floor, and tile installers and finishers learn their trades informally on the job—first by helping carry materials, then learning about the tools and simple tasks, and later performing more difficult tasks like cutting and installing various floor covering materials. Many of those who begin working for someone else eventually set up their own businesses as independent contractors.[9]

Exposures to floor finishers

When a hardwood floor is installed, the wood flooring is first laid down on concrete or another type of foundation layer. Workers then smooth wood imperfections with sanding machines.[9] Then they examine the floor and remove excess glue from joints using a knife or chisel, and they may further sand the wood surfaces by hand with sandpaper.[9] Finally, workers apply a sealer to the floor, followed by a polyurethane varnish. Workers use brushes or rollers, often applying multiple coats of varnish.[9]

Floor sanders and finishers are exposed to dust, noise, and heavy physical exertion. Airborne wood dust, a well-established cause of cancer, often exceeds the NIOSH Recommended Exposure Limits (RELs) during sanding.[10] In addition, some old floors are caked with layers of lead paint, so that sanding creates clouds of highly inhalable lead dust, creating a serious hazard not only for workers but for residents as well.

Hardwood floor installation and finishing usually involve the use of three kinds of chemical products: (1) an adhesive to apply wood flooring

to concrete or another type of foundation layer; (2) a sealer applied to the sanded wood surface; and (3) a varnish applied as a top coat as soon as the sealer has dried.[11] Some sealers contain lacquer to speed drying, and are known as lacquer sealers.[5] Some floor-finishing products contain chemicals that are toxic to the nervous system and reproductive system, cause cancer, and/or trigger allergies or asthma.[4] And so while the fire hazard is perhaps the most frightening, it is not the only risk that these workers face.

> *Lacquer sealers have as much as 80% solvent in them . . . a gallon of lacquer on the floor is like pouring 3 quarts of gasoline on your basement. There are arson laws against that but no restrictions on using lacquer sealers in a closed environment like your home.*
>
> —WoodFloorDoctor.com[5]

How flash fires happen

Most lacquer sealers are made from nitrocellulose alkyd resins and plasticizers.[5] However, it's the added lacquer thinner that makes these sealers both fast-drying and highly flammable.[5] These products are inexpensive, and because they dry very quickly, many contractors use them as a quick first coat under varnish, despite their flammability.[5] We would like to emphasize here that most floor sealers are not lacquers and are not flammable—industry experts who advised the Massachusetts Floor-Finishing Safety Task Force explained that lacquer sealers are not actually designed for floor finishing and fail to bind properly to coats of finish.[12]

For a liquid to be *flammable*, two conditions must be met: the liquid must be able to vaporize, and vapor at a sufficiently high concentration must come into contact with an ignition source. The *flash point* of a liquid is the lowest temperature at which the liquid produces enough vapor to catch fire in the presence of a flame or other ignition source. A product's flash point can be found on its Materials Safety Data Sheet (MSDS), a summary of a chemical's health effects, which employers are required by law to provide to workers, or on the product label, or by calling the product manufacturer.[1]

The lower a liquid's flash point, the more flammable the liquid. Liquids that are formally classified as "flammable" have flash points under 100°F.[4] Some floor-finishing products have much lower flash points, in the range of 25° to 50°F; indeed, the product that led to one of the fatal fires in Massachusetts had a flash point of 9°F.[4] In floor-finishing work, disastrous fires originate when lacquer sealer vapors come into contact with an ignition source, either a flame or a spark.[4,13,14]

It may seem that it should be easy to remember to extinguish pilot lights and other open flames, but this is not an adequate protection when chemicals can volatilize to explosive vapors so quickly. Anything that requires electricity can produce sparks: use of ventilation equipment, turning light switches on or off, unplugging an electric cord from a socket; or striking a metal object, such as a nail or staple in the floor. Even pouring liquid from one container to another can create enough friction to generate sparks if the containers are not grounded.[4]

In floor-finishing work, disastrous fires originate when lacquer sealer vapors come into contact with an ignition source, either a flame or a spark.

Rule of thumb: eliminating hazards is better than controlling them

Workers routinely work safely around highly flammable liquids and gases in a number of industries, including the oil and gas industry and the chemical refining industry. In these industries, there are requirements that all tools be non-sparking—hammers and screwdrivers are made of exotic metals such as bronze or beryllium; all electrical equipment must be elaborately shielded to ensure that sparks cannot occur; fire equipment and fire brigades are mandatory. Clearly, these kinds of precautions are not practical in residential home construction and repair. What are the alternatives?

Occupational hygienists are professionals whose job is to design workplaces to be safe for workers. They follow a set of fundamental principles, called the hierarchy of controls (see sidebar, *Hierarchy of controls*) when they search for solutions to a workplace hazard such as flammable chemicals. Long experience has shown that it is generally more effective to find solutions high up this list,

and move down to lower levels of control only when more effective methods are not feasible. For example, to control lung disease from breathing a toxic dust, it is generally more effective to use a ventilation system (#2 on the list) than a mask (#5). Masks require individual compliance, they often don't fit well, and they are uncomfortable. They leak if they don't have a good seal with the face, and workers often refuse to wear them. A well-designed ventilation system is subject to fewer kinds of failure.

The Massachusetts path to protections for floor-finishing workers

Alarmed by the deaths of floor finishers, community and public interest organizations mobilized in 2004 to protect workers and press for action by the state. As a result, a task force was formed, and its work ultimately formed the basis of a state law protecting floor-finishing workers.

The Massachusetts Floor-Finishing Safety Task Force

In Massachusetts, community organizing and the resulting participatory action research played a critical role in investigating causes of the fatal fires as well as developing and recommending a host of solutions to prevent these fires in the future. The process of many community stakeholders joining forces as well as maintaining this stakeholder partnership over several years (from 2004 until today) was groundbreaking. Through these years, participatory action research included various information collection strategies—for example, focus groups and interviews with the floor-finishing industry representatives, as well as with safety and environmental specialists; laboratory investigations and experiments; surveys among floor finishers; field investigations; and review of existing available data.

Viet-AID (Vietnamese-American Initiative for Development), a community-based organization that has been a leader in the fire investigation efforts, worked closely with the Massachusetts Coalition for Occupational Safety and Health (MassCOSH) and other groups to raise awareness about the dangers of using lacquer sealers. The Dorchester Occupational Health Initiative (DOHI)—funded by the National Institute of Environmental Health Sciences—had been conducting a health study among floor sanders and finishers when the fires occurred, and thus was able to mobilize a response quickly and release recommendations within weeks of the second fatal fire. MassCOSH—a part of DOHI—promptly formed the Massachusetts Floor-Finishing Safety Task Force, which comprised representatives from labor, industry (contractors), floor-finishing product manufacturers, government agencies, and environmental groups, to share their knowledge of the industry.[4,13]

The Task Force conducted focus groups and interviews with business owners and product distributors and also carried out field investigations. In collaboration with the Massachusetts Toxics Use Reduction Institute (TURI), the Task Force tested a range of floor-finishing products in the TURI laboratory. Through this concerted community effort via participatory action research, the Task Force was able to develop a series of policy recommendations for improved protection of hardwood floor sanders/finishers, their customers, the general public, and the environment.[4,13] In particular, the Task Force's findings and recommendations (see sidebars *Key findings* and *Priority Recommendations*) focused on: (1) providing information for legisla-

Hierarchy of controls against workplace hazards: lacquer sealers

1. Substitute a less hazardous chemical or eliminate the need for the chemical altogether. Substitution would involve a less flammable agent, and is the solution that was pursued in Massachusetts. Eliminating the need for the chemical should also be effective. Approaches might include using a different kind of flooring that does not need to be varnished, or installing wood flooring that is pre-varnished in a (safer) factory.
2. Use engineering controls such as ventilation systems to reduce the hazardous exposure.
3. Make administrative changes that could reduce exposures—for example by using the chemical on smaller sections of floor spread out over longer periods of time.
4. Improve training and provide better information about the hazard and ways to avoid it.
5. Provide personal protective equipment. In this case, that's hard to do—fire-proof suits are not feasible enough to merit consideration.
6. Monitor exposures and workers' health.

Key findings of the Massachusetts Floor-Finishing Safety Task Force[4]

1. Non-flammable floor-finishing products are commercially available. Tests conducted by Green Seal and the Massachusetts Toxics Use Reduction Institute have found that non-flammable water-based products meet or exceed nearly all quality measures of flammable products tested. Although water-based products typically cost more than oil-based products ($30–$90 per gallon versus $10–$30 per gallon), a number of Boston-area floor-finishing businesses use water-based finishes for some or all jobs. These companies choose water-based finishes because they are more durable, reduce solvent exposure, dry in less time, allow occupants to return to the premises faster, and do not cause fires. Many non-flammable oil-based products are also available.
2. Small business owners face a number of barriers to safer and healthier products and practices. Increasing numbers of Boston hardwood floor-finishing businesses are owned and operated by Vietnamese immigrants. With little access to training in finishing techniques or health and safety, and virtually no Vietnamese-language information on the industry and its hazards, many of these companies rely on word of mouth and product distributors for advice on products and practices. Yet, some distributors do not promote safer products. Small companies may also lack understanding of the cost-benefit trade offs of using nonflammable products.
3. Massachusetts boasts a range of resources for addressing the urgent issues associated with wood floor finishing. Vietnamese-American community groups have built strong networks of trust and communication with local businesses. Their input will be key to developing effective policies for this industry. Organizations including the Massachusetts Toxics Use Reduction Institute and New Ecology, Inc. possess expertise in the identification, testing, and promotion of safer products. The Division of Occupational Safety (DOS) oversees licensing of asbestos and lead contractors, and the DOS's OSHA Consultation Program provides free health and safety assistance to small businesses. The Dorchester Occupational Health Initiative—a partnership of nonprofit organizations, community health centers, and university researchers—is charged with developing health and safety education with Vietnamese-American hardwood floor finishers in Boston.

tors who seek to promote safer floor-finishing practices; and (2) helping employers, unions, professional organizations, consumers, and community organizations to better understand hardwood floor-finishing hazards and to undertake necessary safety measures.

Recommendations to the Massachusetts legislature and other efforts

On September 29, 2005 MassCOSH, along with its DOHI partners, released its floor-finishing safety report at the Massachusetts State House. The report—*Protecting Workers and Homeowners from Wood Floor-Finishing Hazards in Massachusetts*—called for a sweeping effort by employers, government, and communities to address not only the critical problem of fires but the health concerns associated with floor refinishing.[13] After the report, the Massachusetts Floor-Finishing Safety Task Force (Task Force) was expanded to include members of industry, labor and community, and convened between January and April 2006 to develop specific policy recommendations for the state's legislature.[2] Other efforts to protect workers and the public from floor-finishing hazards were attempted. The level of protection offered by these efforts varied, and they met with mixed success.

The Task Force had found that many non-flammable, effective, floor-finishing products are available on the market. First, the industry tried to

> ***With . . . virtually no Vietnamese-language information on the industry and its hazards, many [immigrant-owned] companies rely on word of mouth and product distributors for advice on products and practices.***

Recommendations of the Floor-Finishing Safety Task Force[4]

1. Establish a licensing program for floor refinishing businesses; to ensure that the program is effective and accessible to people from diverse cultural and economic backgrounds, take immediate steps to form an oversight committee which comprises all affected stakeholders, including workers, small businesses, community organizations, labor unions, and health and safety experts.
2. Require both use and sales of non-flammable floor-finishing products with flash points at or above 100°F in place of flammable products with flash points below 100°F.
3. Promote the use of safer and healthier floor-finishing products through mechanisms such as tax credits, grants, low-interest loans, or other means of providing economic support for small businesses to substitute safer and healthier products and equipment for those associated with fire hazards and other public health hazards. Promote state procurement through the Massachusetts Environmental Purchasing Program.
4. Partner with organizations such as the Dorchester Occupational Health Initiative to develop, distribute, and promote culturally and linguistically appropriate training materials on safer and healthier products and practices. Extend these efforts throughout the state.

move ahead with the voluntary ban of lacquer sealers. Initially nearly all floor-finishing product distributors in Central and Eastern Massachusetts voluntarily stopped selling lacquer sealers. However, one distributor started selling lacquer sealers again in response to the pressure from contractors who were accustomed to using them. Driven by concerns about a "level playing field," all the distributors began selling the products again to avoid losing customers.

Around 2007, the Task Force unanimously called for two pieces of legislation in Massachusetts: (1) a ban prohibiting the use and sale of highly flammable floor-finishing products (those with flash points of less than 100°F), although at this time, the Task Force was skeptical about the likelihood a ban would succeed in being approved by the legislature; and (2) a certification process requiring that a) floor-finishing industry owners and employees become trained and certified, b) owners designate a certified worker to be responsible for completing a safety checklist, and c) companies provide a floor-finishing safety fact sheet to be signed by the consumer.[2]

In addition to the above, Task Force members urged the Massachusetts Board of Fire Prevention Regulations (the Board) to incorporate a ban on highly flammable products into the Massachusetts Fire Code. As a direct response to education and testimony by the Task Force members, the Board did take action. It adopted a regulation, effective June 1, 2010, requiring: (1) a permit and a warning sign on every door of any building where highly flammable products are used for floor finishing; and (2) removal of ignition sources such as pilot lights before the products are used.[14] The Task Force continued to pursue the ban in order to broaden the enforcement beyond fire departments and because a ban would give the distributors, who were in strong support of the ban, the ability to remove the product from the market more easily.[11]

Landmark legislation in Massachusetts

As described above, the Task Force had been doubtful about the ban getting through the legislature. In 2008, an influential legislator expressed a concern about the certification initiative;[a] however, he surprised Task Force members by encouraging them to pursue the ban more actively. Consequently, the Task Force switched gears and actively sought the ban. Despite numerous obstacles, including a last-minute rally by a chemical company, the bill made it through the legislature—one month before the end of the legislative session.

In July 2010, the Massachusetts state legislature banned the commercial use of the highly flammable lacquer sealers for floor finishing that had contributed to the fatalities in Somerville and Hull in 2004 and 2005. The new law prohibits the commercial use and sale of lacquer sealers

a *The certification initiative languished even though experts emphasized there was no safe way to use a flammable product in an industry that by its nature involves friction, wood dust, electricity, and heavy metal machinery.*

In 2010, the Massachusetts state legislature banned the commercial use of flammable lacquer sealers for floor finishing.

with a flashpoint below 100°F if the coating alters a wood surface for purposes that are directly or indirectly connected with any business or other undertaking intended for profit. The law was signed by Governor Deval Patrick on July 2, 2010 and will take effect 180 days from signing.[8,15,16] Governor Patrick described the law as "common-sense."[17] The law sets a minimum $2,500 fine for a first violation and minimum $5,000 fine for subsequent violations with the possibility of imprisonment.[8]

Before its passage, the bill received broad support, including endorsements from product distributors, contractors, labor and community groups, and the Metro Arson/Fire Investigators Association. In a hearing before the legislative committee, Quynh Dang—whose father owned a floor sanding business involved in the Somerville fire of 2004—testified, saying that the only way to make the industry safer was to prohibit the use of flammable lacquer sealers.[18] The Vietnamese business community in Massachusetts is pleased about the Bill's passage. Michael Le, a Task Force member and a product supplier to Vietnamese-owned floor-finishing businesses, called the deaths a "wake up call":

> *I suddenly realized that all these customers were being exposed to these safety hazards. . . . I understood their language, I understood their need to earn a living . . . and I had to play a proactive role to protect these contractors and home owners.*
>
> — Michael Le, Owner of Capital Wood[2]

Common precautions used in industry to prevent sparking around flammable liquids are simply not practical in residential home and construction repair.

LESSONS LEARNED

Approaches at both state and federal levels can be effective in protecting immigrant workers from fire and explosion hazards.

State-level protections for immigrant laborers in small businesses

Immigrant laborers in small businesses are vulnerable to serious injuries and exposures from occupational hazards. As described above, the vast majority of Massachusetts floor sanders and finishers are Vietnamese. All three workers killed in the two fatal fires were Vietnamese. Immigrant groups have also had long-term exposure to hazardous chemicals in other occupational settings, including nail salons (Vietnamese), cleaning services (Brazilians), and dry-cleaners (Korean).[17,18,19]

Safety and health practitioners are aware that even large profit-making businesses can perceive safety measures as a nuisance that threatens their competitive edge. For small enterprises—which must compete hard to keep their businesses alive—a decision to shift to a safer product or process may jeopardize their business. For example, several Massachusetts distributors voluntarily pulled the most flammable products from their shelves. However, as long as sales of these highly flammable materials remained legal, distributors risked losing customers to other businesses who continued to sell the unsafe product.

Immigrant laborers in small businesses—in any industry—need access to safer products; therefore, information and training mechanisms must convey how and where to obtain these safer alternatives. In this case, floor finishers were a market for safer alternatives from the distributors, who were eager to switch to safer alternatives but continued to be pressured by contractors who were accustomed to using lacquer sealers.

Use of safer products should be supported with economic incentives, whereas unsafe products should be discouraged with economic disincentives. Initially, the Task Force thought that economic incentives were necessary to switch to safer floor-finishing alternatives (see sidebar, *Priority Recommendations*, Recommendation 3).[4] Such incentives turned out to be unnecessary in this case. Reader-friendly business cases that demonstrate the cost-benefit trade-offs of safer and healthier alternatives, and show that safe practices do not compromise the quality of the service and success of the business, are useful anywhere. The Task Force called for promoting safer procurement throughout the entire state government through the Massachusetts Environmental Purchasing Program.[4]

The Task Force also requested the Commonwealth of Massachusetts to partner with community-based organizations to develop, distribute, and promote training materials and other information mechanisms that are culturally and linguistically effective (see box: *Priority Recommendations*, Recommendation 4).[4] Otherwise, there is a possibility that businesses will rely on anecdotal information or product distributors' advice on safer and healthier work practices.

States can also adopt broader chemical safety policies to protect both workers and communities. At the time of writing this case study, Massachusetts has a Safer Alternatives bill in the legislature.[20] The bill expands the successful Massachusetts Toxics Use Reduction Act (TURA) program—which has demonstrated that reducing the use of toxic chemicals both protects health and saves businesses money—in supporting industries in their efforts to replace toxic chemicals with safer alternatives in consumer products and manufacturing processes.[20] The Massachusetts Safer Alternatives program would initially target 10 priority chemicals (lead, formaldehyde, trichloroethylene, perchloroethylene, dioxins and furans, hexavalent chromium, organophosphate pesticides, pentabromodiphenylether [PBDE], di-(2-ethylhexyl)phthalate [DEHP], and 2,4-dichlorophenoxyacetic acid [2,4-D]) that are currently replaceable with feasible safer alternatives for many uses.[20]

Federal protections for immigrant laborers in small businesses

With the exception of OSHA's Hazard Communication (HAZCOM) Standard, the current federal regulatory system addresses only poorly the handling of a range of hazardous chemicals at work. As pointed out in other case studies in this publication, US chemical regulations have thus far been characterized by a one-chemical-at-a-time approach, setting Permissible Exposure Limits for individual chemicals. The consequences of floor-finishing fires are so serious that OSHA would be more than justified in issuing an emergency temporary

standard to ban flammable products in floor finishing.

Even the HAZCOM framework remains limited in its capacity to protect workers. First, unless individual states have adopted HAZCOM laws to cover public-sector workers—as is the case in Massachusetts—OSHA's HAZCOM covers only private-sector workplaces. Second, HAZCOM neither guides nor encourages the shift towards less hazardous chemical alternatives when such products are on the market. Third, chemical manufacturers do not do a good job of anticipating "foreseeable" uses of their products, which can end up in private homes and be handled under highly hazardous conditions. Fourth, and perhaps most important, HAZCOM does not take account of the vulnerability of immigrant laborers: the standard does not require labels, Materials Safety Data Sheets, and training materials for non-English speakers to be written in their native languages. The HAZCOM sections about labels and MSDSs in which the words "language" or "languages" appear are:[21]

> *The employer shall ensure that labels or other forms of warning are legible, in English, and prominently displayed on the container, or readily available in the work area throughout each work shift. Employers having employees who speak other languages may add the information in their language to the material presented, as long as the information is presented in English as well. (Section (f)(9))*
>
> *Each materials safety data sheet shall be in English (although the employer may maintain copies in other languages as well), and shall contain at least the following information. (Section (g)(2))*

The EPA's 1976 Toxics Substances Control Act (TSCA) does not offer much protection for any workers in jobs like wood floor finishing. Nonetheless, TSCA reform is a prominent topic for discussion and on-going effort in the US Congress. In September 2009, EPA announced the following six *Essential Principles for Reform of Chemicals Management Legislation*:[22]

1. Chemicals should be reviewed against safety standards that are based on sound science and reflect risk-based criteria protective of human health and the environment.
2. Manufacturers should provide EPA with the necessary information to conclude that new and existing chemicals are safe and do not endanger public health or the environment.
3. Risk management decisions should take into account sensitive subpopulations, cost, availability of substitutes and other relevant considerations.
4. Manufacturers and EPA should assess and act on priority chemicals, both existing and new, in a timely manner.
5. Green chemistry should be encouraged, and provisions assuring transparency and public access to information should be strengthened.
6. EPA should be given a sustained source of funding for implementation.

EPA's principle #3 could address some concerns that have been highlighted in this case study. A reformed TSCA could authorize EPA to ban extremely hazardous products—such as highly flammable floor-finishing materials—when safer alternatives are available on the market.

While the TSCA reform is important, we do not need to stay inactive until the TSCA reform has passed: safer alternatives policies can be initiated and adopted systematically at the state level as well as locally.

In the construction case study in this volume, we discuss further the role of training and advocacy for occupational safety and health for foreign-born immigrant workers. Proper training—especially when enhanced with active problem solving—has been shown to improve occupational safety and health knowledge, safety attitudes, and work practices among foreign-born immigrant laborers despite language barriers, educational background, or documentation status.[23,24]

This case study has described hazards of highly flammable wood floor-finishing products, specific needs of immigrant labor for safer and healthier products, and the new 2010 law in Massachusetts that prohibits the commercial use and sale of flammable lacquer sealers for floor finishing. The Massachusetts example also points the way for promoting similar initiatives nationwide to protect immigrant labor in small businesses.

CASE STUDY 1 — **TIMELINE**[8,14,22]

DATE	EVENT
2004	**Somerville, MA:** Two Vietnamese floor sanders/finishers, Toan Bui (age 35) and Ha Vu (age 35), died in a fatal fire while refinishing wood floors in a three-family house. Two of their co-workers were badly burned. **Danvers, MA:** Floor-finishing fire caused serious damage to a home, and a child of the homeowner was injured.
2005	**2005 Hull, MA:** Tinh Huynh (age 43), a Vietnamese floor sander/finisher, died in a fatal fire in a single-family home. A co-worker sustained minor burns. The workers were applying lacquer sealer which was ignited by a pilot light on a gas hot water heater. **Needham, MA:** Two homes destroyed in a floor-finishing fire.
2006	**Milton, MA:** Floor-finishing fire caused serious injuries to homeowner's father, minor injuries to a worker, and damage to the home. **Taunton, MA:** Home destroyed in a floor-finishing fire. **Dennis, MA:** Home destroyed in a floor-finishing fire.
2007	**Marblehead, MA:** Fire consumed floor-finishing products in a contractor's automobile.
2009	**US EPA** announced its Essential Principles for Reform of Chemicals Management Legislation, which included the principle that risk management decisions should take into account sensitive subpopulations, cost, and availability of substitutes.
2010	**Massachusetts** enacted legislation prohibiting the commercial use and sale of any flammable penetrating floor lacquer sealer with a flash point below 100°F.

Acknowledgments

We would like to acknowledge three sources of documents and support that were instrumental in developing this case study: MassCOSH, which coordinated the Floor-Finishing Fire Safety Task Force in Massachusetts; Dr. Lenore Azaroff of the University of Massachusetts Lowell; and the Massachusetts Department of Public Health.

We thank Marcy Goldstein-Gelb of MassCOSH and Dr. Azaroff for peer reviewing this case study.

References

1. Occupational Health Surveillance Program of the Massachusetts Department of Public Health, Office of the State Fire Marshal of the Department of Fire Services. Wood Floor Sanders Killed When Floor Finishing Product Catches Fire—Massachusetts. *Fire Safety Alert*. 2006. Available at: *http://www.mass.gov/Eeohhs2/docs/dph/occupational_health/wood_floor_sanders.pdf*. Accessed: November 15, 2010.
2. Massachusetts Coalition for Occupational Safety and Health (MASSCOSH). *Protecting Workers and Homeowners from Floor Finishing Hazards*. 2008. Available at: *http://www.masscosh.org/node/76*. Accessed: November 15, 2010.
3. Vietnamese-American Initiative for Development (Viet-AID), Massachusetts Coalition for Occupational Safety and Health (MassCOSH), Dorchester Occupational Health Initiative. *Safety in Hardwood Floor Finishing in Massachusetts: Results of a Survey of Floor Finishers* 2010. Available at: *http://www.masscosh.org/node/538*. Accessed: November 15, 2010.
4. Azaroff, L, Doan, T, Nguyen, H, Goldstein-Gelb, M, Fraser-Cook, M, Kota, S. Protecting workers and residents from wood floor-finishing hazards. *New Solut*. 2006;16(2):119-38.
5. WoodFloorDoctor.com. *Lacquer Finish Floor Fires*. 2001. Available at: *http://www.woodfloordoctor.com/_product_reviews/articles/lacquerfinishfloorfires.shtml*. Accessed: November 15, 2010.
6. Fatality Assessment and Control Evaluation (FACE) Program, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *Two Vietnamese Floor Sanders Die When Wood Floor Finish Product Ignites. Massachusetts Case Report: 04-MA-032*. 2006. Available at: *http://www.cdc.gov/Niosh/FACE/stateface/ma/04ma032.html*. Accessed: November 15, 2010.
7. Fatality Assessment and Control Evaluation (FACE) Program, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *Floor Sander Dies When Wood Floor Refinish Product Ignites. Massachusetts Case Report: 05-MA-044*. 2006. Available at: *http://www.cdc.gov/niosh/face/stateface/ma/05ma044.html*. Accessed: November 15, 2010.
8. Commonwealth of Massachusetts. *An Act Relative to Floor Finishing Products: Chapter 154 of the Acts of 2010*. 2010. Available at: *http://www.mass.gov/legis/laws/seslaw10/sl100154.htm*. Accessed: November 15, 2010.
9. Bureau of Labor Statistics, U.S. Department of Labor. *Carpet, Floor, and Tile Installers and Finishers, Occupational Outlook Handbook, 2010-11 Edition*. 2010. Available at: *http://www.bls.gov/oco/ocos203.htm*. Accessed: November 15, 2010.
10. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *NIOSH Health Hazard Evaluation Report: Ikens Hardwood Floor Services*. 2005. Available at: *http://www.elcosh.org/record/document/815/d000767.pdf*. Accessed: November 15, 2010.
11. Ontario Ministry of Labour. *Alert: Hazards in Hardwood Floor Installation and Finishing*. 1999. Available at: *http://www.labour.gov.on.ca/english/hs/pubs/alerts/c05.php*. Accessed: November 15, 2010.
12. Azaroff, Lenore. *Comment about lacquer sealers in floor finishing (in the case study peer-review)*. Personal Communication. November 4, 2010.
13. Massachusetts Coalition for Occupational Safety and Health (MASSCOSH). *Protecting Workers and Homeowners from Wood Floor-Finishing Hazards in Massachusetts*. 2005. Available at: *http://www.masscosh.org/files/ProtectingFromFloorFinishingHazards.pdf*. Accessed: November 15, 2010.
14. Massachusetts Coalition for Occupational Safety and Health (MASSCOSH). *New Floor Finishing Regulations Approved*. 2010. Available at: *http://www.masscosh.org/node/466*. Accessed: November 15, 2010.
15. Massachusetts Coalition for Occupational Safety and Health (MASSCOSH). *Landmark state bill banning deadly floor sealer signed into law*. 2010. Available at: *http://www.masscosh.org/node/556*. Accessed: November 15, 2010.
16. Anonymous. Massachusetts Bans Certain Floor Finishes. *Paint and Coatings Industry News*. August 7, 2010. 2010. Available at: *http://durabilityanddesign.com/news/?fuseaction=view&id=3979*. Accessed: November 15, 2010.
17. Goldstein-Gelb, M, Newton, J. *Gov. Deval Patrick Signs Law Banning Deadly Floor Products*. 2010. Available at: *http://www.openmediaboston.org/node/1372*. Accessed: November 15, 2010.
18. Anonymous. *House Passes Bill Prohibiting Flammable Floor Products: Bill would end the use of highly flammable wood floor sealants*. 2010. Available at: *http://www.masscosh.org/node/506*. Accessed: November 15, 2010.
19. Gute, DM, Siqueira, E, Goldberg, JS, Galvao, H, Chianelli, M, Pirie, A. The Vida Verde Women's Co-Op: Brazilian immigrants organizing to promote environmental and social justice. *Am J Public Health.* 2009;99 Suppl 3:S495-8.
20. Massachusetts Coalition for Occupational Safety and Health (MASSCOSH). *Safer Alternatives to Toxic Chemicals. House Bill 757 and Senate Bill 442: Safe Alternatives to Toxics Chemicals Bill*. 2010. Available at: *http://drupal.masscosh.org/node/152*. Accessed: November 15, 2010.
21. Occupational Safety and Health Administration, U.S. Department of Labor. *Hazard Communication Standard*. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099*. Accessed: November 15, 2010.
22. U.S. Environmental Protection Agency. *Essential Principles for Reform of Chemicals Management Legislation*. 2009. Available at: *http://www.epa.gov/oppt/existingchemicals/pubs/principles.html*. Accessed: November 15, 2010.
23. Sokas, RK, Emile, J, Nickels, L, Gao, W, Gittleman, JL. An intervention effectiveness study of hazard awareness training in the construction building trades. *Public Health Rep.* 2009;124 Suppl 1:160-8.
24. Williams, Q, Jr., Ochsner, M, Marshall, E, Kimmel, L, Martino, C. The impact of a peer-led participatory health a nd safety training program for Latino day laborers in construction. *J Safety Res*. 2010;41(3):253-61. Epub 2010 Apr 18.

A back injury can force a choice between working in pain or not working at all.

CASE STUDY 2

When My Job Breaks My Back

Shouldering the Burden of Work-Related Musculoskeletal Disorders

Pia Markkanen, David Kriebel, Joel Tickner, Molly M. Jacobs

"I'm a registered nurse; now, a back-injured registered nurse with a cumulative trauma spinal injury from ten years of lifting and moving patients. I worked at an acute care hospital on medical/surgical, telemetry, and intermediate care units. The patients were generally elderly and acutely ill with a variety of cardiac, medical, and surgical conditions. Many were unable to move themselves up or turn side-to-side in bed, to sit up, stand up, or transfer to the chair or bedside commode without being physically pulled, lifted, or occasionally, even picked up and carried. Confused patients sometimes resisted, increasing the strain. Much heavy lifting was required.

"I first experienced severe low back and leg pain while walking through my kitchen during a scheduled day off. I could not walk, sit, and hardly move. I had to call and report that I could not come to work because of back pain. Other than a brief unsuccessful attempt a few months later, I have been unable to return to floor nursing. I've been seen by neurologists, orthopedic surgeons, neurosurgeons, and a chiropractor. I was diagnosed with degenerative disc disease, lumbar strain, and bulging or herniated discs. I've had two MRIs, two discograms, a series of lumbar blocks, and ultimately, an anterior lumbar fusion of L4/L5 and L5/S1, with donor bone grafts to replace the discs, and posterior fixation with four titanium screws. The workers' compensation battle took years before the decision came in my favor that my injury was work related. I had to fight hard before being permitted for modified light duty.

"Almost everything in my life has been altered by being back-injured. I've been unable to do many things that I formerly did with ease. I can no longer flip a mattress or even assist to turn a mattress. I need help changing sheets on the bed. I can't vacuum as before and either let it go, get help, or wait until my analgesic kicks in and then do as much as I can. Sitting for any length of time is painful. Driving is painful because of the vibration and seated position—I drove over 5000 miles with the injury for multiple appointments. I'm not able to pick up small children—the first thing that upset me greatly was realizing that I may not be able to pick up a potential grandchild someday.

"I hope you recognize the healthcare worker's vulnerability and are inspired to work toward zero-lift policies, lift teams, and permanent modified light duty for injured clinicians. Caring for patients and receiving their trust touches us deeply. I loved being a hospital floor nurse. Still, my experience as a back-injured nurse has provided the incentive to learn and the motivation to speak out. I'm grateful for the opportunity to be part of the larger effort for reduction of back injuries to healthcare workers."

— Charney W & Hudson A (Eds). *Back Injury among Healthcare Workers: Causes, Solutions, and Impacts*. Boca Raton: CRC Press. 2004. Adapted with copyright permission.

WORKPLACE ERGONOMIC INjuries remain one of the most significant occupational health challenges in the United States and worldwide. Work-related Musculoskeletal Disorders (MSDs)—also called "ergonomic injuries"—typically involve muscles, tendons, and/or nerves. Taken together, these are the soft tissues that hold the body together and do its physical work.[1] MSDs are one of the leading causes of lost work time in the United States. The situation is the same in Europe, with MSDs accounting for a higher proportion of work absences due to illness/injury than any other health condition.[2] A recent study estimated that 100 million Europeans suffer from chronic pain from a MSD—although 40 percent are undiagnosed.[2] Musculoskeletal disorders are expensive for business and a serious burden for workers. Beyond the lost work time and lost wages, they also mean lost productivity, lowered morale, and "unexplained" absenteeism.[1–4]

A portrait of work-related musculoskeletal disorders

Who is injured at work? How many are injured?

Nurses face very serious risk of back injury, as the story above shows. But MSDs are found in every sector of the economy. They are notoriously under reported in all the available statistics, including the injury logs that employers are required to maintain under the Occupational Safety and Health Act (OSHAct), the surveys of the US Bureau of Labor Statistics (BLS), and state workers' compensation data. So, although we'll use some of these sources to illustrate the magnitude of the problem, keep in mind that the actual burden is probably considerably larger. Table 1 presents data for the five occupational groups that account for the largest numbers of MSDs, according to the 2008 BLS data.[6] Table 2 (page 22) lists the high-MSD occupations within high-risk industry sectors for compensable MSD claims in Washington State during 1993–2001.

Musculoskeletal Disorders (MSDs) are found in every workplace. And they are notoriously underreported.

How much do workers' musculoskeletal disorders cost?

In the United States, estimates of workers' compensation for MSDs range between $13 and $20 billion annually in direct costs.[1] The indirect costs—for example, various production losses as well as hiring and training replacement workers—can multiply this figure by as much as two to five times.[1] The National Academy of Sciences (NAS) concluded in 2001 that $50 billion was a reasonable estimate of the total annual costs of MSDs when compensation costs and lost wages and productivity are factored in.[7] In the healthcare industry, inflation-adjusted direct and indirect costs associated with back injuries are estimated to be $7.4 billion annually, in 2008 dollars.[8,9]

In Europe, direct costs of MSDs account for up to 2 percent of the European gross domestic product annually, and the costs of back pain alone are estimated to exceed €12 billion.[2] In 2002, the World Health Organization (WHO) conducted a global study on the burden of occupational low-back pain. Worldwide, 37 percent of low-back pain was attributed to work, resulting in a total of 818,000 disability-adjusted life years lost annually.[10]

How do people get musculoskeletal disorders from work?

People have probably always recognized that work could lead to injury. Among the earliest to document what we would call "ergonomic hazards" was

ABOUT THIS CASE STUDY

Beginning with a personal story of a nurse's back injury, this case study provides facts and history for the larger crisis of musculoskeletal disorders at work.[5] We reveal data on the magnitude of the problem, including the number of injuries and estimates of how much these injuries cost. A timeline shows the key events in the history of US federal regulation of musculoskeletal hazards. We will identify critical components of a workplace ergonomics program and lessons learned that can lead toward viable solutions for protecting workers.

Manual material handling, as these delivery men are doing, is a "leading cause of work-related musculoskeletal disorders."

TABLE 1

The top five occupational groups for work-related musculoskeletal disorders (MSD): Number of MSD cases and median days away from work for MSDs, by occupation group and part of body affected, in 2008.

Major occupational groups	Total MSDs		Median days away from work by part of body affected					
	Case counts	Incidence rate/10,000 workers	All	Back	Shoulder	Arm	Wrist	Knee
Transportation and material moving occupations	66,240	85	12	8	30	27	12	30
Manufacturing occupations	42,720	49	13	5	19	15	18	23
Health care support occupations	29,640	110	6	5	8	8	6	11
Construction and extraction occupations	28,880	53	11	7	30	45	27	26
Installation, maintenance, and repair occupations	27,540	61	12	6	19	15	12	52
All occupations	317,440	33	10	6	18	17	16	21

Source: Bureau of Labor Statistics. Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work, 2008. *US Department of Labor. 2009. Available at: http://www.bls.gov/news.release/archives/osh2_12042009.pdf. Accessed November 15, 2010.*

TABLE 2
Occupations with the highest rates of compensable MSDs in high-risk industries in the state of Washington, 1993–2001.

High-risk industries	Occupations
Forest nurseries and forest product gathering	Nursery workers Laborers/farmworkers Production inspecting/packing workers Floral designers
Masonry, stonework, tile, plastering	Drywall installers Insulation installers Brickmasons
Roofing	Roofers Carpenters Laborers
Meat products	Butchers and meat cutters Laborers and freight stockers/handlers Hand packers
Dairy products	Laborers and freight stockers/handlers Truck drivers Hand packers
Sawmills	Lumber handlers
Millwork	Laborers Woodworking machine operators Assemblers Cabinetmakers
Iron and steel foundries	Mold and core workers Furnace/oven workers Grind/polish machine operators Laborers Machine operators
Heating, ventilation, and air conditioning	Welders/cutters Assemblers/fabricators Laborers Grind/polish machine operators
Nursing and personal care facilities	Nursing aides and orderlies Health aides Licensed Practical Nurses (LPNs), Registered Nurses (RNs) Maids/housekeeping workers
Local and suburban passenger transport	Emergency medical technicians Bus drivers Physician assistants/registered nurses Mechanics Taxi drivers
Trucking and courier services	Truck drivers Freight handlers/stockers Refuse and recyclables collectors Graders/sorters
Air transportation scheduled and air courier services	Freight/stock handlers Flight attendants Couriers/messengers Transport/ticket/reservations workers Mechanics
Examples of high-risk occupations that cross over many industries	Housekeepers/janitors Data entry operators Stockers/receivers Assemblers/packagers

Source: Silverstein, B, Evanoff, B. Musculoskeletal Disorders. In: Levy B, Wegman D, Baron S, Sokas R, (Eds). Occupational and Environmental Health: Recognizing and Preventing Disease and Injury. *5th edition. Philadelphia (PA): Lippincott Williams and Wilkins. 2006; Table 23-2, 495-496.*

the Italian physician Bernardino Ramazzini (1633–1714). He observed that health problems originated from either prolonged stationary or unnatural postures (e.g., bakers, workers who stand, sedentary workers, weavers) or tasks requiring heavy muscular performance or force (e.g., porters and woodworkers).[11] His diagnoses are entirely modern and correct by current standards: for example, "numbness in the upper extremity in scribes due to incessant movement of the hand and always in the same direction" or "sciatica in potters due to continual turning of the potter's wheel."[1] Ramazzini also recognized the need to undertake measures to prevent MSDs caused by repetitive motions and lifting, and he recommended reduced work time for those in strenuous jobs requiring a standing position or severe muscular effort.[1] Ramazzini and subsequent occupational physicians documented such conditions as "bricklayer's shoulder," "carpenter's elbow," and "telegraphist's cramp," which leave little doubt as to the link between work and physical injury.[12,13] But despite this body of evidence, relatively little public or regulatory attention was paid to MSDs until the 1980s.[12,13]

Today, MSDs are commonly categorized in three broad groups:[1]

1. Low-back pain—associated with heavy manual handling (e.g., lifting), frequent twisting and bending, forceful movements, and full-body vibration.[1] The European Agency for Safety and

In the healthcare industry,… costs associated with back injuries are estimated to be $7.4 billion annually, in 2008 dollars.

Health at Work estimates that lower-back disorders affect 60 to 90 percent of Europeans at some point in their life and that any one time, 15 to 42 percent of Europeans are affected.[14]

2. Neck and upper-extremity disorders (shoulder, arm, elbow, hand/wrist)—associated with the frequency and duration of forceful movements, mechanical stress, static or awkward postures, and hand-arm vibration.[1]
3. Lower-extremity disorders (knees, hips, legs, ankles, feet)—associated with kneeling, squatting, load carrying, and prolonged standing.[15] Less attention has been paid to lower-extremity MSDs; however, there is increasing evidence of work-related knee and hip disorders.[1]

The diagnosis of MSDs is complicated by the fact that many other factors contribute to the risk.[1] In addition to normal life activities, housework, and hobbies, certain individual characteristics also affect risk. These include obesity, spinal abnormalities, genetic predisposition, pregnancy, and aging.[2]

In 1997, after an exhaustive review of the scientific literature, the US National Institute for Occupational Safety and Health (NIOSH) summarized the strength of the evidence for a series of occupational hazards and a wide range of MSDs (Table 3).[16] The authors paid particular attention to assembling evidence and analyzing the strength of the association between MSDs and working conditions, in particular how work-related MSDs could be reduced or prevented.[16] A committee of the National Academy of Sciences (NAS) concurred in 2001 that there is a clear relationship between back disorders and physical load, including material handling, load moment (the turning force of a load on a part of the body), frequent bending and twisting, heavy physical work, and

TABLE 3

There are varying degrees of evidence linking workplace risk factors to different musculoskeletal disorders.

Body part or syndrome	Risk factor	Strong evidence	Evidence	Insufficient evidence
Back	Lifting/forceful movement	✓		
	Awkward posture		✓	
	Heavy physical work		✓	
	Whole body vibration	✓		
	Static work posture			✓
Neck and neck / shoulder	Repetition		✓	
	Force		✓	
	Posture	✓		
	Vibration			✓
Shoulder	Repetition		✓	
	Force			✓
	Posture		✓	
	Vibration			✓
Elbow	Repetition			✓
	Force		✓	
	Posture			✓
	Combination of above	✓		
Carpal tunnel syndrome	Repetition		✓	
	Force		✓	
	Posture			✓
	Vibration		✓	
	Combination of above	✓		
Tendinitis	Repetition		✓	
	Force		✓	
	Posture		✓	
	Combination of above	✓		
Hand-arm vibration syndrome	Vibration	✓		

Source: National Institute for Occupational Safety and Health. Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back. *US Department of Health and Human Services, Centers for Disease Control and Prevention. 1997. Available at: http://www.cdc.gov/niosh/docs/97-141/. Accessed November 15, 2010.*

whole-body vibration. For disorders of the upper extremities—neck, shoulders, arms, elbows, wrists, and fingers—repetition, force, and vibration are particularly important risk factors.[7] One such disorder is carpal tunnel syndrome, caused by compression of the median nerve in the wrist. Table 4 lists jobs that carry a high risk of selected musculoskeletal disorders.

Why did OSHA's Ergonomics Standard fail?

The US regulatory history on protection of workers from MSDs is perhaps the most tumultuous in the world, and the topic remains politically heated. Attempts by the US Occupational Safety and Health Administration (OSHA) to develop an ergonomics standard have been subject to bitter disputes between labor and management as well as among the US Congress and the White House.[4]

The first steps toward federal regulations aimed at reducing MSDs can be traced to voluntary ergonomic guidelines for the meatpacking industry that were issued by OSHA in 1990. The Secretary of Labor, Elizabeth Dole, justified this move by saying, "These painful and crippling illnesses now make up 48 percent of all recordable workplace illnesses. We must do our utmost to protect workers from these hazards, not only in the red meat industry, but all US industries."[17] Secretary Dole committed the Labor Department to "taking the most effective steps necessary to address the problem of ergonomic hazards on an industry-wide basis" and "to begin rulemaking on an Ergonomics Standard."[18] According to Dole, there was sufficient scientific evidence to proceed to address "one of the nation's most debilitating across-the-board worker safety and health illnesses of the 1990s."[18]

Since that time, at least three major publications have demonstrated the strong scientific evidence linking MSDs and workplace risk factors that was needed to justify OSHA's Ergonomic Standard. NIOSH reviewed more than 600 studies and determined, as stated in a 1997 report, that "a large body of credible epidemiological research exists that shows a consistent relationship between MSDs and certain physical factors, especially at higher exposure levels."[16]

The National Academy of Sciences produced two reports.[7,19] In 1998, the NAS brought together 65 leading national and international scientific and medical MSD specialists for a two-day meeting to review the scientific evidence for the work-relatedness of MSDs and to assess whether workplace interventions were effective in reducing ergonomic hazards.[17] The panel found more than enough evidence for OSHA to proceed; however, Congress appropriated almost a million dollars—as a delaying tactic—to the NAS to produce another, more in-depth study.[17] The second NAS study came out in early 2001, but Congress never reviewed it, and the standard was repealed two

TABLE 4
High-risk jobs for selected musculoskeletal disorders.

Musculoskeletal disorder	High-risk jobs	
Low-back pain (sciatica*)	Nurses aides/orderlies Truck drivers Carpenters and apprentices Maids and housekeeping cleaners Drywall installers Carpet installers	Nurses Construction laborers Garbage collectors Glaziers Freight/stock handlers Brick masons
Carpal tunnel syndrome and tendinitis	Meat cutting Food processors Hairdressers Kitchen workers Sewing operators Handpackers Typists Stock handlers/baggers	Lumber turners Carpenters Assembly workers using hand tools Foundry workers Laborers Machine operators Roofers
Elbow/forearm disorders	Carpenters Laborers Assembly work with hand tools Drywall installers Electricians Welders Butchers/meatcutters	Machinists Plumbers Hairdressers Handpackers Bus drivers Grinders/polishers Kitchen/food preparation
Shoulder disorders	Truck drivers Welders Meatpacking assembly workers Nursing assistants Garbage collectors	Carpenters Drywall installers Masons Freight handlers
Neck and neck/shoulder disorders	Dental workers VDT workers Nurse/ assistants	Microscopists Surgeons Electronics assemblers

**Jobs with high-risk activities for sciatica based on Washington State Workers' Compensation Claims for 1993–2001.*

Source: Silverstein, B, Evanoff, B. Musculoskeletal Disorders. In: Levy B, Wegman D, Baron S, Sokas R, (Eds.), Occupational and Environmental Health: Recognizing and Preventing Disease and Injury. 5th edition. Philadelphia (PA): Lippincott Williams and Wilkins. 2006; 488-516.

months later. The most ardent opponents of the Ergonomics Standard were re-elected and became even more determined to stifle any further attempts to prevent ergonomic hazards. [4]

Under OSHA's Ergonomics Standard, general industry employers—with 11 or more workers—whose employees perform manufacturing or manual handling jobs would have been required to implement at least a basic ergonomics program and, under certain circumstances, a full ergonomics program.[20] The basic program would have included a commitment by management to take leadership responsibility for the program, the participation by employees in the program, and the provision of hazard information to workers, along with the creation of a system through which workers could report injuries.

The full program would include, in addition to the elements of the basic program, the following: a hazard analysis of the job; the implementation of engineering, work practice, or administrative controls to eliminate or substantially reduce the hazards identified in that job; training the employees in that job, as well as their supervisors; and the provision of MSD management including, where appropriate, temporary work restrictions and access to a health care provider or other professional if a covered MSD occurred.

OSHA estimated that the Ergonomics Standard would have affected approximately 1.9 million employers and 27.3 million workers in general industry workplaces. The Agency also estimated that the standard would have prevented about 3 million work-related MSDs over the following 10 years, with annual benefits of approximately $9.1 billion.[20] Annual compliance costs were estimated at $900 per establishment and $150 per problematic job fixed. During the first year after promulgation, employers would have been required to control approximately 7.7 million jobs with the potential to cause or contribute to covered MSDs.[20]

The Ergonomics Standard would have required many industries to change their employees' work practices. This is why opposition to the standard was instantaneous, organized, and well funded.[17] The package delivery company UPS, the American Trucking Association, and their allies hammered out a strategy to attach riders to Congressional budget bills for fiscal years 1995–1998, prohibiting OSHA from issuing an ergonomics standard, and in 1996, banning OSHA from collecting "ergonomics data." [17,18]

On November 14, 2000, after more than a decade of preparatory work, OSHA finally issued its Ergonomics Standard. It went into effect on January 16, 2001. Unfortunately, it lived only two months. In March 2001, the Congressional Review Act was invoked—for the first and to date the only time since it took effect in 1996—to invalidate a federal standard.[21] The opposition did more than overturn the federal standard. In November 2003, the state of Washington's ergonomics standard was defeated through a ballot initiative financed by the Building Industry Association of Washington (BIAW) that misled voters into believing that the state standard would cost the state jobs.[18]

OSHA estimated that the Ergonomics Standard would have prevented about 3 million work-related musculoskeletal disorders over the following 10 years.

In the case of Washington State, Silverstein examined how the delicate balance between scientific deliberation and political values was disrupted in the electoral process that resulted in the repeal of the Washington Ergonomics Standard. The Washington State ergonomics rule was most successful in the regulatory and legal areas, where: 1) the process was most transparent; 2) the process was open to public involvement; 3) differing views could be presented fully; and 4) decision makers were expected to explain the rationale for their decisions. The rule did most poorly in the legislature and at the ballot box, where these four features were lost and full deliberation was replaced by unhindered political pressure. The executive agency responsible and accountable for adopting rules was excluded from the electoral debate and could not defend its decisions, facts, and views before the public.[22]

Why did the OSHA Ergonomics Standard fail? In addition to the fact that the vast majority of

occupational safety and health (OSH) rules proposed at the federal or state level have met stern opposition from the business community, Silverstein proposed three other reasons for the exceptional industry attention to opposing ergonomics initiatives: (1) MSDs are widespread across industries and occupations, whereas most previous OSH rules applied to relatively small groups of industries and employers; (2) as workplace ergonomics affects both the work organization and design, the rulemaking raised fears that employers' privileges and power were threatened; and (3) the US political landscape changed dramatically in 1994, when ergonomics became a target for deregulatory enthusiasts and a poster child for the political attack on OSHA.[22]

Some have argued that the Ergonomics Standard was repealed largely on ideological grounds, to rally the most conservative forces in the society to defeat "big government" and "big labor."[24] Some say that employers don't like ergonomics policies because implementation of the programs would involve active worker participation. Another perspective points to limits in the scientific evidence used to support the standard, and confusion over the appropriate ways to weigh the evidence.[25] Costs seem to be one of the main reasons to oppose the standard, despite cost-effectiveness studies. Many employers find it hard to believe that investments in ergonomics interventions are worthwhile and that they would be paid back soon enough in saved workers' compensation costs, reduced absenteeism, and increased productivity.

What has OSHA done since 2000?

OSHA has not issued enforceable regulations on MSD hazards since 2000.[17] The Congressional Review Act that overturned the Ergonomics Standard prohibits OSHA from issuing a standard that is substantially similar to the one that was repealed.[23]

Voluntary guidelines

From 2004 through 2006, the most visible approach by OSHA was the development of voluntary industry-specific ergonomic guidelines. In addition to the earlier Ergonomics Program Management Guidelines for Meatpacking Plants, OSHA has developed guidelines for nursing homes, retail grocery stores, poultry processing plants, and shipyards.[26,27,28,29,30]

General Duty Clause

OSHA inspectors have the power to issue citations for ergonomic hazards by invoking the General Duty Clause of the Occupational Safety and Health Act (Section 5(a)). This clause states: "Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees." Before it invokes the General Duty Clause, OSHA requires a "yes" answer to each of the following questions: (1) Is there an ergonomic hazard that is causing injuries? (2) Does the employer in question know (or should the employer know) about the hazard? (3) Are the injuries caused by the ergonomic hazard resulting in serious physical harm? (4) Are there feasible alternatives available to the employer for reducing, abating, or minimizing the hazard?[4]

Recordkeeping

In 2003, MSDs were removed from the OSHA 300 log (OSHA's Form 300, Log of Work-Related Injuries and Illnesses), which comprises the OSHA-mandated occupational injury and illness recording forms (see the timeline that appears at the end of this profile). In January 2010, the new OSHA administration proposed to restore MSDs to the OSHA 300 log.[32]

Sector-based initiatives: Hope for health care workers

If generic ergonomics regulation has created opposition too fierce to overcome, can a sector-based regulatory approach gain adequate support? The 2008 Bureau of Labor Statistics (BLS) data on nonfatal occupational injuries (Table 1) show that support occupations in health care (nursing aides, orderlies, and attendants) had the highest incidence rate of MSD cases per 10,000 workers nationwide.[6] The nurse's story in the introduction to this case study illustrates how painful—both physically and psychologically—it is to experience a serious back injury. Patient care jobs require much heavy lifting and frequent prolonged days, including evening and night shifts.[33] The greater the patient's

disability, the more frequently non-neutral body postures and overexertion are required of the worker.[34]

However, ergonomic interventions have been successfully applied to patient care tasks (see Table 5, page 28). These interventions have not only reduced injuries but also resulted in cost savings. The injured nurse cited above had this to say:[5]

> *About a year into my injury, I had done my homework. I had learned that lift teams, no-lift policies, and patient lift equipment had proven effective in preventing health care workers' back injures for at least a decade. I had been a nurse for just 10 years. The technology and methods for preventing health care workers' back injures had been available during the entire time. What an awful discovery—my injury could have been prevented.*

Successful interventions have sparked legislative initiatives. In 2003, the American Nurses Association initiated a "Handle with Care" campaign to protect both health care workers and patients against injuries. To date, this campaign has been the impetus for legislation for safe patient handling in nine states.[41] In seven of these states, there is now a comprehensive patient handling program in place: Illinois (2009), Minnesota (2009), Maryland (2008), New Jersey (2007), Rhode Island (2006), Texas (2006), and Washington (2006).[41] Hawaii has passed a resolution calling for safe patient handling.

As multiple states have already acted, the focus has turned to the federal level. In May 2009, Representative John Conyers (D-MI) introduced national legislation—the Nurse and Health Care Worker Protection Act of 2009 (HR 2381)—for the safe handling of patients and nursing home residents throughout the health care system.[42] In June 2009, the Coalition for Healthcare Worker and Patient Safety (CHAPS) was formed to support the bill. The bill is applicable to all health care settings. In particular, it directs the Department of Labor to issue an occupational safety and health standard to reduce injuries to patients and health care workers "by establishing a safe patient handling and injury prevention standard." The standard would specify "the use of engineering controls to perform lifting, transferring, and repositioning of patients and the

Manual handling and transferring of patient is a serious back injury risk to healthcare workers. However, ergonomic interventions have been successfully applied to patient care tasks and these interventions have not only reduced injuries but also resulted in cost savings.

Patient handling may require lifting a patient who is far away from the worker, placing heavy loads on the spine.

TABLE 5

Examples of ergonomic intervention studies in nursing homes and other health care facilities.

Citation in brief	Study duration/ intervention design type	Study setting/ population	Reduced lost work days or injuries	Observed cost-effectiveness
Martin et al., 2009[35]	10-year pre/post.	Nurses in 89 public health services agencies in Victoria, Australia.		24% reduction in back injury claims/1,000 full time equivalent (FTE) nursing staff.
Park et al., 2009[36]	One-year pre/post. Lifting equipment, training.	Ohio nursing home staff.	$500 equipment purchase per nursing home worker was associated with a 21% reduction in back injury rate.	Equipment: Approximately $768 reduction in claim costs per worker. Training: $1,643 reduction in back claim costs over 10 years per employee.
OSHA, 2009[27]	Zero manual lift policy. Electrically adjustable beds.	Wyandot County Nursing Home in Upper Sandusky, Ohio.	No back injuries from resident lifting have occurred in more than five years.	Workers' compensation costs reduced from an average $140,000 to less than $4,000 a year. Reduced absenteeism and overtime: annual savings approximately $55,000. Less staff turnover: additional $125,000 savings.
OSHA, 2009[27]	Zero manual lift policy.	Schoellkopf Health Center in Niagara Falls, New York.	Lost work days reduced from 364 to 52. Light duty days dropped from 253 to 25.	Workers' compensation losses fell from $84,533 to $6,983 annually.
OSHA, 2009[27]	Ergonomics added in safety and health program.	Citizens Memorial Health Care Facility in Bolivar, Missouri.	55% reduction in lost work days. Reduction in lifting-related injuries of at least 45% during each of the next four years.	Direct savings of approximately $150,000 in workers' compensation costs over a 5-year period.
Nelson et al., 2006[37]	1.5-year pre/post design. Six elements: 1) Ergonomic Assessment Protocol; 2) Patient Handling Assessment Criteria and Decision Algorithms; 3) Peer Leader Role, "Back Injury Resource Nurses"; 4) Equipment; 5) After-Action Reviews; 6) No Lift Policy.	824 nurses in 23 units: 19 nursing home units and 4 spinal cord injury units.	18% reduced injuries. Injury rate reduction: 24.0 to 16.9 per 100 caregivers.	Return on investment for patient handling equipment of 3.75 years. Annual post-intervention savings of over $200,000/year (workers' compensation, reduced lost and modified work days).
Fujishiro et al., 2005[38]	4-year pre/post. Ergonomic consultation and financial support for patient handling and lifting devices.	Health care workers in 100 work units in 86 health care facilities.	Injury rate reduction: 12.32 to 6.64 per 200,000 employee-hours.	
Collins et al., 2004[39]	6-year pre/post. Mechanical lifts and repositioning aids, a zero lift policy, and employee training on safe lift usage.	1,728 nursing home staff in 6 nursing homes.	Adjusted pre/post injury rate ratios: 0.39 for workers' compensation claims, 0.54 for OSHA 300 logs, and 0.65 for first reports of employee injury.	Investment of $158,556 for lifting equipment and worker training recovered in less than three years (annual workers' comp savings of $55,000).
Brophy et al., 2001[40]	7-year pre/post. Five-step ergonomics program and mechanical lifting devices	Nursing assistants in 525-bed county nursing home in upstate New York.	Lost work days: 1,476 to 625 per year (58%) Low back injuries among nursing aides: from 15.7 to 11.0 per 100 FTE.	Average low-back injury yearly costs from $201,100 to $91,800.

elimination of manual lifting of patients" by all health care workers.

On May 11, 2010, Senator Patty Murray chaired the US Senate Hearing on Safe Patient Handling and Lifting Standards for a Safer American Workforce.[43] Elizabeth Shoegren, an injured nurse from Minnesota, testified that, in an average eight-hour shift, a nurse on a medical/surgical unit can care for three to eight patients, resulting in lifting 1.8 tons in an average eight-hour shift. A NIOSH representative testified that manual handling of patients is a serious risk to healthcare workers. Patient handling may require lifting a patient who is far away from the worker, placing heavy loads on the spine; repeated lifting of this type can result in scarring that causes more damage. Moreover, studies have suggested that that there can be injury risks even when two people are lifting a 110-pound patient from a bed to a chair.[8,45]

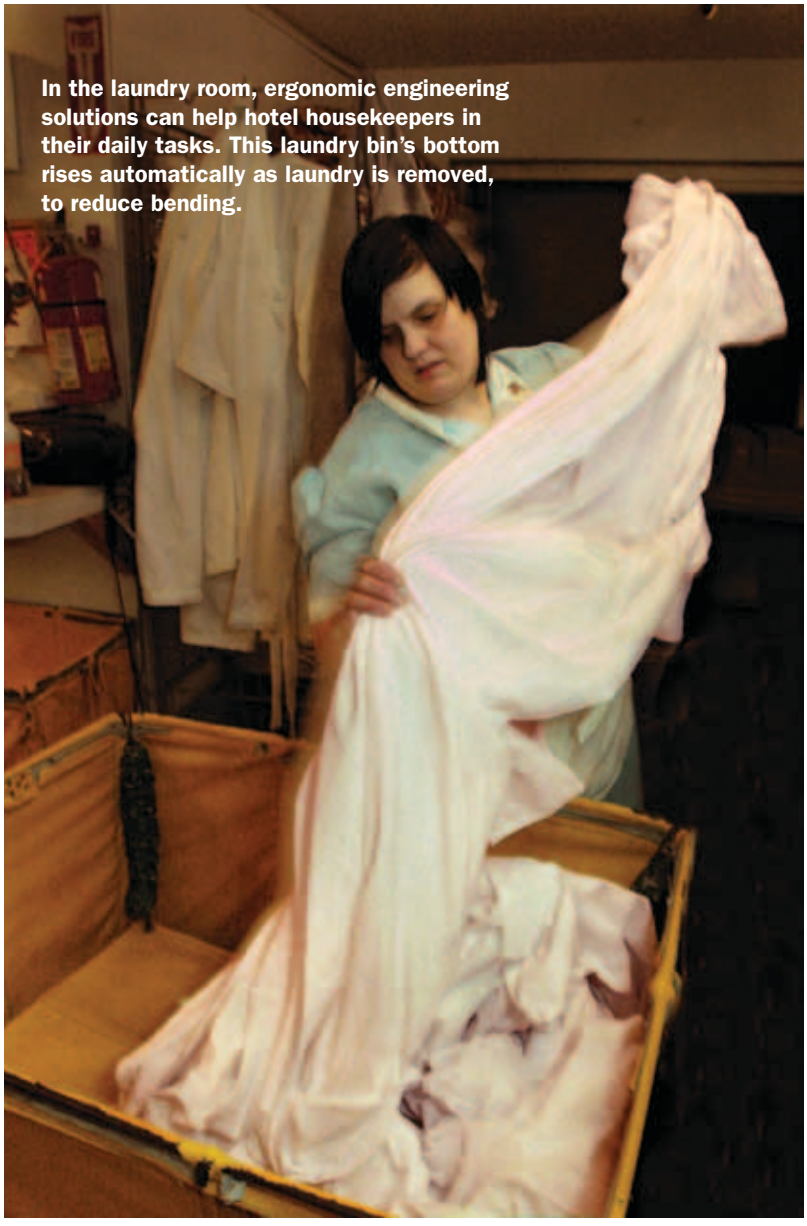
It remains to be seen how successful the House bill will be. In any case, state legislatures have momentum to continue passing safe patient handling bills that protect both health care workers and patients.

Vulnerable workers in high-strain jobs: At high risk for psychosocial hazards

While recent state-led safe patient-handling initiatives have brought renewed hope to those who advocate for workplace ergonomics policy, vulnerable workers in high-risk jobs in other sectors should not be forgotten. In particular, women from ethnic minority groups are often invisible as workers, and thus the most vulnerable to psychosocial hazards—that is, sources of mental stress in the workplace. Such psychosocial hazards often emerge from poor work organization.

The 2001 NAS panel mentioned earlier concluded that certain psychosocial workplace hazards—including rapid work pace, monotonous work, low job satisfaction, low decision latitude, and job stress—were linked in turn with low-back disorders. High job demands and job stress were linked to upper extremity disorders.[7] It has been suggested that psychosocial factors may exert their influence indirectly by altering muscle tension or other physiologic processes and decreasing micropauses in muscle activity.[1]

The Job Demand-Control Model—developed by Robert Karasek—cross-classifies jobs on psychological demands (high/low) and decision latitude (high/low), as shown in Figure 1 (page 30). Jobs in which the worker faces high psychological demands but has little decision latitude are designated high-strain jobs.[46] A high level of psychological demands on the job may contribute to MSDs—particularly in high-strain jobs, in which a worker has little ability to decide what to do, how to do a particular job task, and how to use or develop job skills.[1]



In the laundry room, ergonomic engineering solutions can help hotel housekeepers in their daily tasks. This laundry bin's bottom rises automatically as laundry is removed, to reduce bending.

Many [hotel] housekeepers' bodies today are at the breaking point because their jobs are driven by a room quota, which creates immense time pressure.

Hotel housekeeping

Hotel housekeeping is an example of a high-strain job in which workers are vulnerable to injury. Indeed, many housekeepers' bodies today are at the breaking point because their jobs are characterized by the room quota system, which creates immense time pressure. In addition to ergonomic hazards, they also face job insecurity. The firing in 2009 of nearly 100 Hyatt Hotels housekeepers—mostly immigrant women—in the Boston area prompted a reaction across the United States and raised consciousness of hotel housekeepers' working conditions.[47]

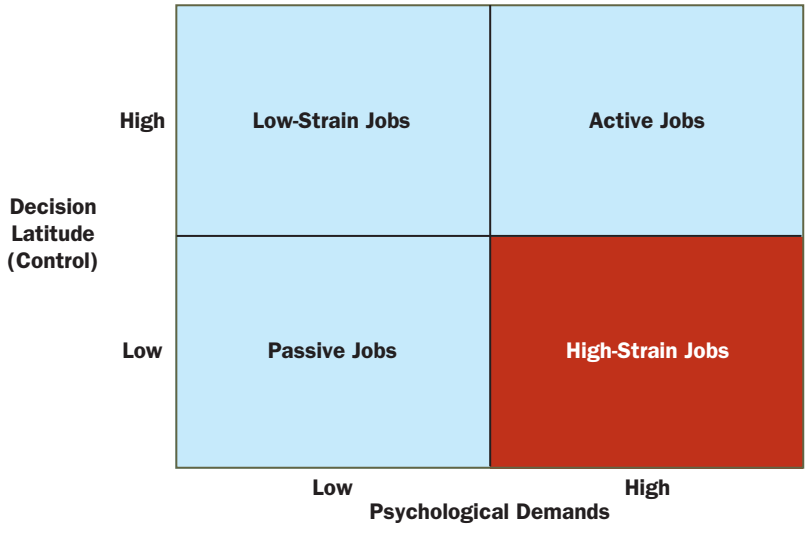
Hotel workers are 48 percent more likely to be injured on the job than the typical worker in the service sector.[48] These workers experience a similar excess of serious, disabling injuries—those that require days away from work or reassignment to light duty: they sustain disabling injuries at a rate 51 percent higher than service sector workers overall.[48] Buchanan and colleagues reported that room cleaning work was of particular concern, and that the injury rate for both traumatic injuries and non-traumatic MSDs was highest among Hispanic female housekeepers. This subgroup also had the highest rate of musculoskeletal disorders.[49]

Valessie McCaskill's story is typical of housekeeping workers' experiences in the hotel industry.[48] She had worked at the Chicago Hilton and Towers for a little over three years when the pain in her right leg became severe. "Some days my leg would swell up and I would literally limp from room to room. When the pain was at its worst, I would sit on the beds and cry because it hurt so much. In the rooms, at least no one would see me." Two years ago, an iron garbage can fell on her while she worked in a linen closet at the end of her shift. "The next day I could barely walk. On my way to work, my leg buckled and I collapsed at the employee entrance. My leg was so swollen the doctors had to cut through my pants."

Eventually, her doctors told her nearly all of the cartilage in her knee was gone and that she needed knee replacement surgery. She was out of work for five months. "The doctors told me I should stay out at least six months, but I had two teenage daughters at home to take care of. Catholic Charities helped me pay some of my rent and utility bills but I needed to go back to work before we lost everything." Today, her knee has significantly improved but she still suffers workplace pain. "Lately, the pain has been the worst in my right arm. I feel like there are needles in my fingertips. So I start every morning with a pill—Aleve, Tylenol, something to get me ready to do all the pulling and lifting."

The higher the quota, the faster the housekeeper has to work. A 16-room quota—which is not uncommon—means that the housekeeper must clean each room in less than 30 minutes to allow time to stock the cart and travel between rooms. House-

FIGURE 1
Karasek's Demand-Control Model. High-strain jobs are those with high psychological demands combined with low decision latitude.



Source: Karasek R. Theorell, T. Healthy Work: Stress, Productivity, and the Reconstruction of Working Life. Basic Books, 1990.

keepers routinely report that they must race through their tasks in order to complete them on time. When rushing to clean a slippery tub or lift a heavy mattress, workers are more likely to get hurt. Further, hotel housekeepers report that clean bed linens and towels are often understocked, and vacuums do not always work well. Such supply shortages or other practical obstacles disrupt the pace of work and consume valuable minutes. In recent years, the workload that hotel companies demand of their housekeepers has increased significantly. Chronic understaffing, coupled with the addition of time-consuming amenities—luxury items like heavy mattresses, fragile coffeepots, and in-room exercise equipment—has placed housekeepers at greater risk of injury. To complete their quotas, housekeepers are increasingly forced to skip meals and other breaks—in other words, to pass up the rest that is necessary to prevent injury.[48]

Poultry processing

Poultry processing is also a high-strain job. In northeastern North Carolina, OSHA inspectors cited two poultry processing plants for serious ergonomics problems in 1989. Work was often carried out in sustained awkward postures with repetitions—in some jobs, repetitive movements were documented at more than 30,000 per shift (roughly once per second over an eight-hour shift).[50] One of these plants was the largest employer of women in the community, located in a sparsely populated area with a black majority; nearly one-third of the population lived below the poverty level. Lipscomb and colleagues stated that these rural women were failed by the occupational safety and health systems designed to protect them. A 30-year-old single mother who had left a job in home health care to make better money in one of these poultry processing plants says:

Awkward postures, overexertion, repetitive motions, and fast-paced work to meet their daily room quotas put hotel housekeepers at a high MSD risk.

Poultry processing is a high-strain job. Work is often performed in sustained awkward postures with serious repetitions.

In some [poultry processing] jobs, repetitive movements were documented at more than 30,000 per shift (roughly once per second over an eight-hour shift).

Before I even got to the plant, they [friends and family] were like "if you ever got to the plant, your hands ain't going to be good no more." And I believe that. You ever start working in a plant, on that line, and start doing chicken stuff, your hands ain't never be the same. Sure ain't. My hands won't never be the same, probably. I don't really think about it. I would say to anybody, the plant is a job. It ain't the worst job. It ain't the best job, but it's better than sitting home, not getting no income. I say, "if you can't find nothing else, go to the plant. But let that be your LAST choice." I would tell the young people, my children, "I'm not going to tell you don't go, but let that be your last choice."[50]

Ergonomic interventions pay for themselves

As mentioned earlier, workplace ergonomic interventions have not only reduced MSDs but have resulted in cost savings. There are numerous studies and workplace examples of the effectiveness of interventions in various industries. We listed nine such studies for nursing homes and health care facilities detailed in Table 5 above. Workplace interventions may include a number of initiatives—for example, ergonomics consultations, zero-lift policies, use of ceiling lifts and inflatable transfer mats, mechanical aids for material handling, and training. Successful workplace ergonomics programs include at least these five elements: (1) leadership commitment; (2) written policy; (3) employee involvement; (4) continuous monitoring; and (5) implementing adjustments based on monitoring results.[4] In addition to leadership commitment and employee involvement, OSHA's voluntary ergonomic guidelines advocate the following program components: (1) worksite analysis; (2) hazard prevention and control; (3) medical management; and (4) training and education.[26-30]

Engineering solutions seem to be the preferred method for primary MSD hazard prevention and control.[4] NIOSH has estimated that a 100-bed nursing home facility can expect to spend $25,000 to $30,000 on portable (not ceiling-mounted) mechanical lifts, depending on how many residents require the use of a lift. A good combination of floor and ceiling lifts can be accomplished with an investment of $50,000–$60,000 in a similar 100-bed facility.[51] Cost-benefit analyses reviewed by NIOSH demonstrated that initial investments in mechanical lifting equipment and training can be recovered in two to three years through reductions in workers' compensation costs.[51]

In 2006, Washington State passed a Safe Patient Handling (SPH) law for acute care hospitals. In testimony before the US Senate Hearing on Safe Patient Handling and Lifting Standards for a Safer American Workforce, Barbara Silverstein described the following requirements and incentives of this law:[43,52]

- a joint management-worker SPH committee with at least half of the committee comprised of direct care staff;
- a needs assessment for all patient care areas;
- a minimum of one patient handling device per 10 acute care beds per unit;
- the right to refuse unsafe handling;
- an annual evaluation;
- a Department of Health audit of SPH implementation and practice;
- a tax credit equivalent to $1,000 per acute care bed for SPH equipment purchases up to $10 million total; and
- a reduced premium for those hospitals in the State Fund workers' compensation program if they have a fully implemented SPH program.

In the same US Senate Hearing, June Altaras, a nurse executive in Washington State, shared the results of the Swedish Medical Center's successful SPH program. In her testimony, she stated:[53]

> *We have developed a system that reduces workplace injuries and corresponding lost or restricted days of work, which has a direct result on our bottom line. Patient safe handling is not simply an initiative or a program or a policy, it is a culture change and as such it requires the engagement and support of front line staff in designing the approach, establishing a workflow and selecting equipment. In addition, it requires the support of senior leadership, middle management and unit experts. This is not a small undertaking, it is a long-term commitment; however, the results can be dramatic.*

Since 2007, there has been a significant decrease in the incidence of workers' compensation claims among workers at Washington hospitals but an increase among workers in nursing homes (which are not covered by the legislation).

Safe patient handling is not simply an initiative or a program or a policy, it is a culture change.

Medical management

Although the main focus must be on primary prevention of MSDs, it is essential that injured workers have access to appropriate and timely medical care. The medical management of a MSD aims at reducing and eliminating symptoms, preventing the disorder from progressing, reducing the duration and severity of functional impairment, and preventing or reducing the severity of disability.[1] A good medical management program comprises surveillance, timely access to appropriate health care providers, follow-up of treated workers, coordination with primary prevention efforts, job evaluation of injured workers, and availability of appropriate job modification.[1]

A recent study on MSDs in the European Union recommended that national governments adopt a version of the United Kingdom's *Fit Note* policy, whereby clinicians and employers are encouraged to focus on the capacity of workers with MSDs, rather than on their loss of capacity, and to improve the flow of information between clinicians and employers.[2] The vast majority of injured workers are able to return to productive work quickly as long as their job is modified to reduce physical exposures to the affected body parts.[1] Job modifications are frequently inexpensive and simple. Modified duties are meaningful to injured workers, as they would like to keep on contributing and applying their skills rather than only draining resources. However, modified duties are

not instituted smoothly. The injured nurse who was quoted earlier shared the following:[5]

> *Workers' Compensation insurance carriers might consider reducing time loss and vocational rehabilitation costs by encouraging employers to retain injured nurses—to keep those nurses who are still able to work employed in the facility where they were injured. This may be a logical piece for cost containment. [As a back-injured hospital nurse], what can I do? All of the hospital-based nursing skills listed except lifting heavy weights. Now, if I'm ready, willing, and able to perform all these skills right now, without re-training, would it not be more cost-efficient to just put me back to work, performing the skills in the facility where I was working when injured, rather than spending scarce resources on re-training and continued time loss payments?*[5]

Lifting Devices Protect Backs…and Patients

Here are two examples of patient lifting devices. Technologies like these can reduce workers' back injuries, keep patients safe and save money.

(Images provided by Vancare.)

Musculoskeletal disorders are a serious problem, not only in occupational health but also in public health more broadly. What are viable measures to protect millions of affected workers? Two are described here.

Effective MSD prevention begins with good data

Most important, it is necessary to acquire more and better data on MSDs across all economic sectors. Adequate information is the foundation for both national and worksite-level analyses. At a minimum, MSDs need to be brought back to OSHA 300 logs, and indeed the new OSHA administration proposed this in January 2010. The Assistant Secretary of Labor for OSHA, Dr. David Michaels, stated:[32]

> *Restoring the MSD column [in the OSHA 300 log for reporting work-related injuries] will improve the ability of workers and employers to identify and prevent work-related musculoskeletal disorders by providing simple and easily accessible information. It will also improve the accuracy and completeness of national work-related injury and illness data.*

Better injury records strengthen the estimates of MSD costs and savings. While restoring MSDs in the OSHA 300 log is essential, health care providers should also participate in the process of enhancing medical records so that they provide more complete evidence on MSDs.[4]

Solutions lacking the force of law do not provide enough protection for workers

In addition, although workplace ergonomics programs continue to play a key role in improving workplace ergonomics, voluntary approaches alone are weak. Workplace policies and programs do not protect workers effectively unless they are backed up by a legal obligation.

OSHA's only enforcement tool for ergonomics, the General Duty Clause, has limited power. As we review the political history of ergonomics and its timeline, it is sadly obvious that the generic (that is, all-industry-wide) ergonomics standard may not get a second chance anytime soon in Congress.

Although the OSHA Ergonomics Standard was defeated, this event did not spell the end of all legislative initiatives on ergonomics. As noted above, advocacy groups and state legislators have been exemplary in campaigning for and adopting safe patient handling legislation to protect both health care workers and patients. Such an initiative might succeed at the federal level as well. Legislative ergonomics initiatives may be most successful when they address first the high-risk tasks, then jobs, and finally entire industries.

Legislative ergonomics initiatives may be most successful when they address first the high-risk tasks, then jobs, and finally entire industries.

CASE STUDY 2 — **TIMELINE**[18]

YEAR	EVENT
1970s-80s	OSHA cites MSD hazards under the OSHAct's General Duty Clause.
1990	OSHA issues Ergonomics Program Management Guidelines for Meatpacking Plants. American National Standards Institute (ANSI) Z-365 committee formed by the National Safety Council to develop a voluntary ergonomics standard. Secretary of Labor Elizabeth Dole commits the Labor Department to "taking the most effective steps necessary to address the problem of ergonomic hazards on an industry-wide basis" and to begin rulemaking on an ergonomics standard.
1993	The Clinton Administration makes the promulgation of an ergonomics standard a regulatory priority. OSHA commits to issuing a proposed rule.
1995	The House passes its FY 1995 recission bill that prohibits OSHA from developing or promulgating a proposed rule on ergonomics. President Clinton vetoes the recission measure.
1996	The House Appropriations Committee passes a 1997 funding measure that includes a rider prohibiting OSHA from issuing a standard or guidelines on ergonomics. The rider also prohibits OSHA from collecting data on the extent of such injuries and, for all intents and purposes, prohibits OSHA from doing any work on the issue of ergonomics. The House of Representatives approves the amendment stripping the ergonomics rider. California issues its final ergonomics standard.
1997	NIOSH releases report *Musculoskeletal Disorders and Workplace Factors*. California's ergonomics regulation becomes effective. Industry groups try to disband the voluntary ANSI Ergonomics Standard committee. A new congressional budget rider: The Congress prohibits OSHA from spending any of its FY 1998 budget to promulgate or issue a proposed or final Ergonomics Standard.
1998	National Academy of Sciences releases report *Work-Related Musculoskeletal Disorders: A Review of the Evidence*.[23] The NAS panel finds that scientific evidence shows that poor workplace ergonomic factors cause musculoskeletal disorders. Congress appropriates a budget for another NAS study on ergonomics. OSHA freed from a prohibition on ergonomic rulemaking.
1999	OSHA releases its draft proposed Ergonomics Standard and it is sent for review by small business groups under the Small Business Regulatory and Enforcement Fairness Act. Industry groups call for OSHA to wait for completion of the NAS study before proceeding with an Ergonomics Standard. North Carolina OSHA adopts draft Ergonomics Rule. Washington State issues a proposed Ergonomics Rule. Federal OSHA issues the proposed Ergonomics Standard.
2000	OSHA concludes public hearings on the proposed Ergonomics Standard. For the first time, the voluntary American Conference of Governmental Industrial Hygienists (ACGIH) voluntary threshold limit values (TLVs) include an ergonomics measure (hand activity level TLV). Washington State adopts its Ergonomics Rule. Congressional budget rider for the Federal OSHA rule: The House Appropriations Committee adopts a rider to the FY 2001 Labor-HHS funding bill prohibiting OSHA from moving forward on any proposed or final Ergonomics Standard. President Clinton promises to veto the Labor-HHS bill. OSHA issues the final Ergonomics Standard on November 14. North Carolina labor commissioner adopts OSHA's final Ergonomics Standard. The Congress adopts Labor-HHS funding bill without a rider on the Ergonomics Standard.

YEAR	EVENT
2001	Ergonomics Standard takes effect on January 16. NAS releases its second report on work-related MSDs.[24] OSHA Ergonomics Standard is repealed by the Congress and the President through the Congressional Review Act in March 2001. The ACGIH TLVs to include lifting TLVs as the second ergonomics measure.
2002	Washington State Superior Court judge upholds the state's Ergonomics Rule.
2003	OSHA issues voluntary ergonomics guidelines for nursing homes. The US Department of Labor revokes both the requirement that employers identify MSDs on the OSHA 300 logs and the definition of MSDs. Washington State's Ergonomics Rule repealed by voters through an industry-funded ballot initiative. ANSI's voluntary Ergonomics Standard abandoned by the National Safety Council.
2004	OSHA holds its National Advisory Committee on Ergonomics symposium. OSHA issues voluntary ergonomic guidelines for the retail grocery store and poultry processing industries.
2006–2007	New Jersey, Rhode Island, Texas, and Washington issue safe patient handling legislation to protect health care workers.[28]
2008	OSHA issues voluntary ergonomics guidelines for the shipyard industry. Maryland issues safe patient handling legislation to protect health care workers.
2009	Illinois and Minnesota issue safe patient handling legislation to protect health care workers. The Nurse and Health Care Worker Protection Act (HR 2381)—the federal safe patient handling legislation—is introduced in the House.
2010	OSHA proposes to revise its recordkeeping regulation by restoring an MSD column on the OSHA 300 log.

Acknowledgments

We would like to acknowledge the work and documents of the following persons and organizations: (1) Drs. Barbara Silverstein and Bradley Evanoff, who co-authored the Musculoskeletal Disorders chapter in the Fifth Edition of *Occupational and Environmental Health: Recognizing and Preventing Disease* (Lippincott Williams and Wilkins, 2006); (2) The AFL-CIO for developing the original timeline for key regulatory and other policy milestones of workplace ergonomics (we have used this work for the basis of our timeline); and (3) NIOSH and OSHA for their continuing efforts on preventing work-related MSDs.

We also thank Dr. Barbara Silverstein for peer-reviewing this case study.

References

1. Silverstein, B, Evanoff, B. Musculoskeletal Disorders. In: Levy B, Wegman D, Baron S, Sokas R, (Eds.) *Occupational and Environmental Health: Recognizing and Preventing Disease and Injury*. 5th edition. Philadelphia (PA): Lippincott Williams and Wilkins. 2006. 488-516.
2. Bevan, S, Quadrello, T, McGee, et al. *Fit For Work? Musculoskeletal Disorders in the European Workforce*. 2009. Available at: *http://www.fitforworkeurope.eu/Website-Documents/Fit%20for%20Work%20pan-European%20report.pdf*. Accessed: December 3, 2010.
3. European Agency for Safety and Health at Work. *Work-related Neck and Upper Limb Musculoskeletal Disorders*. 1999. Available at: *http://osha.europa.eu/en/publications/reports/201*. Accessed: December 3, 2010.
4. Goetch, DL. Ergonomic Hazards: Musculoskeletal Disorders (MSDs) and Cumulative Trauma Disorders (CTDs). In: Helba S, (Ed.) *Occupational Safety and Health for Technologists, Engineers, and Managers.* Fifth edition. Upper Saddle River (NJ): Pearson Prentice Hall. 2005. 159-198.
5. Hudson, A. Injured Nurse Story #2: Preventable. In: Charney W, Hudson A, (Eds.) *Back Injury among Healthcare Workers: Causes, Solutions, and Impacts.* Washington DC: Lewis Publishers. 2004. 19-26.
6. Bureau of Labor Statistics, U.S. Department of Labor. *Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work, 2008*. 2009. Available at: *http://www.bls.gov/news.release/archives/osh2_12042009.pdf*. Accessed: December 3, 2010.
7. National Research Council, Institute of Medicine. *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities*. Washington DC: National Academy Press. 2001.
8. *Testimony of James W. Collins. Subcommittee Hearing - Safe Patient Handling & Lifting Standards for a Safer American Workforce*. U.S. Senate Committee on Health, Education, Labor and Pensions. Subcommittee on Employment and Workplace Safety. May 11, 2010. Available at: *http://help.senate.gov/imo/media/doc/Collins4.pdf*. Accessed: December 3, 2010.
9. Waehrer, G, Leigh, JP, Miller, TR. Costs of occupational injury and illness within the health services sector. *Int J Health Serv*. 2005;35(2):343-59.
10. Punnett, L, Pruss-Utun, A, Nelson, et al. Estimating the global burden of low back pain attributable to combined occupational exposures. *Am J Ind Med.* 2005;48(6):459-69.
11. Franco, G, Fusetti, L. Bernardino Ramazzini's early observations of the link between musculoskeletal disorders and ergonomic factors. *Applied Ergonomics*. 2004;35(1):67-70.
12. Hunter, D. *The Diseases of Occupations*. 6th edition. London: Hodder and Stoughton. 1978. 857-864.
13. Putz-Anderson, V. (Ed.). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs.* Philadelphia: Taylor & Francis. 1988.
14. European Agency for Safety and Health at Work. *Statistics*. Available at: *http://osha.europa.eu/en/statistics*. Accessed: December 3, 2010.
15. Tak, S, Paquet, V, Woskie, S, et al. Variability in risk factors for knee injury in construction. *J Occup Environ Hyg*. 2009;6(2):113-20.
16. National Institute for Occupational Safety and Health. *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*. 1997. Available at: *http://www.cdc.gov/niosh/docs/97-141/*. Accessed: December 3, 2010.
17. Michaels, D. *Doubt is Their Product: How Industry's Assault on Science Threatens Your Health*. New York: Oxford University Press. 2008.
18. AFL-CIO, Department of Occupational Safety and Health. *Chronology of OSHA's Ergonomics Standard and the Business Campaign Against it*. 2004. Available at: *http://www.aflcio.org/issues/safety/ergo/upload/chrono2004.pdf*. Accessed: December 3, 2010.
19. National Research Council, Institute of Medicine. *Work-Related Musculoskeletal Disorders: A Review of the Evidence*. Washington DC: National Academy Press. 1998.
20. Occupational Safety and Health Administration, U.S. Department of Labor. Occupational Safety and Health Administration. *Ergonomics Program* 1999. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=federal_register&p_id=16305*. Accessed: December 3, 2010.
21. Federal Register. *Congressional Review Act, Public Law No. 104-121*. 1996. Available at: *http://www.archives.gov/federal-register/laws/congressional-review/*. Accessed: December 3, 2010.
22. Silverstein, M. Ergonomics and regulatory politics: the Washington State case. *Am J Ind Med.* 2007;50(5):391-401.
23. Occupational Safety and Health Administration. *OSHA Ergonomics: Frequently Asked Questions*. 2008. Available at: *http://www.osha.gov/ergonomics/FAQs-external.html*. Accessed: December 3, 2010.
24. Levenstein, C. The politics of ergonomics. *New Solut*. 2001;11(2):89-90.
25. Frank, JW, Lomax, G. Public health action to control hazards: how good should the evidence be? Reflections on the OSHA Ergonomics Standard hearings. *New Solut*. 2002;12(1):17-23.
26. Occupational Safety and Health Administration. *Ergonomics Program Management Guidelines for Meatpacking Plants*. 1993. Available at: *http://www.osha.gov/Publications/OSHA3123/3123.html*. Accessed: December 3, 2010.
27. Occupational Safety and Health Administration. *Guidelines for Nursing Homes Ergonomics for the Prevention of Musculoskeletal Disorders*. 2009. Available at: *http://www.osha.gov/ergonomics/guidelines/nursinghome/final_nh_guidelines.pdf*. Accessed: December 3, 2010.
28. Occupational Safety and Health Administration. *Guidelines for Retail Grocery Stores: Ergonomics for the Prevention of Musculoskeletal Disorders*. 2004. Available at: *http://www.osha.gov/Publications/osha3192.pdf*. Accessed: December 3, 2010.
29. Occupational Safety and Health Administration. *Guidelines for Poultry Processing: Ergonomics for the Prevention of Musculoskeletal Disorders*. 2004. Available at: *http://www.osha.gov/ergonomics/guidelines/poultryprocessing/poultryall-in-one.pdf*. Accessed: December 3, 2010.
30. Occupational Safety and Health Administration. *Guidelines for Shipyards: Ergonomics for the Prevention of Musculoskeletal Disorders*. 2008. Available at: *http://www.osha.gov/Publications/OSHA3341shipyard.pdf*. Accessed: December 3, 2010.
31. Occupational Safety and Health Administration, U.S. Department of Labor. *OSH Act of 1970*. In: Occupational Safety and Health Administration, ed. Available at: *http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=OSHACT&p_toc_level=0&p_keyvalue=*. Accessed: December 3, 2010.

32. Occupational Safety and Health Administration. *News Release: US Department of Labor's OSHA proposes recordkeeping change to improve illness data*. 2010. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=17124*. Accessed: December 3, 2010.
33. Boyer, JC. *Ergonomic Exposures, Socioeconomic Status, and Musculoskeletal Disorder Risk Among Healthcare Workers*. Doctoral Dissertation. Department of Work Environment. University of Massachusetts Lowell. 2008.
34. Dybel, GD. *Ergonomic Evaluation of Work as a Home Health Aide: Descriptive and Epidemiological Analysis*. Doctoral Dissertation. Department of Work Environment. University of Massachusetts Lowell. 2000.
35. Martin, PJ, Harvey, JT, Culvenor, JF, et al. Effect of a nurse back injury prevention intervention on the rate of injury compensation claims. *J Safety Res*. 2009;40(1):13-9.
36. Park, RM, Bushnell, PT, Bailer, AJ, et al. Impact of publicly sponsored interventions on musculoskeletal injury claims in nursing homes. *Am J Ind Med*. 2009;52(9):683-97.
37. Nelson, A, Matz, M, Chen, F, et al. Development and evaluation of a multifaceted ergonomics program to prevent injuries associated with patient handling tasks. *Int J Nurs Stud*. 2006;43(6):717-33. Epub 2005 Oct 25.
38. Fujishiro, K, Weaver, JL, Heaney, CA, et al. The effect of ergonomic interventions in healthcare facilities on musculoskeletal disorders. *Am J Ind Med*. 2005;48(5):338-47.
39. Collins, JW, Wolf, L, Bell, J, et al. An evaluation of a "best practices" musculoskeletal injury prevention program in nursing homes.
Inj Prev. 2004;10(4):206-11.
40. Brophy, MO, Achimore, L, Moore-Dawson, J. Reducing incidence of low-back injuries reduces cost. *AIHAJ*. 2001;62(4):508-11.
41. American Nurses Association. *State Legislation on Safe Patient Handling*. 2009. Available at: *http://anasafepatienthandling.org/Main-Menu/ANA-Actions/State-Legislation.aspx*. Accessed: December 3, 2010.
42. Anderson, J. *Healthcare Workers, Others, Team Up Behind Safe Patient Handling Bill*. 2009. Available at: *http://www.ergoweb.com/news/detail.cfm?id=2362*. Accessed: December 3, 2010.
43. *Subcommittee Hearing – Safe Patient Handling & Lifting Standards for a Safer American Workforce*. U.S. Senate Committee on Health, Education, Labor and Pensions. Subcommittee on Employment and Workplace Safety. May 11, 2010. Available at: *http://help.senate.gov/hearings/hearing/?id=6a53554d-5056-9502-5da3-4d68be6b9f48*. Accessed: December 3, 2010.
44. *Testimony of Elizabeth Shogren. Subcommittee Hearing – Safe Patient Handling & Lifting Standards for a Safer American Workforce*. U.S. Senate Committee on Health, Education, Labor and Pensions. Subcommittee on Employment and Workplace Safety. May 11, 2010. Available at: *http://help.senate.gov/imo/media/doc/Shogren.pdf*. Accessed: December 3, 2010.
45. Marras, WS, Davis, KG, Kirking, BC, et al. A comprehensive analysis of low-back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. *Ergonomics*. 1999;42(7):904-26.
46. Karasek, R, Theorell, T. *Healthy Work: Stress, Productivity, and the Reconstruction of Working Life*. Basic Books. 1990.
47. Navin, M. *Service Workers Jobs "Outsourced"*. Radio Boston United States: Radio Boston, WBUR. 2009. Available at: *http://www.wbur.org/2009/10/02/service-workers-jobs-outsourced*. Accessed: December 3, 2010.
48. Hotel Workers Rising. *Creating Luxury, Enduring Pain: How Hotel Work is Hurting Housekeepers*. 2006. Available at: *http://www.hotelworkersrising.org/media/Injury_Paper.pdf*. Accessed: December 3, 2010.
49. Buchanan, S, Vossenas, P, Krause, N, et al. Occupational injury disparities in the US hotel industry. *Am J Ind Med*. 2010;53(2):116-25.
50. Lipscomb, HJ, Dement, JM, Epling, CA, et al. Are we failing vulnerable workers? The case of black women in poultry processing in rural North Carolina. *New Solut*. 2007;17(1-2):17-40.
51. National Institute for Occupational Safety and Health. *Safe Lifting and Movement of Nursing Home Residents* 2006. Available at: *http://www.cdc.gov/niosh/docs/2006-117/*. Accessed: December 3, 2010.
52. *Testimony of Barbara Silverstein. Subcommittee Hearing – Safe Patient Handling & Lifting Standards for a Safer American Workforce*. U.S. Senate Committee on Health, Education, Labor and Pensions. Subcommittee on Employment and Workplace Safety. May 11, 2010. Available at:*http://help.senate.gov/imo/media/doc/Silverstein.pdf*. Accessed: December 3, 2010.
53. *Testimony of June Altaras. Subcommittee Hearing – Safe Patient Handling & Lifting Standards for a Safer American Workforce*. U.S. Senate Committee on Health, Education, Labor and Pensions. Subcommittee on Employment and Workplace Safety. May 11, 2010. Available at: *http://help.senate.gov/imo/media/doc/Altaras.pdf*. Accessed: December 3, 2010.

Tests of lung function given to workers in the microwave popcorn factories showed rapid deterioration of breathing ability, ultimately linked to breathing the flavoring compound diacetyl.

CASE STUDY 3

The Poison that Smells Like Butter:
Diacetyl and Popcorn Workers' Lung Disease

Molly M. Jacobs, David Kriebel, Joel Ticker

"My name is Eric Peoples. I was born in Joplin, Missouri and raised in Carthage, Missouri where I presently reside. I am 35 years old and have been married to Cassandra Peoples for 14 years. I have two children, Adrianna, age 13 and Brantley, age 11. I have bronchiolitis obliterans. Bronchiolitis obliterans is a severe, progressive disease of the lung which has robbed me of my health, deprived my wife of a husband and my children of a Daddy.

". . . I went to work at the Jasper Popcorn Company in the fall of 1997 and left in March, 1999. I would give anything to have known then what I know now. At that time I was in perfect health, looking forward to a long, healthy life. The plant was run by local people and was one of the best jobs in the area. My co-workers were kind, honest people and treated me well the entire time I worked there.

". . . Let me bring it home to you if I can. I have a 24% lung capacity. I am currently on the inactive Lung Transplant registry. One case of pneumonia could cause me to need the transplant now. The average rate of survival for someone with a lung transplant is about five years. 75% of lung transplant patients are dead after 10 years.

"One of the doctors who worked on the first case involving the two workers with bronchiolitis obliterans in 1990 said that the flavoring industry was using workers as 'blue collar guinea pigs.' I played by the rules. I worked to support my family. This unregulated industry virtually destroyed my life. Don't let it destroy the lives of others. These chemicals that are used on food in large scale production must be tested and proper instructions and labeling supplied with their sale."

— Statement of Eric Peoples to the House Committee on Education and Labor, 2007[1]

FIRST DESCRIBED IN 1835, *BRONCHIOLITIS obliterans* is a life-threatening and irreversible lung disease. It is a rare disease—most chest doctors see only a handful of cases in their careers. In individuals with *bronchiolitis obliterans*, the airways of the lungs are inflamed and scarred, resulting in severe shortness of breath and a dry cough.

Popcorn worker Gerald Morgan described living with *bronchiolitis obliterans* this way: "Take four bulldozers and put them on your chest. Then put an elephant on top of those bulldozers."[2]

Yet Eric Peoples' disease started out, as many do, as "unremarkable." Patients first present with a non-productive cough or shortness of breath, symptoms that may not be recognized as serious at the beginning. Only 10 months after working in the mixing room of the Jasper Popcorn Company, Eric Peoples developed symptoms that he thought were simply the result of a cold or the flu.[3] As he

> ***"Take four bulldozers and put them on your chest. Then put an elephant on top of those bulldozers."***

described his illness at that time, "We tried to treat it with over-the-counter medications, and nothing seemed to work."[4] Peoples' doctors first diagnosed him with pneumonia. When his symptoms didn't improve, he saw a specialist and was given a diagnosis of asthma.[3] When Peoples was hospitalized for continued breathing difficulties, further tests revealed *bronchiolitis obliterans*.[3] The 27-year-old was told that there was no cure and that he would need a double lung transplant to survive.[3]

Unlike many lung diseases, *bronchiolitis obliterans* is not caused by smoking. It's a poorly understood and uncommon disease, linked to severe viral infections, some bad drug reactions, and, in a small number of prior cases, exposure to strongly irritating vapors or gases like ammonia, sulfur dioxide, and chlorine.[5,6] Because of the tragic stories of Eric Peoples and a handful of other workers, researchers have now added a food flavoring chemical, diacetyl, to the list of agents linked to this disease.

The disease cluster

In early 2000, a lawyer, whose mother had fallen ill working at the same popcorn plant as Eric Peoples, showed the medical records of several workers to Dr. Allen Parmet, a Kansas City physician who specializes in occupational hazards.[3] Immediately seeing a pattern, given the rarity of *bronchiolitis obliterans*, Dr. Parmet wrote to the Missouri Department of Health and Senior Services (MoDHSS) in May 2000, reporting eight cases of *bronchiolitis obliterans* among former workers of the Jasper Popcorn Company, a microwave popcorn manufacturer, now the Gilster-Mary Lee Corporation.[7,8] Dr. Parmet's letter also stated that 20 to 30 former employees might have respiratory symptoms suggestive of subclinical bronchiolitis.[7] MoDHSS sought assistance from the National Institute for Occupational Safety and Health (NIOSH) as it proceeded with its investigation of the cases and also alerted the Occupational Safety and Health Administration (OSHA) on May 19, 2000 requesting that OSHA, ". . . inspect the facility for compliance with your regulations. As a regulatory agency, we believe that you can more promptly address this situation, and if there is an obvious hazard to workers, address it quickly."[7]

OSHA's initial response

A few days later, on May 23, 2000, an OSHA inspector was sent to the Gilster-Mary Lee Corporation popcorn plant. In the inspection report, the inspector noted that company management had only recently become aware of the potential hazard in their facility when told by a workers' compensation attorney that there were eight former employees with breathing problems.[9] Even though company management seemed to dismiss claims of work-related illness, they had asked their insurance carrier to sample the plant for dust.[9] The results were well below the allowable level set by OSHA.[9] Seeing these results, the OSHA inspector conducted no additional dust sampling, because it was his "professional opinion that it would be ludicrous to re-sample the area again."[9] Samples of respirable oil mist were collected and sent to an OSHA lab in Salt Lake City.

Yet the lab did not test the samples, indicating that "OSHA's sampling method for oil mist pertained only to oil mist particulate off gassed from petroleum based oils not vegetable food grade oils."[9] The inspector "determined the company to be in compliance and closed out the case file since

ABOUT THIS CASE STUDY

This case study tells the story of disabling and potentially fatal lung disease among workers exposed to butter flavoring chemicals. The case study follows the chronology of the story as it unfolded, revealing the response by federal and state agencies and the factors that influenced their actions, or lack thereof, to protect workers. This case points out the challenges of chemical-by-chemical regulation spanning multiple agency jurisdictions, and highlights the essential role played by occupational/environmental health specialists on the front lines of detecting and minimizing harm to workers.

there were no other OSHA sampling protocols at his disposal to test further at the plant."[9] OSHA's primary approach to protecting workers is enforcing specific standards. Where there is no standard, OSHA historically has taken only limited action despite its general duty to protect workers.

NIOSH investigates

NIOSH has a different mission—it is charged with investigating hazards and making general recommendations for improving workplace health and safety, including recommendations to OSHA; it has no enforcement powers of its own. Working with MoDHSS, NIOSH investigators quickly determined that the eight sick employees worked primarily in just two production areas of the plant—they had worked either as mixers or as microwave-packaging workers. Based on the presence of eight affected workers, NIOSH and MoDHSS calculated a 5- to 11-fold excess of occupational lung disease compared to what would be expected based on national surveillance data.[8]

In November 2000, the government agencies broadened their investigation to include all current workers at the Jasper plant. They found that the workers had nearly three times the rates of chronic cough and shortness of breath that would be expected based on national data, and twice the rates of physician-diagnosed asthma, and chronic bronchitis.[10]

These early NIOSH and MoDHSS worksite investigations could not identify any known substance to explain the illnesses.[8] Yet because the risk of permanent lung damage was concentrated among mixers and packaging workers, NIOSH issued interim recommendations (with no legal force) in December 2000 that all workers wear respirators until further notice.[8]

As part of the November 2000 survey, NIOSH and MoDHHS also took samples of the worksite air. Samples detected respirable dusts and volatile organic compounds, which were primarily ketones, including diacetyl.[11] Mixing area employees' exposures to diacetyl were 17 to 1,000 times greater than exposures of other employees at the plant, whereas the difference in exposure to respirable dusts was less than 10-fold between the least and most exposed groups.[11] This prompted health investigators to take a closer look at diacetyl.

Diacetyl: Generally recognized as safe?

Diacetyl (also called 2,3-butanedione) occurs naturally in trace quantities in dairy products, fruit, and wine.[12] The microwave popcorn industry found that it made a good butter flavoring and increased the amount of diacetyl in its flavorings for a more intense butter taste.[12] The compound was first identified by the noted scientist Louis Pasteur in the 1860s in his research on the fermentation of beer and ale.[12] In the early 1900s, scientists realized they could inexpensively synthesize diacetyl from methyl ethyl ketone.[12] It is estimated that diacetyl is now added to more than 6,000 food products, including baked goods, beverages, candy, chips, and frozen dinners.[12] Neither OSHA nor NIOSH has required or recommended limits for diacetyl in workplace air that would ensure the safety of workers handling the chemical.[13]

As a chemical in food, diacetyl is regulated under the authority of the federal Food and Drug Administration (FDA). In general, food additives require premarket approval by FDA to ensure that they are safe for their intended use.[14] There's an important loophole, though. Substances that are *generally recognized as safe (GRAS)* are not considered "food additives" and thus do not require premarket FDA approval.[15]

According to the FDA, a substance is determined to be to be GRAS if information about the substance is widely known and if there is consensus among qualified experts that available information indicates that the substance is safe under the conditions of its intended use. For substances used in food before 1958, a GRAS determination can be made through experience based on common use in food.[14]

Diacetyl has been considered GRAS since 1980, when an FDA review committee examined two toxicity studies—neither using humans and neither having any relevance to lung disease—and made the determination that: "There is no evidence . . . that demonstrates or suggests reasonable grounds to suspect a hazard to the public when [diacetyl is] used at levels that are now current or that might reasonably be expected in the future."[16] The two studies that formed the basis of this determination were a test of mutagenic activity in cells cultured in the lab and an animal feeding study looking for

evidence of teratogenicity (effects on the fetus). Each study demonstrated no effect.

With hindsight, we can see a missed opportunity to prevent the cluster of lung disease cases in the microwave popcorn plants when, in 1994, the National Institute for Environmental Health Sciences' National Toxicology Program (NTP) nominated diacetyl for mechanistic, metabolism, and carcinogenicity studies based on ingestion.[17] With very limited funds available for this program, NTP can test only a few chemicals each year, and diacetyl was ultimately dropped from consideration in 1999. However, based on its initial testing, NTP acknowledged "the potent irritant properties of this chemical."[17] Even if diacetyl had been subjected to a larger battery of tests, these might not have found evidence of lung toxicity, because as a food additive, the focus of NTP's additional testing focused on risks from ingestion, not from inhalation.[17]

The more diacetyl a worker had breathed, the worse his/her lung function was.

Why were workers allowed to breathe very high concentrations of a toxic chemical? There were no workplace standards controlling its use, and no evidence that it would be harmful to workers. And, in the absence of any evidence that it was harmful, it was considered safe. Not until 2007, seven years after the Jasper, Missouri cluster was identified, did the NTP begin long-term animal testing, including respiratory toxicity testing, of diacetyl, based on a request by the United Food and Commercial Workers International Union (UFCW).[17]

First links between respiratory illness and butter flavoring chemicals

The NIOSH and MoDHHS survey of the Jasper popcorn factory in November 2000 found the diacetyl concentration in the air of the mixing tank room to average 18 parts per million (ppm). An intermediate concentration, 1.3 ppm, was documented in the packaging area, and lower but still detectable levels (averaging 0.02 ppm) were detected in other areas of the plant.[8] Short-term "peak" concentrations in the popcorn production areas in general were as high as 98 ppm.[11]

This investigation also considered the health of workers, and it didn't just focus on the eight cases of the serious lung disease, *bronchiolitis obliterans*, but examined all the workers to see if there was evidence of a gradient of lung damage in the workforce generally. And there was: rates of symptoms of deep lung damage (such as chronic cough and wheeze) were found to track closely with where a worker spent most of his/her time working.[10] Measurements of breathing capacity across the workforce at Jasper showed the same thing—the more diacetyl a worker had breathed, the worse his/her lung function was.[8,10]

This was particularly strong evidence of diacetyl's danger. Not only was diacetyl linked directly to a handful of cases of disabling lung disease in the most heavily exposed, but it seemed also to have significant pulmonary health effects on those with lower levels of exposure. This meant that there could be thousands of "silent" cases of illness spread across industry, wherever diacetyl was being used.

NIOSH moves forward

In January 2001, NIOSH assisted Gilster-Mary Lee to improve ventilation, thus dramatically decreasing diacetyl concentrations in the mixing and packaging areas and reducing the risk of *bronchiolitis obliterans* in that plant.[11]

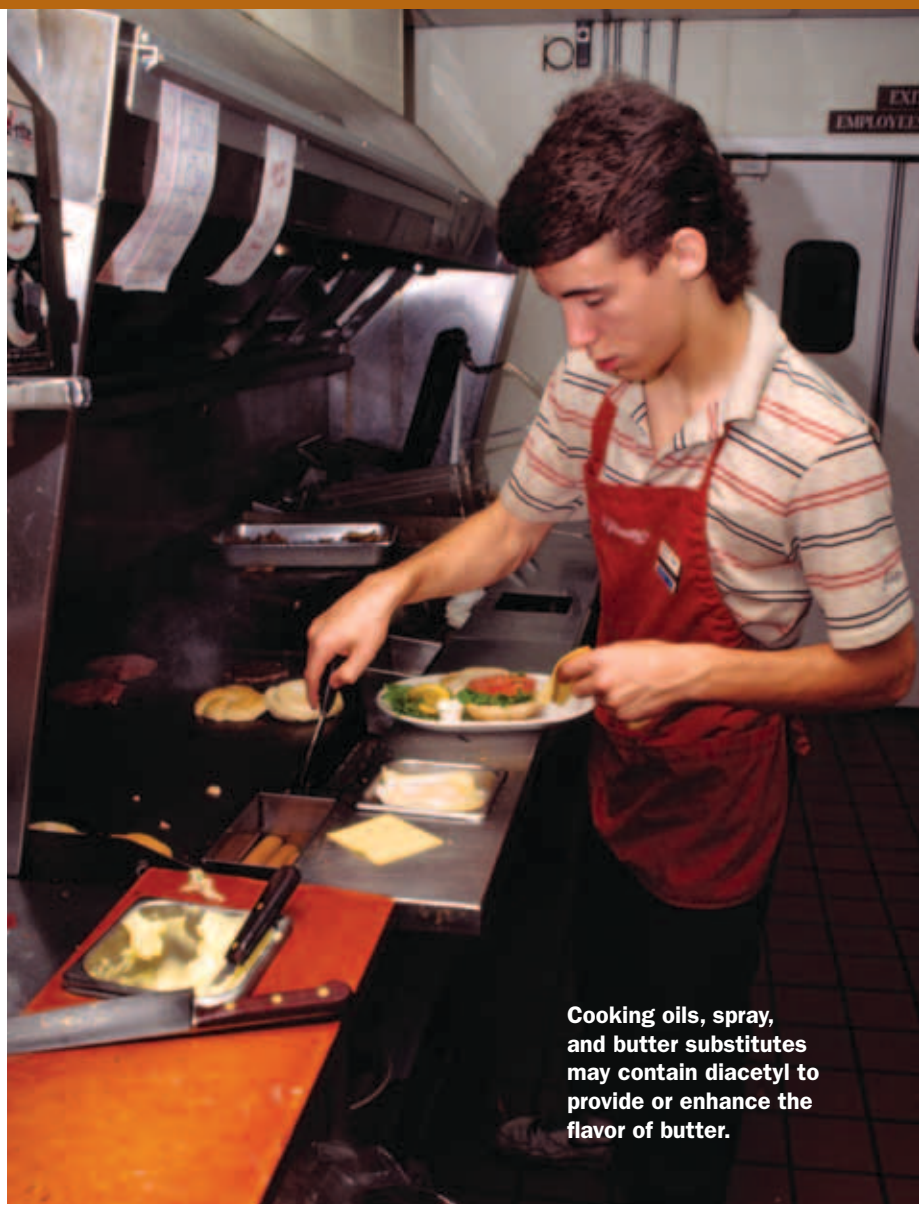
Eight months later, NIOSH issued its interim report on the investigations at the Gilster-Mary Lee plant. It provided evidence that the butter flavoring mixture containing diacetyl and other volatile organic compounds caused damage to the lungs of rats that was consistent with the way that *bronchiolitis obliterans* attacks human lungs.[11] NIOSH promptly shared its findings with workers at the plant in September 2001. The Institute's fact sheet began with the warning: "There is a work-related cause of lung disease in this plant. We at NIOSH believe the problem is continuing even after the company made changes that we recommended."[18]

In 2002, NIOSH published the first of several toxicological studies in which rats were exposed to airborne concentrations of butter flavoring similar to those found in factories.[19] There was substantial lung damage in the rats, described by the lead researcher, Dr. Ann Hubbs, as "the most

dramatic cases of cell death ever seen in some tissues."[20] Subsequent toxicological studies published in 2006 exposed rats to pure diacetyl and found similar results.[21]

Unbeknownst to NIOSH researchers at the time, the German chemical manufacturer BASF had previously conducted an acute inhalation toxicology study, published as an internal report in 1993, that exposed rats to diacetyl for a single four-hour period. The results—which were never published in the scientific literature or reported to any government agency, but emerged during the legal trials of the cases brought by the Gilster-Mary Lee workers—found that in rats, "[exposures at the] mid and high concentrations resulted in an abundance of symptoms indicative for respiratory tract injury."[22,23]

NIOSH also conducted similar medical and industrial hygiene evaluations in five other microwave popcorn plants. Results similar to those at the Gilster-Mary Lee plant were found: the prevalence of respiratory symptoms and the prevalence of airway obstruction were higher among workers in mixing operations and in packaging areas near tanks of oil and flavorings.[24] Among the important findings from these five plants was documentation of airway obstruction in a worker in the flavoring mixing area where the diacetyl concentrations were relatively low—less than 1.0 ppm. This suggested to NIOSH that the "safe" level in air must be well below this concentration.[24]



Cooking oils, spray, and butter substitutes may contain diacetyl to provide or enhance the flavor of butter.

Where was OSHA?

It is often NIOSH that takes the lead to better characterize an occupational health problem and recommend solutions when a new and unknown workplace hazard emerges. Yet these solutions are simply recommendations. Only OSHA has the regulatory authority to enforce NIOSH's recommendations. In contrast to NIOSH, whose scientists made successful efforts to identify hazards and to minimize new cases of respiratory illness among microwave popcorn manufacturing workers, OSHA watched and waited.

Sixteen months after the OSHA inspector had, in effect, closed out the case at the Gilster-Mary Lee facility, an attorney representing several of the sick workers filed a complaint with OSHA, and followed up with another complaint in December 2001. As detailed in a case study of popcorn workers' lung produced by the Project on Scientific Knowledge and Public Policy, the attorney's letter "alleged that not enough had been done to improve ventilation in the plant, as evidenced by the fact that 'one employee lost half of his lung capacity working in the plant *after* the remedial measures that NIOSH suggested were taken' (emphasis in original)."[25]

This prompted OSHA to send another inspector to visit the plant, but the inspector did not conduct an inspection. OSHA then sent a letter to the attorney who had filed the complaints, denying the need for further investigation at the plant. The letter explained: "[T]he hazard which you brought to our attention has been corrected and . . . Gilster *[sic]* Mary Lee is complying with the

recommendations of NIOSH. . . . The hazard does not fall within OSHA's jurisdiction because there is no Permissible Exposure Limits *[sic]* for the food blend chemicals of concern that are used at the factory."[25] But this reasoning is clearly flawed. The lack of a specific standard for diacetyl may limit OSHA's specific regulatory power, but not its authority to ensure that workplaces are safe.

The Occupational Health and Safety Act of 1970 created OSHA and gave it the authority to ensure that workplaces are free from "recognized hazards." Specific standards for individual chemicals are only one way to achieve this. When faced with a hazard for which no standard exists, OSHA has the authority to issue an emergency temporary standard or to invoke the "general duty clause" that requires employers to reduce or eliminate recognized hazards. Yet OSHA's legal advisors within the Department of Labor's Office of the Solicitor often prevent OSHA from taking such actions. The Bush administration's Department of Labor was not interested in having OSHA use its authority under the general duty clause to protect workers from diacetyl exposure. Further, OSHA also denied a petition for emergency temporary standards filed jointly by the United Food and Commercial Workers Union and the International Brotherhood of Teamsters.

In contrast to NIOSH, whose scientists made successful efforts to identify hazards and to minimize new cases of respiratory illness among microwave popcorn manufacturing workers, OSHA watched and waited.

In September 2002, OSHA entered into an alliance with the Popcorn Board, a trade group, to promote hazard communication and outreach efforts to at-risk workplaces.[25] Yet six months later, in March 2003, the alliance ended for reasons unknown, even though concern about exposures to diacetyl and other artificial butter flavoring compounds in the microwave popcorn manufacturing industry was peaking.[25] OSHA began inspecting facilities to control hazards associated with diacetyl exposure only in 2006, six years after it was first alerted to the problem, five years after NIOSH first identified the likely risk factor contributing to the respiratory disease, and four years after strong incriminating evidence emerged from NIOSH's animal studies, showing that diacetyl was the most likely culprit.[26]

Regulation by litigation

As one legal analyst has written about this juncture in the diacetyl story, "In the face of regulatory paralysis and scientific uncertainty came trial lawyers."[27] Workers can't usually sue their employers when their jobs make them sick—workers' compensation laws bar such direct suits. But lawsuits can be filed against the companies that produced the hazardous chemicals—in this case, the diacetyl-containing butter flavorings. Such actions are known as "third-party" suits.[27]

Legal action against the manufacturer of diacetyl

International Flavors and Fragrances (IFF), Inc. acquired the original manufacturer of the butter flavoring used by Gilster-Mary Lee Corporation in 2000. A class action lawsuit was filed against IFF by the Gilster-Mary Lee workers and their spouses in September 2001 alleging that IFF and its corporate predecessor, Bush Boake Allen, Inc. had manufactured butter flavoring that caused their injuries.[28] A trial date was set for March 1, 2004.[28] After complex legal maneuvering separated individual injured worker's claims from the class action, a Missouri jury took just over three hours to deliver a verdict in favor of Eric and Cassandra Peoples. IFF was ordered to pay $18 million to Eric Peoples and $2 million to his wife.[4] During the trial, the plaintiffs argued that IFF had failed to warn Gilster-Mary Lee employees about the dangers of the butter flavorings or to provide adequate safety instructions.[27] IFF argued that diacetyl was not the cause of Peoples' disease, and that even if it was, harm was caused by his improper handling of the chemical.[27] As stated by IFF's attorney in closing arguments, information sent to microwave popcorn plant officials warned that the flavoring should be mixed in a well-ventilated area and that a respirator should be worn when heating it. "We know beyond a shadow of doubt that if you use basic hygiene practices, you don't

> ***"Into the void left by regulatory paralysis and scientific uncertainty came trial lawyers."***

have a problem in this plant."[4] Eric Peoples, however, noted that plaintiff's attorneys had acquired during discovery detailed information that demonstrated IFF's failure to warn Gilster-Mary Lee Corporation of the real harms of diacetyl:[1]

> *The company that supplied the butter flavor, Bush Boake Allen…[acquired by IFF] had extensive notice about the hazards of butter flavor. They treated butter flavor as a hazardous chemical within their own plant. Since at least 1994 their own workers were required to wear respiratory protection when working around the butter flavor. Despite wearing full-face respirators, many of their employees suffered severe eye injuries. Because of the dangers of the product, the entire manufacturing process was enclosed so no one could be exposed to the vapors. In addition, information had come to IFF about the respiratory effects of exposure to diacetyl. In 1986, two employees of a baking company had been diagnosed with bronchiolitis obliterans while mixing a butter flavoring for use on cinnamon rolls.*
>
> *. . . Despite all this information the buckets containing this product said the product was safe. The Material Safety Data Sheets said the product had "no known health hazards" and that's what I believed.*

Between spring and summer 2005, IFF suffered many verdicts against it, and by November 2005 it had settled with 54 microwave popcorn plant workers.[2] All cases severed from the original class action were settled.[27] Today, hundreds of cases in several states are still pending. In August 2010, a jury in Chicago awarded another Jasper popcorn plant worker with *bronchiolitis obliterans* a $30.4 million verdict.[29]

The early litigation results and rising consumer concern about the safety of microwave popcorn probably played a role in the decision by leading microwave popcorn manufacturers to eliminate diacetyl from their products in 2007, as described below.[30]

Successful regulation by litigation? Not so fast

The diacetyl legal cases were rather quickly tried and settled compared to many other "toxic torts," cases. In toxic tort cases, plaintiffs claiming harm bear the burden of proving causation by a preponderance of the evidence. The diacetyl plaintiffs thus had the burden of demonstrating that their lung problems would not have developed without their exposure to diacetyl, and that their disease should have been foreseen by their employer.[27]

Demonstrating that an industrial or environmental chemical exposure was the cause of a plaintiff's disease is not an easy task. The legal requirement to demonstrate "factual" causation is inherently difficult because of scientific uncertainty: no matter how much we study the health effects of a chemical, uncertainties in our knowledge linger, given the complexities of the human body and limitations in the design of observational and even experimental studies.

Science by its very nature never operates in absolute certainties, but by the weight of the evidence. Despite this tenet of science, companies being sued in toxic torts often raise the specter of doubt by focusing on the limitations and uncertainties in the scientific evidence.[31] These uncertainties are magnified further in cases when the plaintiff's disease has a long latency period (like cancer) or when the disease might also have been caused by some common exposure (like smoking).

In addition, in federal courts and in some state courts that follow the Supreme Court's *Daubert* decision, judges have the authority to decide—often pretrial—whether expert evidence is sufficiently scientific to merit consideration in the case.[a] While judges have always maintained the authority to determine the admissibility of evidence, *Daubert* courts apply a more rigorous standard of evidence

a *Daubert v. Merrell Dow Pharmaceuticals, Inc. (1993) directed federal judges to serve as "gatekeepers" of expert testimony. In a subsequent 1997 decision in General Electric v. Joiner, the Supreme Court set a high bar for overturning trial judges' decisions about admissibility of expert testimony: appellate judges were to uphold trial judges' decisions unless they could find that the trial judge had abused his discretion. In 1999, the Supreme Court clarified in Kumho Tire v. Carmichael that it intended Daubert to apply to all expert testimony, not just evidence that relies on science. These three cases are known as the Daubert Trilogy. See Berger, MA. What has a decade of Daubert wrought? American Journal of Public Health. 2005:95:S59-65.*

and determine whether specific scientific expert testimony is both "relevant" and "reliable." Because plaintiffs bear the burden of proof, defendants often file a *Daubert* motion first, calling into question the relevance and reliability of the plaintiff's expert scientific testimony. These evidentiary standards are a giant hurdle for plaintiffs to surpass.[32] Judges have routinely misinterpreted scientific uncertainty to mean that specific evidence is "irrelevant" or "unreliable," and have thus supported a defendant's motion for summary judgment, by which cases are dismissed before ever being heard before a jury.[33]

Science by its very nature never operates in absolute certainties, but by the weight of the evidence.

As legal scholars have noted, the diacetyl cases did not exhibit the barriers typical of most toxic tort cases.[27] While scientific uncertainty linking health harms associated with diacetyl remains—as it does for nearly every exposure-disease association—*bronchiolitis obliterans* is a rare disease with only a few known causes. Rule out other known risks, such as organ transplantation and exposure to other toxic fumes, and you're left with only one likely cause: diacetyl. And unlike many diseases, *bronchiolitis obliterans* has not been linked to smoking.

In addition, breathing diacetyl leads to severe, disabling lung disease without much of a time lag, and this simplifies the investigation of causal risk factors. Lastly, Eric Peoples' case and the other initial Gilster-Mary Lee Corporation employees' cases against IFF were filed in state courts not subject to evidentiary standards under the *Daubert* decision.

Thus, while our tort law system worked to provide a remedy for harms incurred by diacetyl-exposed workers, and may have ushered in a move towards eliminating this hazard in the absence of regulation by our federal and state governments, regulation by litigation is not a solution for the vast majority of toxic harms facing workers. Even though a successful toxic tort claim prevented future cases of disease, it can't restore Eric Peoples' lungs. Clearly, the best solution is to identify and replace toxic chemicals before they enter the economy.

The hierarchy of industrial hygiene controls: when substitution isn't safe

NIOSH follows a well-established hierarchy of industrial hygiene controls when making recommendations to control workplace hazards. An employer is typically urged to start at the top of the list and try to control the hazard there, before moving down to a less effective strategy. The NIOSH hierarchy for diacetyl looks like this:[13]

1. Substitute a nonhazardous flavoring for the hazardous one.
2. Use engineering controls such as a closed production system, isolated mixing rooms, or very good local exhaust ventilation.
3. Make administrative changes to reduce exposures, such as enforcing procedures for safe handling, attention to maintenance, and rapid cleaning of spills.
4. Improve training and provide better information about the hazard and ways to avoid it.
5. Provide personal protective equipment such as respirators and gloves.
6. Monitor exposures and workers' health.

The hierarchy of industrial hygiene controls for diacetyl, like those for most other industrial chemicals, puts substitution at the top because, if the chemical is eliminated, it can't do any harm—there's no need to worry about whether the ventilation system is being properly maintained, or whether each worker is using his/her respirator properly, for example.

But in its warning to popcorn manufacturers in 2003, NIOSH skipped substitution in its recommendations: "Engineering controls are the *primary* method for minimizing exposure associated with the use or manufacture of potentially hazardous flavoring."[13] Why? NIOSH was likely worried that so little was known about the safety of flavorings that the manufacturers might choose a substitute chemical for which there was no evidence of risk, but which later turned out to be just as hazardous as diacetyl.

This is a serious systemic flaw in the way chemicals are regulated today. So few of the chemicals in commerce have been adequately tested that substi-

tution may be a risky proposition. The Government Accountability Office (GAO) has called the Environmental Protection Agency's (EPA's) meager record in assessing the toxicity of chemicals—among the tens of thousands in commerce—a "high risk" issue for public health.[34] Safe workplace exposure limits (either OSHA's Permissible Exposure Limits (PELs) or NIOSH's recommended Exposure Limits (RELs)) have been developed for fewer than 5 percent of the 1,037 flavoring ingredients that have the potential to be respiratory hazards based on their volatility and irritant properties.[13]

Despite this context, substitution is precisely what many microwave popcorn manufacturers did. In 2007, Pop Weaver and ConAgra, the two largest suppliers of microwave popcorn, announced that they were eliminating diacetyl from their products.[30] Two other suppliers, General Mills and American Pop Corn, subsequently followed the same course of action, each stating they were on the road to "eliminating" diacetyl from their recipes, or had already done so.[35]

But they didn't eliminate the hazard. The "new, safer, butter substitutes" in some cases are at least as toxic as diacetyl, and in other cases are essentially diacetyl by another name.[36] "Diacetyl trimmer" releases diacetyl in the presence of heat and water; and "butter starter distillates (starter mix)" contains high concentrations of diacetyl.[36]

"We've been very clear to flavor manufacturers, food companies and regulators that the so-called substitutes are diacetyl," said John Hallagan, general counsel for the Flavor and Extract Manufacturers Association.[36] On December 23, 2009, NIOSH Director John Howard sent a letter to David Michaels, the new Assistant Secretary of Labor for OSHA, stating that research at NIOSH and the National Institute of Environmental Health Sciences addressing the respiratory toxicity of diacetyl substitutes demonstrates that the principal component of one such substitute, 2,3-pentanedione, has very similar animal toxicity to that of diacetyl. Moreover, another substitute, acetoin, lacks toxicity testing data and "accompanies diacetyl in many of the workplaces where *bronchiolitis obliterans* occurs in workers who make or use flavorings."[37]

While substitution is the preferred approach to protect not only workers but also the broader

Bronchiolitis obliterans—a lung disease as frightening as it sounds—was diagnosed in a cinema employee who routinely popped dozens of bags of microwave popcorn to fill a dispenser like this.

public from chemical hazards, it's dangerous to pick substitutes without a thorough overhaul of our system to manage the safety of chemicals in commerce. Even limited evidence of hazard from a chemical should stimulate the search for safer alternatives. Designed correctly, chemical regulations can stimulate scientific research and technological innovation. But at present, the United States has a disjointed collection of overlapping jurisdictions for chemicals, and a system that tends to treat hazards as "safe until proven hazardous"—just the opposite of what is needed to protect workers and the public. Tragically, the doctor quoted by Eric Peoples was right when he said that workers are our nation's "blue collar guinea pigs."[1]

What is the true scope of diacetyl's impact?

From the public health perspective, Eric Peoples and the other Gilster-Mary Lee workers made sick by diacetyl are sentinels: their experience raised the alert about this chemical. But a much larger group of people have been affected by it.

More workers affected

Nobody knows how many workers are exposed to artificial butter flavorings, because there is no way to identify facilities that use these chemicals. In 2004 and 2006, Dr. Phil Harber, an occupational physician at the University of California at Los Angeles, diagnosed the first two cases of *bronchiolitis obliterans* in California. The two worked at separate flavoring manufacturing facilities, and both handled diacetyl.[38] These cases triggered an investigation by the California Department of Health Services of medical surveillance data from 15 flavor manufacturing companies in California. The study found evidence of increased risk of severe airway obstruction—a broad category of serious lung disease that includes *bronchiolitis obliterans*.[39] Eight workers in this study were confirmed as having either *bronchiolitis obliterans* or fixed obstructive lung disease.[39]

Nobody knows how many workers are exposed to artificial butter flavorings, because there is no way to identify facilities that use these chemicals.

When these two sentinel cases of *bronchiolitis obliterans* were found in California, the California Department of Health Services' Hazard Evaluation System and Information Services (HESIS) wanted to rapidly warn other workers about the risk of diacetyl, but had no way of finding out which workplaces used butter flavorings.[40] California's experience is emblematic of this problem nationally: there are no federal laws requiring firms to disclose the volume of chemicals that they produce or the customers to whom they sell them.[b] In California, attempts to request that chemical manufacturers and importers voluntarily disclose their client lists have been ineffective. For example, of the 96 manufacturers and importers that HESIS contacted requesting client lists for seven chemicals that pose chronic health hazards, only six companies complied with the request.[40] Of 127 manufacturing facilities in California using flavorings, only 16 voluntarily disclosed that they used diacetyl.[41] California attempted to pass a law to rectify this problem, but the bill was vetoed by the Governor in 2007.[40] The lack of an infrastructure to support health officials in meeting their responsibility to identify and warn workers who are at risk, and identify early-stage cases of disease, is a significant gap in efforts to protect worker safety and health.

The first cases among the public

When the cases of *bronchiolitis obliterans* at the Jasper popcorn plant hit the national news media, one of the first questions journalists asked was: is there a risk to people who buy and eat microwave popcorn? In 2003, EPA's Indoor Air Quality Research program began a study to characterize compounds released when microwave popcorn was popped and opened. The study was completed in late 2005.[42] The Agency circulated its report to the popcorn industry to assure company officials that no confidential business information was

b *Massachusetts and New Jersey have the only state laws that require high volume users of toxic chemicals (facilities that use 10,000 pounds per year and employ at least 10 employees) to report their use to state agencies. Supply chain information is not included in these laws.*

Workers have a right to a safe and healty workplace. But that won't happen as long as chemicals like diacetyl are untested and unregulated.

disclosed or would be released to the public.[43] Yet EPA never publicly released its results. Despite a petition and a Freedom of Information Act request to get EPA to release its findings to the public, EPA refused to do so, saying that this might prevent the scientists involved in the study from getting their work published in the peer-reviewed literature.[42,43] The EPA scientists' research was published in November 2007. Their work revealed that diacetyl was one of the predominant emissions and that 80 percent of the total chemical emissions occur when the microwave popcorn bag is first opened after popping.[44] Yet the research fell short of determining what, if anything, these results mean for consumer risk.

Nevertheless, risks to consumers did come to light. Two months before EPA's scientists published their research, Dr. Cecile Rose, the director of occupational disease clinical programs at National Jewish Medical and Research Center in Denver, evaluated a 53-year-old Colorado man for decreasing lung function.[45] The man had eaten microwave popcorn twice a day for more than 10 years.[45] As Dr. Rose told the *New York Times*, "When he broke open the bags, after the steam came out, he would often inhale the fragrance because he liked it so much."[45] Dr. Rose later measured diacetyl levels in the man's home that were similar to levels found in the microwave popcorn plants.[45] Since 2007, cases of lung disease possibly linked to butter flavoring exposure in microwave popcorn have been identified, including a Blockbuster Video employee who, every Friday and Saturday, popped 30 bags of microwave popcorn in a small back room of the store and emptied them into a larger popcorn machine for patrons to scoop out and enjoy with their movies. A lung biopsy confirmed a diagnosis of *bronchiolitis obliterans*.[36]

Hope for greater protections through regulatory action

With intensifying public pressure, thanks in part to a significant number of media stories about the cases of popcorn workers' lung, as well as public health scientists calling upon FDA, EPA, and OSHA to act, more protective policies are being pursued by some, but not all, agencies.[25]

FDA: Despite petitions to the FDA by the Project on Scientific Knowledge and Public Policy on September 6, 2006 and by US Congressional

Representative Rosa DeLauro of Connecticut on September 11, 2007 requesting that FDA revoke diacetyl's GRAS status, diacetyl is still on the GRAS list as of this writing. In January 2010, the Project on Scientific Knowledge and Public Policy received a letter from Mitchell Cheeseman, Acting Director of the FDA's Office of Food Additive Safety, stating that the petition is still under active review, and that this review is incorporating all existing scientific evidence and is considering the issue of inhalation.[46]

EPA: Despite publishing its research in 2007 confirming emissions of diacetyl from opening a bag of microwave popcorn after cooking, EPA has not acted on this evidence or explained what its findings mean for consumer health.

Cal OSHA: Prompted by the cases of *bronchiolitis obliterans* among workers in California exposed to butter flavoring ingredients and inaction by OSHA on the issue, California pushed forward regulatory options to prevent harm to workers who are exposed to diacetyl. On August 18, 2006, the Division of Occupational Safety and Health at the California Department of Health Services received a letter from 23 California legislators requesting adoption of an emergency standard and then a permanent standard covering exposure to diacetyl. A similar letter was sent to the Occupational Safety and Health Standards Board by the California Labor Federation and the California affiliate of the United Food and Commercial Workers International Union.

In November 2009, a proposed diacetyl standard was issued for public comment. The first diacetyl standard in the country was passed by a 6-1 vote by the California Occupational Safety and Health Standards Board on September 16, 2010. The adopted standard affects flavoring and food manufacturing facilities that use diacetyl and food flavorings that contain 1 percent or greater concentration of diacetyl. This "process-oriented standard" does not mandate a PEL, but rather a series of industrial hygiene controls, hazard communication, and medical surveillance procedures that affect exposure levels not only of diacetyl, but of other butter flavoring ingredients as well. Thus the standard has the capacity to reduce exposures not only to diacetyl, but also to hundreds of chemicals that are found with diacetyl in various butter flavoring mixtures.

OSHA: OSHA has faced pressure by Congress to use its regulatory authority to protect workers from diacetyl. On June 13, 2007, Congresswoman Lynn Woolsey introduced a bill entitled "Popcorn Workers' Lung Disease Prevention Act." The bill would require OSHA to (1) issue an interim standard within 90 days to regulate worker exposure to diacetyl; (2) issue a final standard within two years that provides no less protection than the recommendation in NIOSH's December 2003 Alert; and (3) require NIOSH to study and report to OSHA on the safety of food flavorings that may be used as substitutes for diacetyl.[47]

The bill was passed on September 26, 2007. Yet days before, OSHA preempted the legislation by announcing that it would initiate a rule-making process for diacetyl, issue a Safety and Health Information Bulletin, and provide Hazard Communication Guidance. Both of these products simply provide basic information about a hazard. The former is intended for the public and OSHA's internal staff; the latter is intended for employers.

OSHA has issued its Safety and Health Information Bulletin and Hazard Communication Guidance, but has yet to promulgate a rule. On January 21, 2009, OSHA issued an Advanced Notice of Proposed Rulemaking in the federal register. On November 25, 2009, Senator Sherrod Brown wrote to Secretary of Labor Solis urging her to expedite the final rule-making process, taking place 10 years after the dangers of diacetyl were first publicly documented.[48]

On a factsheet about diacetyl on its website, OSHA still maintains (as of this writing) that "a cause-effect relationship between diacetyl and *bronchiolitis obliterans* is difficult to assess because of mean diacetyl exposure levels ranging over four orders of magnitude for workplaces with affected individuals. In addition, food-processing and flavor-manufacturing employees with this lung disease were exposed to other volatile agents."[49] According to OSHA's spring 2010 regulatory agenda, its next step is to conduct a scientific peer review of its draft risk assessment of diacetyl.[50]

LESSONS LEARNED

The story that unfolded in a small popcorn plant in Jasper, Missouri, provides important lessons for the entire country.

First, when physicians are trained in occupational health and effective state occupational health surveillance systems are in place, workers' lives are protected. If it were not for astute physicians such as Dr. Alan Parmet and Dr. Phil Harbor, who diagnosed the first cases of occupation-induced illness among workers exposed to butter flavoring chemicals and who initiated effective health hazard investigations by their state health departments and NIOSH, even more workers' illnesses would have gone unnoticed and additional cases would undoubtedly have occurred. We are extremely fortunate that the popcorn lung story unfolded in the time and places it did, as the chance of a rapid response in other cities and states across the United States might not have been as likely, given lack of capacity and resources.

The Institute of Medicine has declared that there is a "critical shortage" of specialty-trained occupational and environmental physicians in communities, in academic medical centers, and in public health and related agencies.[51] According to a survey of medical school graduates, only 1.4 percent have taken an occupational medicine elective, and among the half of medical schools that require teaching of occupational medicine, the mean required curriculum time over the four years was four hours.[52,53] Similarly, according to a survey by the Council of State and Territorial Epidemiologists, 34 of 50 US states have minimal to no surveillance or epidemiology capacity in occupational health.[54] The occupational medical and epidemiologic response seen in this case study is a model for the type of public health infrastructure needed across the United States.

A second key lesson revealed by this story is that protecting workers from future diacetyl/butter flavorings disasters requires a new system of ensuring adequate safety and health information regarding all chemicals in commerce and a more coordinated federal chemicals management infrastructure. While the Department of Labor's failure to respond by having OSHA use its regulatory authority to protect workers using butter flavorings is indefensible, we must ask a much larger and more fundamental question. Why is our chemicals management system in the United States—a system that spans jurisdictional boundaries across EPA, FDA, OSHA, and other agencies—dependent on first destroying the lives of workers like Eric Peoples, our "blue collar guinea pigs"? Why was diacetyl determined to be "generally recognized as safe" based on minimal testing, and why was no thought given to the impacts on workers or the general public exposed by routes other than ingestion? And while substituting a safer butter flavoring for diacetyl is the most protective strategy to prevent occupational illnesses, why is there no system to foster research that produces and identifies safer chemicals?

No tale of toxic harms has a happy ending. But the story of popcorn workers' lung teaches us of the need for effective occupational health and chemical regulatory systems to prevent workers from falling ill simply by showing up for work and doing the job asked of them.

The story of popcorn workers' lung teaches us of the need for effective occupational health and chemical regulatory systems to prevent workers from falling ill simply by showing up for work and doing the job asked of them.

CASE STUDY 3 — **TIMELINE**

DATE	EVENT
1980	FDA issues a GRAS designation for diacetyl based on a test of mutagenic activity in cells cultured in the lab and an animal feeding study examining evidence of teratogenicity. No inhalation studies were conducted.
February 1993	Researchers for the German company BASF publish an internal report of the inhalation toxicity of diacetyl in rats. The rats underwent a single four-hour exposure to diacetyl vapors. Animals exposed at medium and high concentrations showed an abundance of symptoms indicative of respiratory tract injury.
1994	NTP nominates diacetyl for comprehensive mechanistic, metabolism, and carcinogenicity studies based on ingestion exposure.
1999	NTP drops diacetyl from its comprehensive testing list, though initial testing found the chemical to have potent irritant properties.
May 2000	Dr. Parmet notifies the MoDHHS to report multiple cases of *bronchiolitis obliterans* among workers of a Jasper, Missouri, popcorn plant. Dr. Parmet's letter also suggests that dozens of former workers also show symptoms of subclinical *bronchiolitis obliterans*.
May 2000	MoDHHS notifies OSHA of Dr. Parmet's letter and asks OSHA to inspect the Jasper, Missouri, popcorn plant.
May 2000	OSHA inspector visits the plant, but oil mist samples cannot be analyzed by OSHA's laboratory.
August–November 2000	NIOSH investigates a Missouri microwave popcorn facility; findings indicate that workers exposed to flavorings at the microwave popcorn plant are at risk for developing obstructive lung disease.
December 2000	NIOSH issues interim recommendations to the Jasper microwave popcorn plant for all workers to wear respirators to control exposure to the artificial butter flavoring compounds pending the implementation of engineering controls.
August 2001	NIOSH issues its Interim Report about its Jasper popcorn plant investigation.
September 2001	NIOSH investigators return to the Jasper factory they studied to distribute materials describing investigation results, ongoing activities, and precautions to be taken by workers.
September 2001	A class action lawsuit is filed against IFF by Jasper plant workers and their spouses.
September and December 2001	Attorney representing sick workers files complaints with OSHA, noting that workers' health continued to decline after the Jasper plant took measures recommended by NIOSH.
February 2002	OSHA replies to complaint filed by attorney, stating that the hazard has been corrected based on the plant's compliance with NIOSH's exposure control recommendations and that OSHA does not have jurisdiction over the food chemicals concerned because there is no Permissable Exposure Limit (PEL).
April 2002 and August 2002	Articles in *Morbidity and Mortality Weekly Report* (April 26, 2002) and in the *New England Journal of Medicine* (August 2002) are published describing MoDHHS's and NIOSH's investigations. The articles reveal that the rates of airway obstructive symptoms were higher among workers who worked in the production area of the plant versus other areas. The papers also reported that the more a worker was exposed to diacetyl, the worse her/his lung function was.
2002–2003	NIOSH scientists conducting toxicity experiments find significant adverse respiratory effects from exposure to diacetyl vapors. One of the lead researchers reveals that the substantial lung damage observed in the rats tested represented "the most dramatic cases of cell death ever seen in some tissues."

DATE	EVENT
September 2002–March 2003	OSHA begins alliance with the Popcorn Board to promote hazard communication to at-risk workplaces. The alliance ends six months later without issuing and circulating any hazard information.
Spring–Summer 2003	EPA's Indoor Air Quality Research Update reports that a project to characterize compounds emitted through popping and opening microwave popcorn is expected to be completed in December 2003.
December 2003	A *NIOSH Alert* is issued suggesting safeguards and asking employers to caution workers. The alert recommends: "engineering controls are the primary method for minimizing exposure associated with the use or manufacture of potentially hazardous flavoring."
March 2004	A Missouri jury delivers a verdict in favor of Eric and Cassandra Peoples for $20 million—the first of many trials of Jasper popcorn plant workers.
August 2006	A group of California legislators, UFCW, and the California Labor Federation petition Cal OSHA to adopt an emergency temporary standard for diacetyl in California.
September 2006 & May 2007	The Project on Scientific Knowledge and Public Policy and Congresswoman Rosa DeLauro write to FDA Commissioner Andrew von Eschenbach requesting that the agency re-examine diacetyl to revoke its GRAS status.
June 2007	FDA Commissioner Andrew von Eschenbach responds to DeLauro's request, stating that "the agency does not have evidence that would cause it to take immediate action with respect to diacetyl" and that "FDA continues to monitor the scientific literature for studies conducted to define and clarify the dangers associated with exposure to diacetyl vapors."
June 2007	Congresswoman Lynn Woolsey introduces a bill that would force OSHA to set an interim standard for diacetyl exposure within six months and a final rule in two years.
August 2007	Manufacturer Pop Weaver announces that it has eliminated diacetyl from its microwave popcorn.
September 2007	Dr. Cecile Rose, chief occupational and environmental medicine physician at National Jewish Medical and Research Center, diagnoses a case of *bronchiolitis obliterans* in a man who did not have occupational exposure to diacetyl but was a regular, heavy consumer of microwave popcorn.
November 2007	EPA scientists publish their research in *Critical Reviews in Food Science and Nutrition* finding that diacetyl was a predominant compound emitted from cooking microwave popcorn and that more than 80 percent of the total chemical emissions occur when the bag is first opened after cooking.
September 2007–December 2007	ConAgra, Pop Weaver, General Mills, and American Pop Corn announce that they are eliminating diacetyl from their products or have already done so.
September 2007	The US House of Representatives passes the Popcorn Workers Lung Disease Prevention Act, which requires OSHA to set a standard to protect workers from diacetyl.
January 2009	OSHA issues a Advanced Notice of Proposed Rulemaking for a diacetyl standard.
November 2009	Senator Sherrod Brown writes Secretary of Labor Solis to expedite diacetyl rulemaking.
November 2009	Proposed Cal OSHA standard for diacetyl is issued for public comment.
December 2009	FDA's Acting Director of the Office of Food Additive Safety states that petitions from the Project on Scientific Knowledge and Public Policy and Congresswoman DeLauro about diacetyl's GRAS status are still under review.
December 2009	NIOSH Director John Howard sends letter to David Michaels, Assistant Secretary of Labor for OSHA stating that the new substitutes for diacetyl demonstrate animal toxicity very similar to that of diacetyl.

Acknowledgments

This case study draws on several others that have come before it, notably: (1) David Michaels, Chrissy Morgan, and Celeste Monforton's "A Case of Regulatory Failure—Popcorn Workers Lung" along with continued analysis and links to historical and recent material posted by staff of the Project on Scientific Knowledge and Public Policy website (*www.defendingscience.org*) and the blog, The Pump Handle (*http://scienceblogs.com/thepumphandle*); as well as (2) Andrew Dulberg's "The Popcorn Lung Case Study: A Recipe for Regulation" that was published in the New York University Review of Law and Social Change (2009). We are deeply grateful for the investigative journalism of Andrew Schneider, whose writings brought the subject of hazards to workers using diacetyl and butter flavorings to the attention of millions and who continues to educate us about recent developments. We also extend our gratitude to Dr. Robert Harrison and Celeste Monforton for reviewing this case study and to Gale Bateson as well as Dr. Robert Harrison, who spoke with us at length about California's experience in its efforts to protect workers from exposure to diacetyl and other butter flavoring chemicals.

References

1. Statement of Eric Peoples. *Have OSHA Standards Kept up with Workplace Hazards? Hearing Before the Subcommittee on Workforce Protections of the House Committee on Education and Labor, 110th Congress*, 2007. Available at: *http://www.defendingscience.org/case_studies/upload/Eric_Peoples_Testimony_April07.pdf*. Accessed: February 27, 2010.
2. Rock S. Popcorn plant lawsuits winding down. *The Kansas City Star*. November 25. 2005.
3. Labaton S. OSHA leaves worker safety largely in hands of industry. *The New York Times*. April 25. 2007. Available at: *http://www.nytimes.com/2007/04/25/washington/25osha.html*. Accessed: February 27, 2010.
4. Farrow C. Popcorn worker awarded $20 million in lawsuit over lung damage from butter flavoring. *The Associated Press*. March 16. 2004.
5. Kullman G, Boylstein R, Jones W, et al. Characterization of respiratory exposures at a microwave popcorn plant with cases of bronchiolitis obliterans. *J Occup Environ Hyg.* 2005;2(3):169-78.
6. Sharples LD, McNeil K, Stewart S, et al. Risk factors for bronchiolitis obliterans: a systematic review of recent publications. *J Heart Lung Transplant.* 2002;21(2):271-81.
7. Roberts D. Letter to Occupational Safety and Health Administration. May 19, 2000. Available at: *http://defendingscience.org/case_studies/upload/Roberts-Letter.pdf*. Accessed: February 27, 2010.
8. Simoes E, Phillips P, Maley R, et al. Fixed obstructive lung disease in workers at a microwave popcorn factory—Missouri, 2000-2002. *MMWR.* 2002;51(16):345-347.
9. Occupational Health and Safety Administration. *Inspection Report, May 23, 2000*. September 26, 2000. Available at: *www.defendingscience.org*. Accessed: February 25, 2010.
10. Kreiss K, Gomaa A, Kullman G, et al. Clinical bronchiolitis obliterans in workers at a microwave-popcorn plant. *N Engl J Med.* 2002;347(5):330-8.
11. Gormaa A, Kullman G, Fedan K, et al. *NIOSH investigation of Glister Mary Lee—Technical Assistance to Missouri Department of Health. Interim Report.* Report No:HETA#2000-0401. Missouri Department of Health, Office of Epidemiology. August 21, 2001. Available at: *http://www.cdc.gov/niosh/hhe/reports/pdfs/2000-0401-2991.pdf* (Appendix C). Accessed: February 27, 2010.
12. Schneider A. Additive found in more than 6,000 products its not new - Pasteur identified diacetyl in 1860s. *Seattle Post-Intelligencer*. December 21. 2007. Available at: *http://www.seattlepi.com/national/344349_history21.html*. Accessed: September 27, 2010.
13. National Institute for Occupational Safety and Health. *NIOSH Alert: Preventing Lung Disease in Workers Who Use or Make Flavorings*. Report No:2004-110. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. 2003. Available at: *http://www.cdc.gov/niosh/docs/2004-110*. Accessed: February 27, 2010.
14. U.S. Food and Drug Administration. *History of the GRAS List and SCOGS Reviews*. Available at: *http://www.fda.gov/Food/FoodIngredientsPackaging/GenerallyRecognizedasSafeGRAS/GRASSubstancesSCOGSDatabase/ucm084142.htm*. Accessed: February 15, 2010.
15. Gaynor P, Cianci S. How U.S. FDA's GRAS notification program works. *Food Safety Magazine.* December 2005/January 2006.
16. U.S. Food and Drug Administration. *Database of Select Committee on GRAS Substances (SCOGS) Reviews: Diacetyl*. Available at: *http://www.accessdata.fda.gov/scripts/fcn/fcnDetailNavigation.cfm?rpt=scogsListing&id=103*. Accessed: February 15, 2010.
17. National Toxicology Program. *NTP Research Concept: Artificial Butter Flavoring and Certain Components, Diacetyl and Acetoin*. Available at: *http://ntp.niehs.nih.gov/files/Artificial_butter_flavoring_concept_for_BSC.pdf*. Accessed: February 16, 2010.
18. National Institute for Occupational Safety and Health. *Important Worker Health Notice about the Popcorn Plant in Jasper, Missouri*. September 9, 2001, Available at: *http://defendingscience.org/case_studies/upload/NIOSH-Worker-Notice.pdf*. Accessed: March 21, 2010.
19. Hubbs AF, Battelli LA, Goldsmith WT, et al. Necrosis of nasal and airway epithelium in rats inhaling vapors of artificial butter flavoring. *Toxicol Appl Pharmacol.* 2002;185(2):128-35.
20. Shipley S. Microwave popcorn—study showed chemical was toxic. *St. Louis Post-Dispatch*. February 28. 2004. Available at: *http://www.mindfully.org/Pesticide/2004/Microwave-Popcorn-Toxic28feb04.htm*. Accessed: March 21, 2010.
21. Hubbs A, Battelli L, Mercer R, et al. Inhalation toxicity of the flavoring agent, diacetyl (2,3-butanedione), in the upper respiratory tract of rats. *Toxicol Sci.* 2004; 78:438–439.

22. BASF. *Study on the Acute Inhalation Toxicity LC50 of Diacetyl FCC as a Vapor in Rats 4-hour Exposure*. BASF, Department of Toxicology. 1993. Available at: *http://defendingscience.org/case_studies/upload/BASF-Study.pdf*. Accessed: March 21, 2010.
23. Michaels D. Popcorn lung: OSHA gives up. In: *Doubt Is Their Product: How Industry's Assault on Science Threatens Your Health*. New York, NY: Oxford University Press, Inc. 2008. 110-123.
24. Kanwal R, Kullman G, Piacitelli C, et al. Evaluation of flavorings-related lung disease risk at six microwave popcorn plants. *J Occup Environ Med.* 2006;48(2):149-57.
25. The Project on Scientific Knowledge and Public Policy. *A Case of Regulatory Failure: Popcorn Workers Lung*. Available at: *http://defendingscience.org/case_studies/A-Case-of-Regulatory-Failure-Popcorn-Workers-Lung.cfm*. Accessed: February 16, 2010.
26. Finkel A. *Personal Communication.* August 20, 2009.
27. Dulberg AS. The popcorn lung case study: a recipe for regulation? *Rev Law Soc Change.* 2009;33(1):87-126.
28. *Int'l. Flavors & Fragrances, Inc. v. Valley Forge Ins. Co.,* 2007 WI App 187, 304 Wis. 2d 732, 738 N.W.2d 159.
29. Lehr J. Illinois worker wins $30 million verdict in diacetyl popcorn chemical lawsuit. *The Joplin Globe*. August 16, 2010. Available at: *http://www.joplinglobe.com/local/x369041172/Illinois-worker-wins-30-million-verdict-in-diacetyl-popcorn-chemical-lawsuit*. Accessed: August 31, 2010.
30. Schneider A. Popcorn supplier to drop toxic chemical. Consumer's lung disease may be linked to flavoring. *Seattle Post-Intelligencer*. September 5. 2007. Available at: *http://www.seattlepi.com/food/330230_popcorn05.html*. Accessed: February 27, 2010.
31. Michaels D. *Doubt is Their Product: How Industry's Assult on Science Threatens Your Health*. New York: Oxford University Press. 2008.
32. Berger MA. What has a decade of Daubert wrought? *Am J Public Health.* 2005;95 Suppl 1:S59-65.
33. The Project on Scientific Knowledge and Public Policy. *Daubert: The Most Influential Supreme Court Ruling You've Never Heard of*. Tellus Institute. June 2003. Available at: *http://www.defendingscience.org/upload/Daubert-The-Most-Influential-Supreme-Court-Decision-You-ve-Never-Heard-Of-2003.pdf*. Accessed: February 27, 2010.
34. U.S. Government Accountability Office. *High-Risk Series: An Update*. Report No:GAO-09-271. U.S. Government Accountability Office. January 2009. Available at: *http://www.gao.gov/products/GAO-09-271*. Accessed: February 27, 2010.
35. Associated Press. Popcorn firms removing flavoring chemical. Additive linked to lung ailments in factory workers. *The Boston Globe*. December 18. 2007. Available at: *http://www.boston.com/business/globe/articles/2007/12/18/popcorn_firms_removing_flavoring_chemical*. Accessed: February 27, 2010.
36. Schneider A. Just when you thought it was safe to make popcorn. *AOL News.com*. December 10. 2009. Available at: *http://www.aolnews.com/nation/article/just-when-you-thought-it-was-safe-to-make-popcorn/19273632*. Accessed: February 27, 2010.
37. Howard J. Letter to David Michaels, Assistant Secretary of Labor for Occupational Safety and Health. December 23, 2009. Available at: *http://thepumphandle.wordpress.com/2010/01/05/perils-of-butter-flavorings-diacetyl-substitutes*. Accessed: February 25, 2010.
38. Associated Press. California struggles with its own diacetyl problem. *AP Features*. October 23. 2007. Available at: *http://www.thefreelibrary.com/_/print/PrintArticle.aspx?id=1611403697*. Accessed: February 27, 2010.
39. Centers for Disease Control and Prevention. Fixed obstructive lung disease among workers in the flavor-manufacturing industry—California, 2004-2007. *MMWR.* 2007;56(16):389-393.
40. Gail Bateson. Executive Director, Work Safe. *Personal Communication.* March 4, 2009.
41. von Euw M. *The Search for Diacetyl among Flavoring Manufacturers in California*. Summer internship final presentation. 2010.
42. Funk J. Popcorn markers work to remove chemical. *Washington Post*. September 5. 2007.
43. Michaels D. What do Pop Weaver and the EPA know about diacetyl? *The Pump Handle*. August 30. 2007. Available at: *http://thepumphandle.wordpress.com/2007/08/30/what-do-pop-weaver-and-the-epa-know-about-diacetyl*. Accessed: February 5, 2010.
44. Rosati JA, Krebs KA, Liu X. Emissions from cooking microwave popcorn. *Crit Rev Food Sci Nutr.* 2007;47(8):701-9.
45. Harris G. Doctor links a man's illness to a microwave popcorn habit. *The New York Times*. September 5, 2007. 2007. Available at: *http://www.nytimes.com/2007/09/05/us/05popcorn.html*. Accessed: February 27, 2010.
46. Cheeseman MA. A letter to Drs. Monforton and Wood. 2010. available at: *http://defendingscience.org/case_studies/upload/FDA-response-to-petition-Jan-28-2010.pdf*.
47. 110th Congress 2007-2008. *H.R. 2963: Popcorn Workers Lung Disease Prevention Act*. 2007. Available at: *http://www.govtrack.us/congress/bill.xpd?bill=h110-2693*. Accessed: March 31, 2010.
48. Brown S. A letter to the Honorable Hilda L. Solis. November 25, 2009. Available at: *http://defendingscience.org/case_studies/upload/SherrodBrown_Diacetyl_11_25_09.pdf*. Accessed: March 10, 2010.
49. Occupational Safety and Health Administration. *Chemical Sampling Information; Diacetyl*. Available at: *http://www.osha.gov/dts/chemicalsampling/data/CH_231710.html*. Accessed: February 16, 2010.
50. Regulatory Info.gov. *RIN Data; DOL/OSHA; RIN:1218-AC33; Occupational exposure to diacetyl and food flavorings containing diacetyl*. Spring 2010. Available at: *http://www.defendingscience.org/upload/OSHARegAgendaApril-2010-Diacetyl.pdf*. Accessed: April 26, 2010.
51. Institute of Medicine. *Addressing the Physician Shortage in Occupational and Environmental Medicine: Report of a Study*. National Academy of Sciences. 1991.
52. Levy BS. The teaching of occupational health in United States medical schools: five-year follow-up of an initial survey. *Am J Public Health.* 1985;75(1):79-80.
53. Association of American Medical Colleges. *Student graduation questionnaire.* Washington, DC. 1987
54. Council of State and Territorial Epidemiologists. *2009 Epidemiology Capacity Assessment*. 2009. Available at: *http://www.cste.org/dnn/Portals/0/2009EpidemiologyCapacityAssessmentReport.pdf*. Accessed: March 15, 2010.

This welder looks about as well protected as could be. But real safety requires more than personal protection equipment. Safety in construction means planning and managing every aspect of a site with safety in mind.

CASE STUDY 4

Injuries Are Not Accidents:

Construction Will Be Safe When It's Designed to Be Safe

Pia Markkanen, David Kriebel, Joel Tickner, Molly Jacobs

On August 13, 2005, a 56-year-old male construction worker was fatally injured when he was run over by a bulldozer. He had been working at a commercial construction site in North Carolina. As he stepped in front of a gravel pile to direct a truck driver, he was struck by a bulldozer running in reverse. His boss, the owner of the contracting company, was operating the bulldozer, spreading gravel. The dozer's back-up alarm was on. A co-worker in a skid-steer loader near the gravel pile saw the bulldozer backing toward the victim, and he yelled a warning. But neither the driver of the bulldozer nor the worker in its path heard him shout. The track of the bulldozer struck the victim on the back of his legs and rolled over his legs and torso. Emergency medical workers arrived promptly after the 911 call and found that the victim had no signs of life. He was pronounced dead at the site.

— *Fatality Assessment and Control Evaluation (FACE) Program,* National Institute for Occupational Safety & Health (NIOSH)[1]

UNNECESSARY DEATHS LIKE THIS one happen all the time—there are approximately three fatal construction injuries each day in the United States.[a] And for every death, there are more than 100 nonfatal injuries serious enough to result in time lost from work.[b]

Fatal injuries in construction continue to take a heavy toll despite a long history of government efforts to enforce safety measures. Yet safety management systems involving workers and managers in continuous assessment and prevention *can* provide the commitment to safety that is critical to reducing deaths and injuries on the job.

When people hear about these tragic and avoidable deaths, they often have one of two reactions. They either say, "It should be so simple—how hard can it be to keep workers from falling, or being crushed, or being electrocuted?" Or they say, "Accidents will always happen. It's nobody's fault." The latter view is clearly wrong, and the evidence can be found in very safe construction projects all over the world, even if they are not as common as they should be. The first view is also wrong, but in a subtler way. The final error that leads to the injury or death—the bulldozer running over the worker—may be simple to avoid when viewed in isolation. However, keeping workers safe requires careful, participatory design of the organization of work practices and the worksite. Investigations of fatal injuries invariably find a complex web of causal factors that led up to the final moments of the terrible, avoidable event.

This case study highlights the complex, very hazardous, and often fast-paced work of construction, an industry that is also known to employ a

a *Based on the US Bureau of Labor Statistics' total fatality cases (975) in construction, in 2008.*

b *Based on the US Bureau of Labor Statistics' total non-fatal cases (120,240) in construction, in 2008.*

vulnerable population of immigrant workers. To manage its countless occupational hazards and protect workers adequately, the construction sector requires a more comprehensive approach than mere compliance with government standards or sporadic application of control measures after serious incidents occur. One of the best solutions is to implement an occupational safety and health management system (OSH-MS) in the worksite.

The highly hazardous construction sector

A complex and dynamic work environment

The construction industry is one of those complex economic sectors that pose particular challenges in protecting workers' safety and health.[2] Construction work embraces not only building projects but also maintaining, repairing, renovating, and demolishing houses, apartment buildings, and office buildings. Larger-scale construction projects include not only major buildings (for example, health care facilities), but also infrastructure components (e.g. roads, tunnels, bridges, airports, docks).[2,3] In these various activities, the worker experiences highly hazardous conditions—not only the hazards of his/her own job, but also hazards from co-workers.[2,3] Construction workers also operate in an unusually dynamic workplace: construction requires the physical transformation of the site: each new stage of the project brings along different materials, technologies, work processes, and hazardous exposures.[4]

Dangerous job conditions may include work at heights or in excavations; the clutter of building materials; motor vehicles and equipment; prolonged standing, bending and stooping; noise, dust, and welding fumes; power tools; confined spaces and cramped spaces; temperature extremes; electricity; and sometimes work underwater. Other features of construction work that may contribute to hazardous conditions include working at a fast pace, having many employers on the site, working jobs of relatively short or episodic duration, and working alongside trades that generate other hazards.[3] Furthermore, construction workers are highly mobile and employers may change. All these factors make the documentation of construction jobs and hazardous exposures complex.[2] When employed, most workers in the construction industry work at least full time and many of them more than 40 hours a week.[5]

Construction industry tops the injury numbers

Workers in the construction sector are about 8 percent of the US workforce (more than 11 million workers), but the industry consistently accounts for a larger number of total fatalities than any other sector—accounting for about 22 percent of fatalities across all industries.[6] In 2008, the Bureau of Labor Statistics (BLS) reported 975 deaths from acute traumatic injuries.[7,8] The 2008 fatality rate, at 9.6 deaths per 100,000 full-time construction workers, was the fourth-highest after agriculture, mining, and transportation.[8] Although preliminary BLS data indicate that construction fatalities declined to 816 in 2009,[9] the construction industry continues to top the list of high-fatality industries.

The leading causes of construction fatalities and injuries, accounting for 90 percent of cases, are:[10,11]

- falls from elevations (e.g., from floors, platforms, ladders, roofs);
- being struck by something that is moving (e.g., objects, pieces of equipment, vehicles);
- being caught in/between events or objects (e.g., cave-ins, unguarded machinery, equipment); and
- electrical shock (e.g., by overhead power lines, power tools and cords, outlets, temporary wiring).

Falls are the most frequent cause of fatalities in construction, each year accounting for one-third of all construction-related deaths.[12] The proportion is higher in residential construction, where falls account for nearly half of work-related deaths.[13] Figure 1 shows trends of construction fatalities for falls, highway accidents, contact with

ABOUT THIS CASE STUDY

The first section of the case study profiles the chief characteristics of this hazardous employment sector: number of injuries, especially hazardous trades, costs of construction injuries, and the magnitude of the immigrant workforce and the nature of its work. The second part highlights actions by government and the construction industry that could make this sector safe.

electric current, and being struck by objects during 1992–2005.[14]

In 2008, BLS reported that the construction industry experienced a total of 120,240 serious nonfatal injuries causing days away from work (11 percent of such injuries across all industries); this is the fourth highest percentage among all US industry sectors, behind trade, transportation and utilities (30 percent); education and health services (17 percent); and manufacturing (13 percent).[15] Construction sector injuries causing days away from work had the highest lost-time rate (174 injuries per 10,000 full-time workers) of any US industry sector.[15]

Studies of non-fatal construction-related contact injuries (that is, injuries in which a worker is struck by an object or a piece of equipment) treated in emergency departments during the period 1998–2005 found that contact injuries accounted for over half of all construction injuries treated in emergency departments.[16,17] The most common injuries were due to contact with discharged nails from pneumatic nail guns, hand-held power saws, and fixed saws.[16] Some injuries may involve multiple workers (e.g., trench cave-ins, collapses of walls, roofs, or scaffolding of buildings under construction).[16] Seven specific tools or pieces of equipment—ladders, nail guns, power saws, hammers, knives, power drills, and welding tools—were responsible for almost two-thirds of the injury burden in emergency departments.[17]

Construction workers suffer not only occupational injuries, but also numerous occupational illnesses. Many of these illnesses are difficult to capture in statistics because of long latencies, as described below.

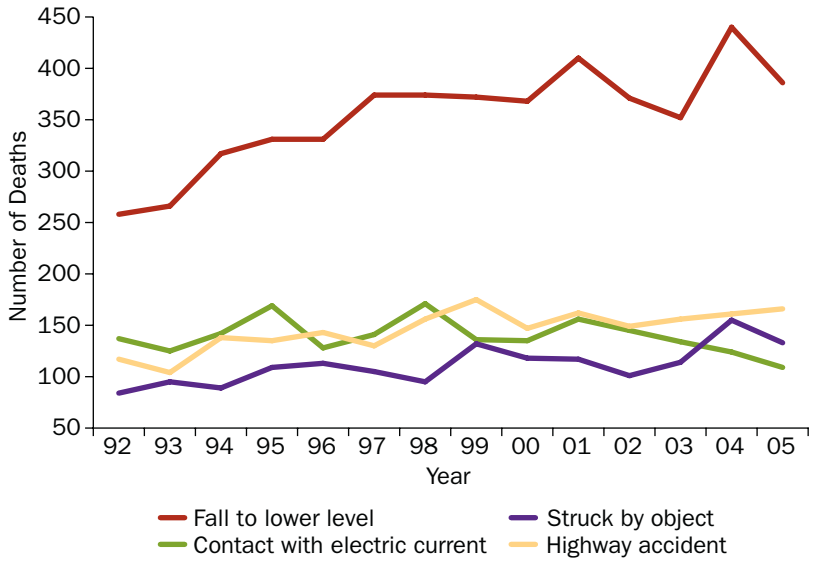
Among the many trades and occupations involved in the construction industry roofers, along with structural iron and steel workers, were the trade groups suffering from both the highest rates and largest numbers of fatal injuries in 2008.[8] Construction laborers were the largest group suffering from non-fatal injuries in 2008.[15]

Injuries are not the only risk: occupational illnesses of construction workers

Several specific work-related diseases have been associated with working in the construction trades, including these:

In the United States, the construction industry consistently accounts for the largest number of total fatalities of any industrial sector.

FIGURE 1
Leading causes of work-related deaths in construction, 1992–2005.



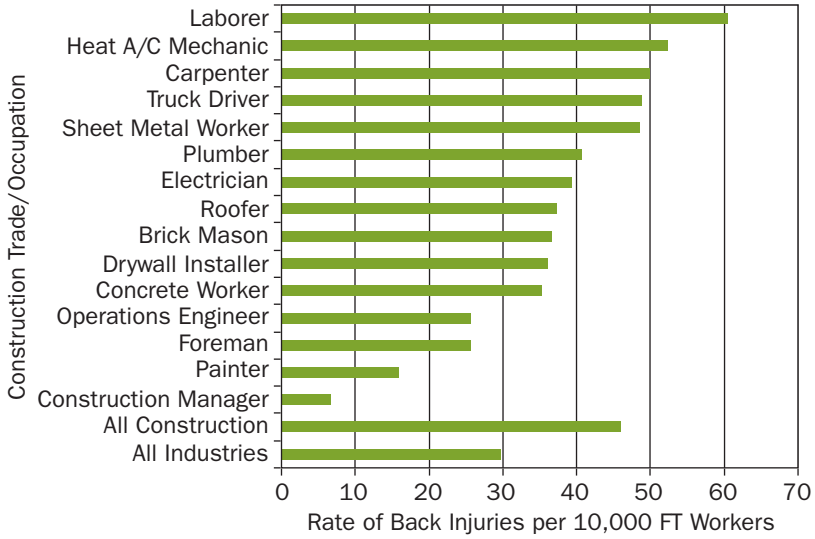
Source: CPWR – The Center for Construction Research and Training. The Construction Chart Book. 2008. Chart 36c, p36.

- lung cancer among asbestos insulation workers, roofers, welders, and woodworkers;[3,18-21]
- silicosis among sand blasters, tunnel builders, rock drill operators, masonry and concrete workers, and workers in other trades;[3,13,18,22-31]
- asbestosis and mesothelioma among asbestos insulation workers, steam pipe fitters, building demolition workers, and sheet metal workers;[3,13,20,32-35]
- chronic obstructive pulmonary disease (COPD) among cement masons, brick masons, plasterers, sheet metal workers, and welders;[13,21,36,37]
- skin diseases among laborers who work with cement or concrete, masons, tile setters, terrazzo workers, painters, and others;[3,38-45] and
- neurologic disorders among painters, welders and other workers exposed to organic solvents and metals (e.g., lead, chromium, manganese).[3,13,46-52]

Welch and colleagues have examined in some depth the risk of asbestos-related lung disease among sheet metal workers, studying more than 18,000 workers with more than 20 years' work experience who had been screened between 1986 and 2004.[35] At the first screening, almost 10 percent had asbestosis and 21 percent had scarring of the pleura (the lining of the lungs). A second exam, given an average of 10 years later to those with no evidence of asbestos-related lung disease on first exam, found that more than 5 percent had developed asbestosis and more than 12 percent had developed pleural scarring.[35] Lead poisoning has been documented not only among painters but also among building finishing workers, street and bridge rehabilitation workers, and utilities workers.[3,13,46-48] Asthma, neurological disorders (e.g., manganese-induced Parkinsonism), and cancer have been documented among welders, who are exposed to a variety of metal fumes, including manganese and iron.[49-52]

FIGURE 2

Rate of back injuries and illnesses per 10,000 full-time (FT) workers with days away from work, by selected construction occupation in 2005.



Source: CPWR – The Center for Construction Research and Training.
The Construction Chart Book. *2008. Chart 16b, p16.*

Musculoskeletal disorders

Schneider carried out a comprehensive review of musculoskeletal injury evidence in construction—the study showed that construction workers are at significant musculoskeletal injury risk.[53] The evidence review included the following data sources: (1) historical evidence; (2) injury data (e.g., BLS data); (3) workers' compensation data; (4) medical exam data; (5) worker symptom survey data (e.g., National Health Interview Survey data); and (6) job exposure analysis data.[53]

In the ergonomics case study of this publication, we present the BLS 2008 data on the top five occupational groups for musculoskeletal disorders (see Table 1 of the case entitled *When My Job Breaks My Back: Shouldering the Burden of Work-Related Musculoskeletal Disorders*).[15] The construction and extraction occupations were among the top five groups. Overexertion is the leading cause of musculoskeletal disorders (MSDs) in construction.[14] For construction and extraction occupations, the 2008 BLS data indicated that arm and shoulder MSDs resulted in the highest number of days away from work in construction.[15] However, the incidence rate per 10,000 full-time workers in construction and extraction occupations was higher for back injuries than for injuries of any upper extremity (arm, shoulder, hand, wrist, and finger) or lower extremity (knee, ankle, foot, toe).[15] Each day, construction workers lift materials repeatedly, lift and twist at the same time, bend over for long periods of time, perform sudden movements, and are exposed to whole-body vibration—all these are common causes of back injuries and illnesses.[14] Figure 2 illustrates the rate of back injuries and illnesses per 10,000 full-time workers in selected construction occupations in 2005.

Ergonomic risk factors are present in all construction trades, but increased risk of specific MSDs is associated with certain occupations.[14,53-58] Figure 2 indicates that laborers are at the greatest risk of back injuries and illnesses.[14] The Chartbook of the CPWR (The Center for Construction Research and Training, formerly the Center to Protect Workers' Rights) points out that laborers are also at the greatest risk for overexertion injuries.[14]

Hartmann documented that scaffolders, bricklayers, and carpenters regularly handle heavy weights, with resulting excessive pressure on the back.[59] And bricklaying required bent postures during as much as 35 percent of daily worktime. Painters, plumbers, and carpenters worked frequently in kneeling

Personal protective equipment should not be the only solution for protecting construction workers' safety and health.

postures. In addition, painters often worked with their arms overhead.[59] Overhead drilling into concrete or metal is one of the most physically demanding tasks: the work is done with heavy, rotary impact hammer drills.[60] Workers who drill into concrete or metal ceilings suffer pain and MSDs at the wrist, forearm, shoulder, and back due to high forces and non-neutral shoulder and wrist postures.[60,61]

How much do construction injuries cost?

In 2009, the construction industry constituted about 4 percent of the total gross domestic product in the United States. The proportion declined steadily from 2006 to 2009 with the slowdown of residential and building construction.[62] Various researchers have attempted to estimate how much construction injuries cost.[63,64-67] For example, the 2008 Chartbook from CPWR provides a useful summary of costs of work-related injuries and illnesses in the construction sector.[14] Calculating an accurate cost estimate for injuries and illnesses is difficult. While certain aspects can be calculated rather easily (e.g., wage replacement, workers' compensation costs, medical payments, or production losses), other aspects (e.g., the victim's and family's suffering) are very hard to capture in numbers.[14] Many costs are not compensated, partly because they are difficult to link to specific work exposures. Construction workers may serve several employers —even within a single year—and perhaps have dozens of employers over their careers.[14] In addition, occupational illnesses (e.g., noise-induced hearing loss, cancers, neurological disorders) are usually identified long after the start of the exposure and thus may not be successfully linked to a work-related exposure and then compensated. MSDs can be classified either as illnesses due to

repeated trauma (e.g., carpal tunnel syndrome and tendinitis) or as injuries due to sprains and strains (e.g., back injuries).[14,53] Finally, about one-fourth of the construction workforce is self-employed, and most of these self-employed workers are not covered by workers' compensation, so that workers' compensation costs are not captured.[63]

CPWR estimated the total cost of fatal and nonfatal injuries in the construction industry at nearly $13 billion annually.[14,c] This is intended to capture direct costs (medical payments), indirect costs (wage losses, household production losses, costs of administering workers' compensation), as well as quality-of-life costs (pain and suffering of victims and their families). Deaths are estimated to represent 40 percent of the total cost, and nonfatal injuries and illnesses the rest.[14] The death of a construction worker is estimated to cost $4 million in losses; a nonfatal injury costs approximately $42,000.[14]

Waehrer and colleagues developed a cost model based on fatal and non-fatal injuries in the construction industry, its subsectors, and 50 construction occupations, seeking to capture quality-of-life costs along with direct and indirect costs.[64,65] The total cost of fatal and nonfatal injuries was estimated at $11.5 billion, representing 15 percent of all injury costs for private industry.[64] The average cost per case of fatal or nonfatal injury was estimated at $27,000 in 2002, significantly higher than the cost per case of $15,000 for all industries in 2002.[64]

The total cost of fatal and nonfatal injuries was estimated to be $11.5 billion.

Construction laborers and carpenters ranked the highest in costs for both fatal and nonfatal injuries. They account for 40 percent of all the construction industry costs.[65] The costs of fatal injuries for construction laborers and carpenters were more than $1.2 billion and $376 million, respectively. The costs of nonfatal injuries to construction laborers amounted to almost $2.1 billion, and to carpenters, about $1.6 billion.[65]

Horowitz and McCall examined all accepted workers' compensation claims by Oregon construction employees (N = 20,680) during the period 1990-2007.[66] Over 50 percent of claims were filed by workers under 35 years old and with less than one year on the job. The average claim cost was $10,084 and the mean time period (i.e., mean indemnity time) for which a worker received the compensation was 57.3 days.[66] Structural metal workers had the highest average days of indemnity (72.1), the highest average costs per claim ($16,472), and the highest injury share of all construction trades examined.[66]

Immigrant construction workers and the nature of their work

The US construction sector is characterized by a multi-ethnic workforce. In 2008, almost 25 percent of construction workers were foreign born.[68] In 2007, more than four-fifths of foreign-born workers originated from either Mexico (59 percent) or another Latin American country (25 percent).[68]

The share of workers who are Hispanic is greater than 40 percent in drywall installation, roofing, and concrete work, and among laborers (Figure 3). The total number of Hispanic construction workers increased rapidly from 705,000 in 1990 to nearly 3 million in 2007, but dropped sharply during 2007-2008 due to the economic downturn.[14]

In 2008, 11 percent of Hispanic workers in the construction trades belonged to a union, compared to 18 percent of non-Hispanic workers. Hispanic union members made $7.60 more per hour than their non-union counterparts; however, Hispanic construction workers continue to make less than their white non-Hispanic counterparts, in both union and non-union jobs. Also, the highest paid construction trades have fewer Hispanic workers.

Evidence indicates that Hispanic construction workers are more likely to suffer fatal and non-fatal injuries than their white non-Hispanic co-workers.[69,70] During 1992-2006, fatal falls accounted

c *CPWR estimates in this paragraph are all based on the 2002 dollar value.*

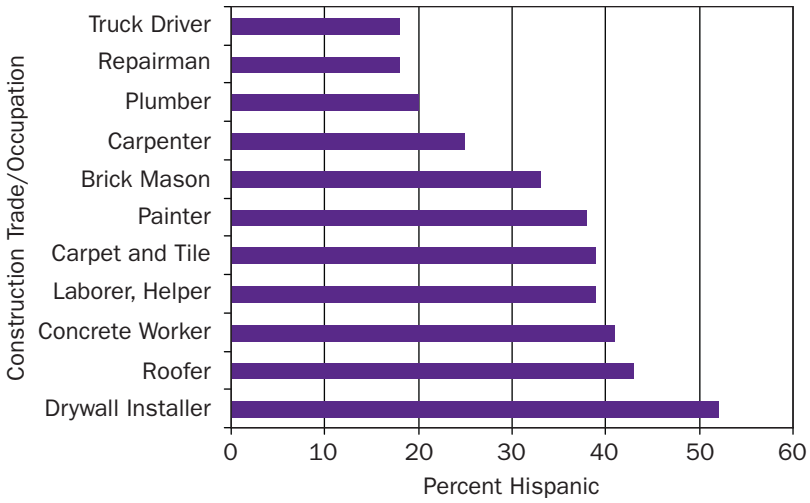
for nearly 40 percent of all deaths of Hispanic construction workers, compared to 31 percent for white non-Hispanics.[13,68,71] Furthermore, Dong and colleagues showed that Hispanic workers were 53 percent more likely to have medical conditions resulting from work-related injuries than their white non-Hispanic counterparts, but 48 percent *less* likely to receive payment for medical costs from workers' compensation.[63] The average medical cost per injury was about $210 more (12.4 percent higher) for Hispanic construction workers than for white non-Hispanic workers.[63]

New immigrant workers—in particular undocumented workers—experience communication, legal, and cultural barriers to understanding and exercising their workplace rights.[63] Many undocumented immigrant workers are day laborers hired from street corners. They are often employed in dangerous conditions and afraid to speak up for their rights for fear of possible retaliation.[72,73] Undocumented day laborers have few job alternatives because of their lack of work authorization, weak English, relative youth, limited formal education, and lack of job experience.[72] The majority are hired by non-union residential construction contractors or directly by landlords/homeowners to carry out tasks such as roofing (e.g., carrying shingles up to the roof), demolition, drywall installation, painting, and repairs carried out on ladders or scaffolds.[72] These employers have typically little awareness of occupational safety and health concerns and rarely use measures to prevent injuries and illnesses (e.g., guard rails and other fall prevention systems, training, personal protective equipment).[72]

Government action

Since the passage of the OSHAct, OSHA has developed and adopted a number of standards for the construction sector. Most recently, in 2010 OSHA issued the Final Rule on Cranes and Derricks in Construction and also proposed a rule on Walking-Working Surfaces and Personal Protective Equipment (Fall Protection Systems) to prevent injuries from slips, trips and falls.[74,75] Furthermore, OSHA has suggested changes in the OSHAct's General Duty Clause that would extend an employer's general duty to protect employees from recognized hazards beyond protecting its own employees to protecting contract employees as well.[76] These and other key events in the history of occupational safety and health in the construction industry are listed in the timeline that appears at the end of this case study.

FIGURE 3
Percent of workers who are Hispanic in selected trades in 2007.



Source: CPWR—The Center for Construction Research and Training. The Construction Chart Book. *2008. Chart 41d, p41.*

Hispanic construction workers are more likely to suffer fatal and non-fatal injuries than their white non-Hispanic co-workers.

Tackling enforcement challenges: OSHA's focused inspections

Currently, OSHA has about 1,100 federal inspectors and a considerable amount of their time is devoted to monitoring safety and health conditions in the construction sector.[77] The number of construction inspections dropped in the mid-1990s and has been increasing slightly since 1997. However, the total number of inspections performed in 2006 is about 26 percent lower than in 1988.[14] At the same time, the number of construction establishments increased about 47 percent from 1987 to 2005.[14] Further, the dynamic nature of construction work creates enforcement

Unions play an important role in safety and health training, information, advocacy, and support for immigrant construction workers.

challenges that are different from those in a fixed manufacturing location.[4]

Since 1994, OSHA has been carrying out a "focused" inspection program in the construction industry—looking only at the four leading hazards (falls, struck-by, caught-in-between, and electrocutions).[11] To qualify for a focused inspection, a contractor must have established an effective safety and health program.[11] In 2006, 6 percent of OSHA construction inspections were classified as "focused."[14] The focused inspection approach enables inspectors to target their efforts on sites that are likely to be more hazardous. They are thus able to conduct more comprehensive inspections at these sites.

National safety and health priorities in the US construction industry

Through the National Occupational Research Agenda of the National Institute for Occupational Safety and Health (NIOSH),[10] various stakeholders in the construction sector have developed the National Construction Agenda. The Agenda consists of 15 occupational safety and health priorities to guide the research community and industry in addressing recognized challenges (Table 1).[1]

Resources are needed not only for the 15 priorities on the National Construction Agenda, but also for recently designated emerging issues relevant to construction workers' safety and health. Gillen & Gittleman have reviewed and highlighted the following emerging issues:[78]

- climate change and energy considerations, including not only green construction developments and opportunities but also work-related heat hazards among construction workers (e.g., heat stress/stroke, air pollution, vector-borne diseases, and extreme weather events).

- potential hazards from the use of new materials, in particular nanomaterials or lightweight composites. One such example is titanium dioxide nanoparticles, which are added to cement to break down organic pollutants via catalytic reactions—this allows concrete to retain its whiteness and resist staining. Also, nanoscale silica is added to cement to improve particle packing, increasing the cement density structure, improving the mechanical properties of the cement.
- changes in industry structure and practice to address safety more efficiently. The construction industry's highly complex structure includes multiple layers of organizations and disciplines simultaneously performing specialized tasks. The communication challenges and self-interests of these multiple entities can adversely affect both safety planning and safety program implementation, as well as business innovation in general. More integrated delivery of construction and expanded early engagement of all project stakeholders are needed. For example, the architecture community is developing new "integrated practice" approaches to address these limitations and inefficiencies.
- changes in the makeup of the workforce, including the greater presence of immigrant workers and the aging of the workforce.
- underreporting of injuries as well as shifting costs and other burdens from the employer to workers' families, health insurance, social services, and future employers.
- understanding the root causes of illnesses and injuries, and in particular understanding the connections among the causal factors and processes involved in incidents.

TABLE 1

Fifteen priorities reflected in strategic goals set by the National Construction Agenda to improve construction workers' safety and health[10]

Reduce traumatic injury/events
• Falls • Electrocution • Struck-by hazards
Reduce other health hazards and their impacts
• Noise and hearing loss • Silica exposures and associated illnesses • Welding fumes and associated illnesses • Ergonomic factors and associated musculoskeletal disorders
Address contributing factors
• Modify construction culture • Implement construction safety and health management systems • Improve understanding of organizational factors in causing injury and illness • Implement construction hazards prevention through design (CHPtD) • Enhance training and education • Reduce disparities in health and safety in construction • Improve surveillance of hazards and outcomes • Engage the media to raise awareness and improve safety and health in construction

LESSONS LEARNED

Four key strategies emerge from our analysis of construction safety and health: (1) implementing management systems in construction safety and health; (2) implementing construction hazards prevention through design (CHPtD); (3) enhancing training and other supports for immigrant construction workers; and (4) engaging the media to raise awareness and improve safety and health in construction.

Need for an occupational safety and health management systems approach

A complex, very hazardous, dynamic, and fast-paced industry needs a comprehensive and systematic OSH solution. One of the best such approaches is an occupational safety and health management system (OSH-MS). An OSH-MS encompasses every critical function through the plan–do–check–act cycle: workplace policy planning and set-up, implementation and operation of the system, evaluation of the system, and continual improvement of OSH performance. OSHA qualifies for focused inspections those construction contractors that have a comprehensive OSH program (i.e., an OSH-MS) in place at their sites.

Without an OSH-MS, many companies (and not only in the construction field) approach safety and health sporadically. Some corrective action might be taken when serious incidents occur, but these actions rarely tackle root causes or aim toward continual improvement. All too often, incident reporting and tracking are not taken seriously. It is tempting to cut corners when facing deadlines. Even when programs are established at worksites, their goal often seems to be compliance with a certain standard rather than preventing and minimizing as many hazards as possible.[79]

Management systems have been gaining in popularity ever since the International Organization for Standardization (ISO) passed its Quality Management 9000 Series (in 1986) and its Environmental Management 14000 Series (in 1996).[80] OSH was seen as a logical component of both these ISO standards.[80] Since then, various frameworks have been developed worldwide, including the International Guidelines for Occupational Safety and Health Management Systems under the leadership of the International Labour Organization (ILO) in 2001 (Figure 4).[81] In 1988, the ILO adopted its Safety and Health in Construction Convention (No.167), which has been ratified by 24 countries to date.[82,d]

In the United States, OSHA proposed a safety and health program rule in 1998 but it was withdrawn in 2002.[83] In 2005, the American National Standards Institute (ANSI) adopted an OSH-MS consensus standard.[79] The ANSI OSH-MS standard was developed by a committee of more than 40 OSH specialists representing industry, labor, government, and others.[79] The committee was known as the Z10 committee, and hence the standard is generally known as ANSI Z10. To date, many companies have successfully implemented

FIGURE 4
Main elements of the OSH management system of the International Labour Organization

Source: International Labour Organization. Guidelines on Occupational Safety and Health Management Systems *(ILO-OSH 2001). Figure 2, p5.*

d The United States has not ratified the ILO's Safety and Health in Construction Convention (No. 167, 1988). The only ILO Convention related to occupational safety and health that the United States has ratified (in 2001) is the Safety and Health in Mines Convention (No. 176. 1995).

construction safety and health management systems (see sidebar, *A success story*).

Sustaining the Construction Hazard Prevention through Design (CHPtD) movement

In 2007, NIOSH established a national initiative called Prevention through Design (PtD).[85] In all business decisions, the PtD approach emphasizes the importance of designing out, or at least minimizing, occupational hazards early in the design stage to prevent occupational injuries and illnesses. The first step for the PtD launch was the 2007 National Workshop, at which stakeholders from eight sectors—including construction—convened to formulate the PtD strategy.[85] Construction Hazard Prevention through Design (CHPtD) is a procedure in which construction engineers and architects consider the safety of construction workers as they design a facility.[86]

CHPtD has been recognized and implemented internationally as a feasible method to reduce occupational hazards in construction—in particular in the United Kingdom (UK) and Australia.[87] In 1995, the UK passed a law requiring architects and construction engineers to incorporate CHPtD when designing facilities.[86] In contrast, in the United States, many professional organizations were not aware of the NIOSH PtD initiative in 2007.

Construction Hazard Prevention through Design (CHPtD) is a procedure in which construction engineers and architects consider the safety of construction workers as they design a facility.

In all countries, there seem to be similar challenges in implementing CHPtD, such as designers' lack of safety expertise and additional costs,[86] but in the United States

A success story: One corporation's construction safety and health management system[84]

As a result of a partnership between AMEC Construction Management, Inc., and OSHA—a partnership that originated in Calumet City, Illinois—comprehensive safety and health management systems have been developed and implemented at participating AMEC job sites. The management systems include these core elements: (1) management leadership and employee involvement; (2) worksite analysis; (3) hazard prevention and control; and (4) safety and health training. For example, the following activities have been undertaken at the sites:

- safety and health orientation training for new employees;
- daily safety site audits and weekly hazard assessments, including identification and correction of hazards;
- weekly mandatory safety tool-box talks to review the results of the site's safety audits and hazard assessments; and
- investigation of near-miss incidents.

To date, over 2,000 employees have received training through the toolbox talks and new employee orientations. Since the partnership began in April 2002, the overall rate of recordable case incidents for participating AMEC subcontractors declined from 9.1 in 2002 to 2.8 in 2004, a 69 percent reduction. AMEC's 2004 case incident rate of 2.8 is 59 percent below the 2002 non-residential construction industry national average of 6.9 case incidents.

LESSONS LEARNED

there are some distinct concerns in moving the CHPtD effort further. The most important of these is US architects' and engineers' fear of liability for not following standard practices. In contrast, in the United Kingdom and Australia, liability is less of a concern because of legislative requirements for safety. The construction sector stakeholders in the National Workshop developed seven recommendations to sustain CHPtD in the United States (see sidebar).[87]

Research has identified three distinct benefits of CHPtD: (1) Project decisions that dramatically influence project safety occur early in the project, and are usually made by designers and owners. (2) Since many construction hazards are associated with forces, stresses, dynamic motion, and electricity, it would clearly be beneficial to include site safety in design decisions (e.g., regarding soil cave-ins, the safety of cranes, and protection from falls). (3) Engaging all parties in worker safety is important for both symbolic reasons and for making better plans.[86]

Emerging issues in the National Construction Agenda (listed above) are particularly relevant to CHPtD.[78] There are recommendations to incorporate CHPtD in the US Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) movement.[87] The LEED structure has faced criticism for not addressing the safety of construction workers. It is vital that green building and sustainability practices—such as LEED—incorporate prevention of injuries, illnesses, and fatalities during construction.[78,87]

For example, the use of skylights is increasing—and as a green construction and energy conservation measure, this is a good thing. However, falls through fragile skylights have resulted in death or serious injury to construction workers. Design solutions that protect against the risk of falls through skylights during construction, maintenance, and demolition activities include the following:[88]

- use of non-fragile skylights that withstand the live load associated with a construction or maintenance worker inadvertently stepping on or falling on a skylight;
- installation of a permanent guard or screen over each skylight to handle heavy loads;
- installation of temporary guardrails around the perimeter of a skylight installation area; and
- upgrading of fragile existing skylights by installing permanent guards or screens (the latter are recommended for plastic dome skylights and light-transmitting panels because they can degrade over time).

Seven recommendations to sustain CHPtD in the United States[87]

1. Gather, combine, and share programs, checklists, best practices,…customized by type of construction and firm size.
2. Develop case studies for owners and designers.
3. Clarify liability issues with insurers and attorneys to distinguish between real versus perceived liability.
4. Create PtD education for continuing education units (CEUs) that are required for Professional Engineer and Registered Architect certification renewals in some states.
5. Develop consensus PtD standards (ANSI, building code, etc.) to define PtD and the PtD process.
6. Apply LEED/sustainability experiences to spread PtD.
7. Collaborate with and educate key professional organizations (American Institute of Architects, Construction Industry Institute, and Construction Users Roundtable).

OSH training, advocacy, and community support to protect immigrant construction workers

The construction sector employs a particularly vulnerable population of immigrant workers. Immigrant workers need proper safety equipment, safe tools and materials, and training in a language they understand. Further, it is essential that immigrant workers neither fear to report nor hesitate to report concerns about workplace OSH problems to OSHA.[89]

The significance of training cannot be over emphasized, and there is evidence that proper training reduces work injuries. A study by Sokas and colleagues found significant improvements in OSH knowledge and attitudes, as well as improvements in practices on the job, three months after a 10-hour OSH awareness class among both US-born and Mexican-born union construction workers.[90] Another study, by Williams and colleagues, showed that participatory training emphasizing active problem solving not only encourages workers to protect themselves but also equips workers with the knowledge they need to make informed decisions on work assignments and work practices.[72] Despite economic barriers, limited formal education, undocumented status, and limited control over their work environment, Hispanic day laborers are receptive to OSH training and to protecting themselves and co-workers on the job.[72] In addition to training, community support remains crucial for offering a public voice for immigrant labor. Researchers at the University of Massachusetts Lowell have developed educational and training materials especially for Hispanic workers, including materials for the OSHA 10-hour construction training program (see sidebar, *Hispanics Work Safe Project*).

Hispanics Work Safe Project[91]

Hispanics Work Safe materials include linguistically and culturally appropriate training modules on construction safety and health, each with three basic components: (1) a description of the most dangerous tasks; (2) identification of the hazards associated with these hazardous tasks; and (3) recommended methods of controlling and reducing the identified hazards. An important training component is an introductory 30-minute lecture ("Welcome, Hispanic Worker!"), which focuses on the following topics: Why is this training important? What are we going to learn? How can we take advantage of the training and translate the knowledge acquired into our own daily work practices? All participants receive a training manual and a set of educational materials. Upon successful completion of the 10-hour course, the participants receive an OSHA 10-hour card, a document that is mandatory for employment in construction in a number of states, including Massachusetts.

The media's role in improving safety

Schneider and Check have analyzed the vital role of the media in preventing construction-related injuries. Changes in legislation, regulations, other policies, and work practices can all be promoted through the media, with a positive effect on construction workers' lives.[92] There are two major challenges in current media reporting: (1) The news media tend to cover catastrophic incidents (e.g., involving cranes) in which several workers die at once, whereas individual fatalities rarely receive coverage. (2) There is no in-depth focus on the "why and how" of the incident. Instead, the media often portray construction injuries and fatalities as unpreventable tragedies.[92] These authors emphasized that these challenges present an opportunity for safety and health professionals to: (1) encourage news media to provide deeper, more sustained coverage of construction injuries; and (2) provide data, insights, and expertise that will help reporters and editors to do so. Schneider and Check have provided examples of extraordinary in-depth media reporting of construction-related injuries—for example, Alexandra Berzon's coverage in the *Las Vegas Sun* of 11 fatalities among construction workers within 17 months on Las Vegas' gigantic CityCenter and Cosmopolitan construction projects.[93] Berzon's coverage revealed the patterns, root causes, and potential solutions of the safety problems that led to these fatalities.[92] Furthermore, it raised awareness of construction safety among the public and policymakers, resulting in changes across the entire Las Vegas construction industry.[92]

Final thoughts

This case study has provided an overview of the highly hazardous construction sector and recommended an occupational safety and health management system (OSHMS) approach as the most important key to improving

LESSONS LEARNED

safety in construction. Issuing a national OSH-MS framework for the construction sector should not be an impossible task. In fact, models already exist, including OSHA's Draft Proposed Safety and Health Program Rule of 1998, ILO-OSH 2001, and ANSI Z10.

It is also vital to keep the momentum going on Construction Hazard Prevention through Design (CHPtD). The stakeholders who participated in the National PtD Workshop felt strongly that a government regulation on CHPtD is not a viable short-term strategy—but that it is important for governmental agencies to continue leading the CHPtD movement. CHPtD is also an avenue to incorporate construction workers' safety and health in green building and other sustainability programs.

NIOSH-FACE Program recommendations for employers to prevent collisions[1]

- Develop, implement, and enforce a policy that requires workers on foot to maintain a safe clearance from mobile equipment and train all workers regarding this policy.
- Develop, implement, and enforce a policy that requires mobile equipment operators to operate mobile equipment in accordance with safety guidance provided in the equipment operator's manual and provide additional training to all mobile equipment operators regarding this policy.
- Consider conducting a pre-work safety meeting each day to discuss the work to be performed, potential safety hazards and safe work procedures, and means to be used for communicating changes to the work plan.
- Ensure that personal protective equipment, including high-visibility clothing, is provided and used in accordance with company policy.

The media often portray construction injuries and fatalities as unpreventable tragedies.

It is critical to identify ways to reduce the growing number of fatal and non-fatal injuries among immigrant workers, in particular among day laborers. Workplace training and community support are among the most important interventions. OSH interventions grounded in partnerships with community-based organizations can offer successful strategies for reaching out to immigrant workers, understanding their needs, and developing solutions based on those needs.

The potential exists to improve construction workers' safety and health by highlighting fundamental issues through in-depth reporting by the traditional media, as well as through internet-based and social media. To enable reporters and editors to provide deeper, more sustained coverage of OSH matters in construction—with adequate data, insights, and expertise—the construction OSH community must develop relationships with media outlets. As a result of this kind of networking, the news media will become less likely to cover only catastrophic incidents or leave the false impression that construction injuries are unpreventable tragedies.

We started this case study by describing a struck-by fatality, documented by NIOSH-FACE Program.[1] How can occurrences similar to this collision fatality be prevented? The NIOSH investigators developed four recommendations for employers to prevent similar incidents (see sidebar).[1,e]

In addition to the four recommendations for employers, the NIOSH investigators recommended a specific Prevention-through-Design (PtD) action for manufacturers of equipment (e.g., bulldozers): "manufacturers of heavy equipment should explore the possibility of incorporating collision avoidance technology in their

e *The NIOSH-FACE report offers more detailed discussion of each recommendation at http://www.cdc.gov/niosh/face/In-house/full200511.html.*

Falls are the most frequent cause of fatal injuries among construction workers in the United States.

equipment."[1] Radio frequency identification (RFID) tags and tag readers are one such collision warning technology: each worker on foot wears a small RFID tag, each piece of mobile equipment is equipped with a tag reader, and the equipment operator receives a warning when a tag is sensed.[1,94]

OSHA and NIOSH are part of the Roadway Work Zone Safety and Health Alliance, which includes these six other partners from the employers' and employees' organizations: American Road and Transportation Builders Association (ARTBA), Associated General Contractors of America (AGC), International Union of Operating Engineers (IUOE), Laborers' International Union of North America (LIUNA), LIUNA Education and Training Fund, and National Asphalt Pavement Association (NAPA).[95] The Alliance provides construction industry employers, workers (including Spanish-speaking and other high-risk or hard-to-reach workers), and others with information, guidance, and training resources specifically to reduce and prevent exposures to roadway work zone safety and health hazards (e.g. flagger safety, safer deployment of traffic control and direction devices, safer night work precautions, work zone speeding control as well as runover/ backover control).[95] The National Work Zone Safety Information Clearinghouse is located at *http://www.workzonesafety.org*—many tools and documents developed by the Alliance are at this site.

An important overall strategy to prevent collisions in worksites is an Internal Traffic Control Plan to design worksite traffic patterns in such a way that the amount of vehicle backing is reduced and the exposure of workers on foot to vehicles is minimized.[96] Collisions happen in part because of limited visibility around the equipment.[97] NIOSH has developed blind zone analysis diagrams for various types of construction equipment.[97]

CASE STUDY 4 — **TIMELINE**

YEAR	EVENT
1971	The first OSHA standards are published in the Federal Register on May 29, 1971, including those for construction. Safety and health standards for the construction industry are found in "Part 1926" under Title 29 of the Code of Federal Regulations (CFR).[98]
1973	The Advisory Committee on Construction Safety and Health (ACCSH) is established to advise OSHA on setting construction standards and policy matters.[99]
1978	At the construction site for a power plant in Willow Island, West Virginia, scaffolding around the cooling tower collapses, killing 51 workers.[98]
1978	In Bridgeport, Connecticut, the collapse of the L'Ambiance Plaza building, under construction, kills 28 workers.[98]
1982	OSHA formally announces the Voluntary Protection Program (VPP) to recognize workplaces with exemplary safety and health management systems and designates the first VPP site.[100]
1986	The International Standardization Organization adopts its Quality Management 9000 Series.[81]
1988	The International Labour Organization (ILO) adopts its Safety and Health in Construction Convention (No. 167, 1988).[82]
1989	OSHA issues its voluntary guidelines for safety and health program management.[101]
1990s	Several major construction safety and health standards are finalized.[98]
1994	OSHA begins its focused inspection initiative for contractors who have established and fully implemented a corporate safety and health program and site-specific plans. [11]
1996	The International Standardization Organization adopts its Environmental Management 14000 Series.[81]
1998	OSHA proposes its occupational safety and health program rule (29 CFR 1900.1). The rule will be withdrawn in 2002.[102]
2001	The ILO adopts the International Guidelines for Occupational Safety and Health Management Systems, known as ILO-OSH 2001.[81]
2001	The World Trade Center attack results in a massive "worksite," where intensive rescue efforts in the midst of unprecedented hazards are followed by more than eight months of demolition and cleanup, and eventually by reconstruction.[98]
2002	OSHA launches its Alliance Program, which brings OSHA together with businesses, trade or professional organizations, unions, and educational institutions.[98]
2005	The American National Standards Institute adopts an occupational safety and health management system consensus standard, known as ANSI Z-10. [80]
2007	NIOSH establishes its national initiative, Prevention through Design (PtD) that focuses on designing out or minimizing occupational hazards and risks early in the design of technology.[85]
2007	On August 1, the I-35W Bridge in Minneapolis, Minnesota, collapses, killing 13 people and injuring 98. A construction worker was among those killed.[98]
2007-2008	Eleven construction workers die within 17 months in CityCenter and Cosmopolitan construction projects in Las Vegas.[92]
2008-2009	Construction accounts for the largest number of work-related fatalities and ranks as the fourth highest for non-fatal serious injuries.
2010	OSHA issues a final rule on updating the standard for cranes and derricks in construction.[75]

Acknowledgments

We wish to acknowledge valuable injury and illness prevention work by various organizations that have improved safety and health among construction workers in the United States. These organizations include the National Institute for Occupational Safety and Health (NIOSH), NIOSH's Fatality Assessment and Control Evaluation (FACE) program, CPWR: The Center for Construction Research and Training, the Occupational Safety and Health Administration, the National Safety Council, and many others.

The year 2010 marked the 20th anniversary of the Construction Research Program at NIOSH.[101] To celebrate the anniversary, the National Safety Council, NIOSH, and the National Construction Center assembled a special issue of the *Journal of Safety Research* on construction workers' safety and health.[101] Many articles of this special issue have been cited in this case study. In particular, we would like to give a special acknowledgement to CPWR, which has created significant databanks and summaries on OSH in construction that are available on its website (*www.cpwr.com*). These resources include: the Construction Chart Book[14], Hispanic Employment in Construction, the Electronic Library of Construction Occupational Safety and Health (eLCOSH), and Construction Solutions Database.[4,68,102,103]

We thank Dr. Laura Welch of CPWR for peer reviewing this case study.

References

1. Fatality Assessment and Control Evaluation (FACE) Program, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *Construction Worker Dies After Being Run Over By a Bulldozer at a Commercial Construction Site - North Carolina (NIOSH In-house FACE Report 2005-11)*. 2006. Available at: *http://www.cdc.gov/niosh/face/In-house/full200511.html*. Accessed: November 15, 2010.
2. Baron S, Welch L, Lipscomb J. Addressing Health and Safety Hazards in Specific Industries: Agriculture, Construction, and Health Care. Construction Workers by Laura S. Welch. In B Levy, D Wegman, S Baron, et al. (Eds.), *Occupational and Environmental Health: Recognizing and Preventing Disease and Injury*. 5th edition. Philadelphia (PA): Lippincott Williams and Wilkins. 2006. 668-675.
3. Weeks JL. *Health and Safety Hazards in the Construction Industry*. In JM Stellman (ed.), *Encyclopaedia of Occupational Health and Safety*. Fourth edition. Vol III: 93.2-93.8. Geneva: International Labour Office, 1998.
4. Weil D. *Making OSHA Inspections More Effective: Alternatives for Improved Inspection Targeting In the Construction Industry*. CPWR—Center for Construction Training and Research. 2004. Available at: *http://www.elcosh.org/record/document/701/d000663.pdf*. Accessed: November 15, 2010.
5. Bureau of Labor Statistics, U.S. Department of Labor. *Career Guide to Industries, 2010-11 Edition: Construction*. 2010. Available at: *http://www.bls.gov/oco/cg/cgs003.htm*. Accessed: November 15, 2010.
6. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *NIOSH Safety and Health Topic: Construction*. 2009. Available at: *http://www.cdc.gov/niosh/topics/construction/*. Accessed: November 15, 2010.
7. Bureau of Labor Statistics, U.S. Department of Labor. *Revisions to the 2008 Census of Fatal Occupational Injuries (CFOI) counts*. 2010. Available at: *http://www.bls.gov/iif/oshwc/cfoi/cfoi_revised08.pdf*. Accessed: November 15, 2010.
8. Bureau of Labor Statistics, U.S. Department of Labor. *National Census for Fatal Occupational Injuries*. 2009. Available at: *http://www.bls.gov/news.release/pdf/cfoi.pdf*. Accessed: November 15, 2010.
9. Bureau of Labor Statistics, U.S. Department of Labor. *National Census for Fatal Occupational Injuries in 2009 (Preliminary Results)*. 2010. Available at: *http://www.bls.gov/news.release/pdf/cfoi.pdf*. Accessed: November 15, 2010.
10. NORA Construction Sector Council. *National Occupational Research Agenda (NORA) for Occupational Safety and Health Research and Practice in the U.S. Construction Sector* 2008; (10/27/08 Revision). Available at: *http://www.cdc.gov/niosh/NORA/comment/agendas/construction/pdfs/ConstOct2008.pdf*. Accessed: November 15, 2010.
11. Occupational Safety and Health Administration, U.S. Department of Labor. *Focused Inspections in Construction*. 1996. Available at: *http://www.osha.gov/doc/outreachtraining/htmlfiles/focused.html*. Accessed: November 15, 2010.
12. Occupational Safety and Health Administration, U.S. Department of Labor. *Preventing Fatal Falls in Construction*. 2008. Available at: *http://www.osha.gov/doc/falls/preventingfalls.html*. Accessed: November 15, 2010.
13. CPWR—the Center for Construction Research and Training. *Highlights 2009: Endings & Beginnings*. 2009. Available at: *http://www.cpwr.com/pdfs/Highlights%202009.pdf*. Accessed: November 15, 2010.
14. CPWR—the Center for Construction Research and Training. *Construction Chart Book*. 2008. Available at: *http://cpwr.com/rp-chartbook.html*. Accessed: November 17, 2010.
15. Bureau of Labor Statistics, U.S. Department of Labor. *Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work, 2008*. 2009. Available at: *http://www.bls.gov/iif/oshwc/osh/case/osnr0033.pdf*. Accessed: November 15, 2010.
16. Lipscomb HJ, Schoenfisch AL, Shishlov KS. Non-fatal contact injuries among workers in the construction industry treated in U.S. emergency departments, 1998-2005. *J Safety Res*. 2010;41(3):191-5.

17. Lipscomb HJ, Schoenfisch AL, Shishlov KS, et al. Nonfatal tool- or equipment-related injuries treated in US emergency departments among workers in the construction industry, 1998-2005. *Am J Ind Med*. 2010;53(6):581-7.
18. Tjoe Nij E, Heederik D. Risk assessment of silicosis and lung cancer among construction workers exposed to respirable quartz. *Scand J Work Environ Health.* 2005;31(Suppl 2):49-56.
19. Jarvholm B, Silverman D. Lung cancer in heavy equipment operators and truck drivers with diesel exhaust exposure in the construction industry. *Occup Environ Med.* 2003;60(7):516-20.
20. Koskinen K, Pukkala E, Martikainen R, et al. Different measures of asbestos exposure in estimating risk of lung cancer and mesothelioma among construction workers. *J Occup Environ Med.* 2002;44(12):1190-6.
21. Purdue MP, Gold L, Jarvholm B, et al. Impaired lung function and lung cancer incidence in a cohort of Swedish construction workers. *Thorax.* 2007;62(1):51-6.
22. Meeker JD, Cooper MR, Lefkowitz D, et al. Engineering control technologies to reduce occupational silica exposures in masonry cutting and tuckpointing. *Public Health Rep.* 2009;124 Suppl 1:101-11.
23. Akbar-Khanzadeh F, Milz S, Ames A, et al. Crystalline silica dust and respirable particulate matter during indoor concrete grinding—wet grinding and ventilated grinding compared with uncontrolled conventional grinding. *J Occup Environ Hyg.* 2007;4(10):770-9.
24. Meeker JD, Susi P, Pellegrino A. Exposure to silica and metals among painters using specular hematite abrasive. *J Occup Environ Hyg.* 2005;2(8):D60-4.
25. Yasui S, Susi P, McClean M, et al. Assessment of silica exposure and engineering controls during tuckpointing. *Appl Occup Environ Hyg.* 2003;18(12):977-84.
26. Flynn MR, Susi P. Engineering controls for selected silica and dust exposures in the construction industry—a review. *Appl Occup Environ Hyg.* 2003;18(4):268-77.
27. Rappaport SM, Goldberg M, Susi P, et al. Excessive exposure to silica in the US construction industry. *Ann Occup Hyg.* 2003;47(2):111-22.
28. Shepherd S, Woskie SR, Holcroft C, et al. Reducing silica and dust exposures in construction during use of powered concrete-cutting hand tools: efficacy of local exhaust ventilation on hammer drills. *J Occup Environ Hyg.* 2009;6(1):42-51.
29. Woskie SR, Kalil A, Bello D, et al. Exposures to quartz, diesel, dust, and welding fumes during heavy and highway construction. *AIHA J (Fairfax, Va).* 2002;63(4):447-57.
30. Bello D, Virji MA, Kalil AJ, et al. Quantification of respirable, thoracic, and inhalable quartz exposures by FT-IR in personal impactor samples from construction sites. *Appl Occup Environ Hyg.* 2002;17(8):580-90.
31. Virji MA, Bello D, Woskie SR, et al. Analysis of quartz by FT-IR in air samples of construction dust. *Appl Occup Environ Hyg.* 2002;17(3):165-75.
32. Engholm G, Englund A. Asbestos hazard in the Swedish construction industry—recent trends in mesothelioma incidence. *Scand J Work Environ Health.* 2005;31(Suppl 2):27-30.
33. Fonte R, Gambettino S, Melazzini M, et al. Asbestos-induced peritoneal mesothelioma in a construction worker. *Environ Health Perspect.* 2004;112(5):616-9.
34. Merler E, Bressan V, Somigliana A. [Mesothelioma in construction workers: risk estimate, lung content of asbestos fibres, claims for compensation for occupational disease in the Veneto Region mesothelioma register]. *Med Lav.* 2009;100(2):120-32.
35. Welch LS, Haile E. Asbestos-related disease among sheet metal workers 1986-2004: radiographic changes over time. *Am J Ind Med.* 2009;52(7):519-25.
36. Dement JM, Ringen K, Welch LS, et al. Mortality of older construction and craft workers employed at Department of Energy (DOE) nuclear sites. *Am J Ind Med.* 2009;52(9):671-82.
37. Dement JM, Welch L, Ringen K, et al. Airways obstruction among older construction and trade workers at Department of Energy nuclear sites. *Am J Ind Med*. 2010;53(3):224-40.
38. Guo YL, Wang BJ, Yeh KC, et al. Dermatoses in cement workers in southern Taiwan. *Contact Dermatitis.* 1999;40(1):1-7.
39. Chou TC, Chang HY, Chen CJ, et al. Effect of hand dermatitis on the total body burden of chromium after ferrous sulfate application in cement among cement workers. *Contact Dermatitis.* 2008;59(3):151-6.
40. Chen CJ, Shih TS, Chang HY, et al. The total body burden of chromium associated with skin disease and smoking among cement workers. *Sci Total Environ.* 2008;391(1):76-81.
41. Macedo MS, de Avelar Alchorne AO, Costa EB, et al. Contact allergy in male construction workers in Sao Paulo, Brazil, 2000-2005. *Contact Dermatitis.* 2007;56(4):232-4.
42. Uter W, Ruhl R, Pfahlberg A, et al. Contact allergy in construction workers: results of a multifactorial analysis. *Ann Occup Hyg.* 2004;48(1):21-7.
43. Katsarou-Katsari A, Bankovska E, Lambrinopoulou K, et al. Trends in allergic contact dermatitis and preventive measures among cement workers (1985-1999). *Contact Dermatitis.* 2003;48(3):174-5.
44. Bock M, Schmidt A, Bruckner T, et al. Occupational skin disease in the construction industry. *Br J Dermatol.* 2003;149(6):1165-71.
45. Winder C, Carmody M. The dermal toxicity of cement. *Toxicol Ind Health.* 2002;18(7):321-31.
46. Tak S, Roscoe RJ, Alarcon W, et al. Characteristics of US workers whose blood lead levels trigger the medical removal protection provision, and conformity with biological monitoring requirements, 2003-2005. *Am J Ind Med.* 2008;51(9):691-700.
47. Virji MA, Woskie SR, Pepper LD. Task-based lead exposures and work site characteristics of bridge surface preparation and painting contractors. *J Occup Environ Hyg.* 2009;6(2):99-112.
48. Virji MA, Woskie SR, Pepper LD. Skin and surface lead contamination, hygiene programs, and work practices of bridge surface preparation and painting contractors. *J Occup Environ Hyg.* 2009;6(2):131-42.

49. Flynn MR, Susi P. Neurological risks associated with manganese exposure from welding operations—a literature review. *Int J Hyg Environ Health.* 2009;212(5):459-69.
50. Flynn MR, Susi P. Manganese, iron, and total particulate exposures to welders. *J Occup Environ Hyg*. 2010;7(2):115-26.
51. Meeker JD, Susi P, Flynn MR. Manganese and welding fume exposure and control in construction. *J Occup Environ Hyg.* 2007;4(12):943-51.
52. Welch LS, Rappaport SM, Susi P. Construction welding exposures to manganese likely to exceed proposed TLV. *J Occup Environ Hyg.* 2004;1(6):D63-5.
53. Schneider SP. Musculoskeletal injuries in construction: a review of the literature. *Appl Occup Environ Hyg.* 2001;16(11):1056-64.
54. Buchholz B, Paquet V, Wellman H, et al. Quantification of ergonomic hazards for ironworkers performing concrete reinforcement tasks during heavy highway construction. *AIHA J (Fairfax, Va).* 2003;64(2):243-50.
55. Kittusamy NK, Buchholz B. Whole-body vibration and postural stress among operators of construction equipment: a literature review. *J Safety Res*. 2004;35(3):255-61.
56. Moir S, Paquet V, Punnett L, et al. Making sense of highway construction: a taxonomic framework for ergonomic exposure assessment and intervention research. *Appl Occup Environ Hyg.* 2003;18(4):256-67.
57. Paquet V, Punnett L, Woskie S, et al. Reliable exposure assessment strategies for physical ergonomics stressors in construction and other non-routinized work. *Ergonomics.* 2005;48(9):1200-19.
58. Tak S, Paquet V, Woskie S, et al. Variability in risk factors for knee injury in construction. *J Occup Environ Hyg*. 2009;6(2):113-20.
59. Hartmann B, Fleischer, AG. Physical load exposure at construction sites. *Scand J Work Environ Health.* 2005;31(Suppl 2):88-95.
60. Rempel D, Star D, Barr A, et al. Field evaluation of a modified intervention for overhead drilling. *J Occup Environ Hyg*. 2010;7(4):194-202.
61. Rempel D, Star D, Barr A, et al. Overhead drilling: comparing three bases for aligning a drilling jig to vertical. *J Safety Res*. 2010;41(3):247-51.
62. U.S. Bureau of Economic Analysis. *Gross-Domestic-Product-by-Industry Accounts: Value Added by Industry as a Percentage of Gross Domestic Product*. 2010. Available at: *http://www.bea.gov/industry/gpotables/gpo_action.cfm?anon=506501&table_id=25696&format_type=0*. Accessed: November 15, 2010.
63. Dong X, Ringen K, Men Y, et al. Medical costs and sources of payment for work-related injuries among Hispanic construction workers. *J Occup Environ Med.* 2007;49(12):1367-75.
64. Waehrer GM, Dong XS, Miller T, et al. Costs of occupational injuries in construction in the United States. *Accid Anal Prev.* 2007;39(6):1258-66.
65. Waehrer GM, Dong XS, Miller T, et al. Occupational injury costs and alternative employment in construction trades. *J Occup Environ Med.* 2007;49(11):1218-27.
66. Horwitz IB, McCall BP. Disabling and fatal occupational claim rates, risks, and costs in the Oregon construction industry 1990-1997. *J Occup Environ Hyg.* 2004;1(10):688-98.
67. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *NIOSH Fatal Occupational Injury Cost Fact Sheet: Construction*. 2006. Available at: *http://www.cdc.gov/niosh/docs/2006-153/*. Accessed: November 15, 2010.
68. CPWR - the Center for Construction Research and Training. *Hispanic Employment in Construction*. 2009. Available at: *http://www.cpwr.com/pdfs/Hispanic_Data_Brief-Nov-09.pdf*. Accessed: November 15, 2010.
69. Dong X, Platner JW. Occupational fatalities of Hispanic construction workers from 1992 to 2000. *Am J Ind Med.* 2004;45(1):45-54.
70. Dong XS, Men Y, Ringen K. Work-related injuries among Hispanic construction workers-evidence from the medical expenditure panel survey. *Am J Ind Med*. 2010;53(6):561-9.
71. Dong XS, Fujimoto A, Ringen K, et al. Fatal falls among Hispanic construction workers. *Accid Anal Prev.* 2009;41(5):1047-52.
72. Williams Q, Jr., Ochsner M, Marshall E, et al. The impact of a peer-led participatory health and safety training program for Latino day laborers in construction. *J Safety Res*. 2010;41(3):253-61.
73. Solis HS. A preventable epidemic: Latino deaths on the job. *The Huston Chronicle*. April 20, 2010. Available at: *http://www.chron.com/disp/story.mpl/editorial/outlook/6967754.html*. Accessed: November 15, 2010.
74. Occupational Safety and Health Administration, U.S. Department of Labor. *US Department of Labor's OSHA publishes final rule on cranes and derricks in construction*. 2010. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=NEWS_RELEASES&p_id=18048*. Accessed: November 15, 2010.
75. Occupational Safety and Health Administration, U.S. Department of Labor. Occupational Safety and Health Administration. Proposed Rule: Walking-Working Surfaces and Personal Protective Equipment (Fall Protection Systems). *Federal Register*. May 24, 2010; 75:28862-29153. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=21518*. Accessed: November 15, 2010.
76. *Testimony of David Michaels, Assistant Secretary for Occupational Safety and Health, U.S. Department of Labor*. The Committee on Health, Education, Labor and Pensions, U.S. Senate. 2010. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=TESTIMONIES&p_id=1122*. Accessed: November 15, 2010.
77. Weil D. A strategic approach to labour inspection. *International Labour Review*. 2008;147(4):349-375.
78. Gillen M, Gittleman JL. Path forward: emerging issues and challenges. *J Safety Res*. 2010;41(3):301-6.
79. Palassis J, Schulte PA, Geraci CL. A new American management systems standard in occupational safety and health – ANSI Z10. *Journal of Chemical Health & Safety*. 2006(January/February):20-23.
80. International Labour Organization. *About the ILO OSH-MS Guidelines*. 2001. Available at: *http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/publication/wcms_110496.pdf*. Accessed: November 15, 2010.

81. International Labour Organization. *Guidelines on occupational safety and health management systems. (ILO-OSH 2001)*. 2001. Available at: *http://www.ilo.org/public/libdoc/ilo/2001/101B09_287_engl.pdf*. Accessed: November 17, 2010.
82. International Labour Organization. *Safety and Health in Construction Convention. 1988(No. 167)*. Available at: *http://www.ilo.org/ilolex/english/convdisp1.htm*. Accessed: November 15, 2010.
83. Occupational Safety and Health Administration. *Draft Proposed Safety and Health Program Rule: 29 CFR 1900.1, Docket No. S&H-0027. 1998. Available at: http://www.osha.gov/dsg/topics/safetyhealth/nshp.html*. Accessed: November 15, 2010.
84. Occupational Safety and Health Administration, U.S. Department of Labor. *AMEC Construction Partnership implements safety and health management systems and reduces injury and illness incident rate.* 2010. Available at: *http://www.osha.gov/dcsp/success_stories/partnerships/region5/191_amec_success.html*. Accessed: November 15, 2010.
85. National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. *Prevention through Design*. Available at: *http://www.cdc.gov/niosh/topics/ptd/*. Accessed: November 15, 2010.
86. Toole TM, Gambatese J. The trajectories of Prevention through Design in construction. *J Safety Res*. 2008;39(2):225-30.
87. Behm M. Construction sector. *J Safety Res*. 2008;39(2):175-8.
88. OSHA Alliance Program's Construction Roundtable. *Construction Workplace Design Solution: Non-Fragile Skylights and/or Skylight Guards*. 2010. Available at: *http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20%28MG-TB%20update%205-3-10%29.pdf*. Accessed: November 15, 2010.
89. Hassan M. OSHA urges Morris County NJ Latino workers to report safety violations. *Daily Record*. July 27, 2010.
90. Sokas RK, Emile J, Nickels L, et al. An intervention effectiveness study of hazard awareness training in the construction building trades. *Public Health Rep*. 2009;124 Suppl 1:160-8.
91. Hispanics Work Safe Project. *Training & Educational Materials for Hispanic Construction Workers: OSHA 10-hr Construction Training Course*. Available at: *http://www.hispanicsworksafe.org/view.php?page=osha&sub=10hr&lang=english*. Accessed: November 15, 2010.
92. Schneider S, Check P. Read all about it: the role of the media in improving construction safety and health. *J Safety Res*. 2010;41(3):283-7.
93. Berzon A. Construction Worker Deaths on the Strip: Pace is the new peril. Amid pressure to finish massive projects, 9 men have died in 16 months. *Las Vegas Sun*. March 30, 2008.Available at: *http://www.lasvegassun.com/news/2008/mar/30/construction-deaths/*. Accessed: November 15, 2010.
94. National Institute for Occupational Safety and Health. *Building safer highway work zones: measures to prevent worker injuries from vehicles and equipment. DHHS (NIOSH) Publication No. 2001-128*. 2002. Available at: *http://www.cdc.gov/niosh/docs/2001-128/*. Accessed: November 15, 2010.
95. Occupational Safety and Health Administration, U.S. Department of Labor. *OSHA Alliance Program: The Roadway Work Zone Safety and Health Partners*. Available at: *http://www.osha.gov/dcsp/alliances/roadway/roadway.html*. Accessed: November 15, 2010.
96. The Roadway Safety Alliance. *Internal Traffic Control Plans*. 2005. Available at: *http://www.workzonesafety.org/files/documents/training/fhwa_wz_grant/itcp.pdf*. Accessed: November 15, 2010.
97. National Institute for Occupational Safety and Health. *Highway Work Zone Safety: Construction Equipment Visibility*. 2002. Available at: *http://www.cdc.gov/niosh/topics/highwayworkzones/BAD/*. Accessed: November 15, 2010.
98. Occupational Safety and Health Administration, U.S. Department of Labor. *Reflections on OSHA's History*. 2009. Available at: *http://www.osha.gov/history/OSHA_HISTORY_3360s.pdf*. Accessed: November 15, 2010.
99. Occupational Safety and Health Administration, U.S. Department of Labor. *ACCSH: Background, History, and Charter*. Available at: *http://www.osha.gov/doc/accsh/backgroundandhist.html*. Accessed: November 15, 2010.
100. Occupational Safety and Health Administration, U.S. Department of Labor. *Voluntary Protection Programs: All About VPP*. Available at: *http://www.osha.gov/dcsp/vpp/all_about_vpp.html*. Accessed: November 15, 2010.
101. Howard J, Stafford P, Branche C, et al. Twenty years of NIOSH construction research. *J Safety Res*. 2010;41(3):187-8.
102. CPWR—the Center for Construction Research and Training. *Electronic Library for Construction Occupational Safety and Health (eLCOSH)*. CPWR—the Center for Construction Research and Training. Available at:*http://www.elcosh.org/*. November 15, 2010.
103. CPWR—the Center for Construction Research and Training. *Construction Solutions. Database*. 2010. Available at: *http://www.cpwrConstructionSolutions.org/*. Accessed: November 15, 2010.


NIOSH estimates
20,000 cancer deaths
and 40,000 new cases
of cancer per year
can be attributed to
exposures at work.

CASE STUDY 5

Regulating Methylene Chloride:

A Cautionary Tale about Setting Health Standards One Chemical at a Time

Molly M. Jacobs, Joel Tickner, David Kriebel

On June 30, 2000 a 35-year-old female worker from a North Carolina cushion company was carried to the local emergency room because she could no longer walk without assistance.[1] Days before, headaches had progressed into severe numbness and burning sensations in her feet, legs, thighs, and lower back.[1]

Her job at the cushion company was to glue foam cushion pieces together with a spray adhesive containing 55 percent (by weight) 1-bromopropane, which had been introduced into the workplace not long before workers started to get sick.[2]

One case of this neurological illness turned into many as similarly exposed and sick workers from other cushion manufacturing companies were reported.[2] Months and years later, these workers' neurological symptoms still persist.[1,3]

The sad irony: the companies had switched to a 1-bromopropane-based adhesive in place of one containing methylene chloride in response to the Occupational Safety and Health Administration's new methylene chloride standard.

How could a system of regulating toxic hazards to protect workers result in additional sick workers?

SINCE THE EARLIEST DAYS OF THE Occupational Safety and Health Administration (OSHA), the agency has realized the severe limitations of issuing regulations substance by substance, and hazard by hazard. Yet despite this understanding, OSHA regulates exposures to only a small fraction of the tens of thousands of chemicals on the market in the United States today. And the majority of existing health standards allow "acceptable" workplace exposures based on evidence from the 1950s, despite scientific findings that reveal health effects at exposures well below current legal limits.

OSHA's methylene chloride health standard is a success story: it is comprehensive in scope to protect workers, it survived legal challenges and a threatened Congressional review, and it is based on early signs of harm revealed by animal toxicology studies. Yet despite these successes, the methylene chloride standard clearly reveals lessons learned about the politicization of science to delay regulation, the inherent dangers of a substance-by-substance system of regulating toxic hazards, and the missed opportunity for workplace health regulations to stimulate innovation of safer chemistries.

OSHA's standard setting: Early attempts to remedy problems through substance-specific regulations

The primary mechanism that the 1970 Occupational Safety and Health Act (OSHAct) established to protect workers was OSHA's capacity to regulate through specific occupational health and safety standards. Section 6 (b)(5) of the OSHAct specifically addresses the need for OSHA, in regulating toxic materials or harmful physical agents, to promulgate the standard that "most adequately assures to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life."

Those who drafted the law realized that if the OSHAct was to effectively protect workers, it was imperative that OSHA quickly adopt existing national consensus limits or federal standards for exposures to chemical agents. Within one year of the OSHAct's passage, Permissible Exposure Limits (PELs) for roughly 450 hazardous agents were established. These interim standards were based on assessments by a private professional organization: the American Conference of Governmental Industrial Hygienists' (ACGIH) 1968 threshold limit values (TLVs).[4] Formal rulemaking ensued, and during the first years of OSHA, the agency devoted much of its resources to setting more comprehensive and permanent health standards for a number of occupational carcinogens, including asbestos in 1972, vinyl chloride and a group of 14 other chemicals in 1974, coke oven emissions in 1976, and benzene, dibromochloropropane, inorganic arsenic, and acrylonitrile in 1978.[5] Yet with a rate of roughly two final regulations in the first nine years of the agency, OSHA quickly learned that issuing rules for hazardous chemicals one at a time could achieve only meager results in the context of the sheer number of chemicals to which workers were exposed.[6]

Back in the day: OSHA tries (and fails) to regulate many carcinogens at once

By the late 1970s, OSHA was under significant pressure by Congress, organized labor, and environmental groups to speed up the standard-setting process.[7] With nearly a decade of experience, the agency had also reflected on the need to resolve and streamline decision-making for specific issues of science policy that were encountered repeatedly during public hearings for each proposed standard—and yet again in the courts as nearly every standard was subsequently challenged by industry.[6] Issues continually debated included, for example: (1) whether there is a threshold (no-effect) exposure for carcinogenic effects of chemicals; (2) whether it's possible to extrapolate from animal data to human risk; and (3) the importance of studies that demonstrate a health risk versus those that find no effect.[6] As a result of these scientific challenges, OSHA issued its Generic Carcinogen Policy in 1980.

The preamble of the Generic Carcinogen Policy acknowledged that "to follow the past system and procedure for each and every individual substance and hazard would be, we believe, beyond the abilities of an agency, no matter how large a staff it may have."[8] To accelerate the rule-making process for carcinogens, the Generic Carcinogen Policy established binding scientific policy determinations, regulatory procedures, and specific provisions that govern OSHA's regulation of carcinogens.[6] Priority was placed on issuing protective health regulations based on early evidence revealed through animal studies, rather than on waiting for conclusive epidemiologic studies documenting effects in humans. Moreover, positive study results (i.e., evidence demonstrating harm) were prioritized over negative results (i.e., evidence demonstrating no harm). Thus a key principle in the policy was prevention—an orientation consistent with OSHA's highly protective mandate concerning worker health. As explained by OSHA, "To wait for years

ABOUT THIS CASE STUDY

This case study examines our existing occupational health and safety system, which is meant to control and prevent exposures to hazardous substances on the job. We describe administrative and legal structures that have impeded OSHA's attempt to expeditiously protect workers from exposures to chemicals, and we explore the Agency's methylene chloride standard to illustrate these lessons in more detail.

for science to provide further depth of understanding to the complex issues of cancer causation or cure, without having today some consistent and workable system for the reduction or prevention of human exposures to those toxic substances for which there is evidence of a carcinogenic potential to workers, would be inconsistent with OSHA's statutory obligations and unacceptable to all."[9]

The policy outlined a process for OSHA to screen candidate substances and to set priorities for regulation. For substances prioritized as highest-risk "Category 1 potential carcinogens," a priority-setting mechanism was established whereby OSHA would select 10 substances for comprehensive rule-making at any one time. For all Category I substances, OSHA would require the resulting permanent health standards to reduce exposure to the lowest feasible level.[10] If there was a suitable substitute, no occupational exposure would be permitted.[10] In 1980, OSHA issued a candidate list of 204 substances for further scientific review under the terms of the policy.[10]

Threats to new and innovative chemicals policy: The US Supreme Court's Benzene Decision and a new "deregulatory" philosophy

The Generic Carcinogen Policy had real potential to comprehensively address carcinogenic exposures in workplaces and also to offer a prevention-oriented model for accelerating standard setting for other toxic substances. It set in motion a general policy that the only safe exposure to carcinogens was no exposure, and that the only factor that should limit efforts to reduce exposure was technological feasibility.

However, the policy was weakened almost as soon as it began. A few months after the Generic Carcinogen Policy was established, the US Supreme Court issued what has become known as the Benzene Decision—a decision that dramatically affected OSHA's ability to regulate hazards in the workplace. In this 1980 decision, the Supreme Court stated that before OSHA promulgates a permanent health standard, the Secretary of Labor is required to make a determination, first, that a workplace is unsafe due to the presence of a "significant risk" to workers, and second, that this risk can be eliminated or lessened by the promulgation of a standard or a change in a standard.[11]

The Supreme Court offered general guidance for future OSHA rule-making by noting that *the significant risk requirement is not meant to be a mathematical straightjacket* and that responsibility fell on OSHA to determine what it considers to be a significant risk, based largely on policy considerations.[11] The Court provided only one concrete example of significant risk: "If the odds are one in a billion that a person will die from cancer by taking a drink of chlorinated water, the risk clearly could not be considered significant. Yet on the other hand, if the odds are one in a thousand that regular inhalation of gasoline vapors that are two percent benzene will be fatal, a reasonable person might well consider the risk significant and take appropriate steps to decrease or eliminate it."[11] With guidance to regulate risks somewhere in the range from one in one thousand to one in one billion, the Supreme Court gave OSHA broad discretion to determine how stringently to protect the health of workers from cancer risks considered significant. Yet, subsequent OSHA standards have tended to control exposures only to risks at the upper end of this range. What started with the new Reagan administration's interpretation of the Supreme Court ruling—that a significant occupational health risk is defined as one cancer death per 1,000 workers exposed to a specific agent over a lifetime—has defined OSHA's own interpretation of acceptable risk levels ever since.[12]

The Generic Carcinogen Policy had real potential to comprehensively address carcinogenic exposures in workplaces.

Under the Generic Carcinogen Policy, significant risk did not have to be demonstrated in order for OSHA's Category I substances to be regulated to the lowest feasible PEL. However, the Benzene Decision opened the possibility that any subsequent rulemaking on these substances might be overturned by the courts. With a new Republican administration in the White House, the government decided not to pursue implementation of the policy and thereby risk legal challenge.

Delays in regulating methylene chloride meant continued exposure for thousands of workers like these in the furniture industry.

In January 1981, OSHA published changes to the Generic Carcinogen Policy in response to the Benzene Decision.[13] These changes modified the regulatory requirement for Category 1 substances such that exposure levels would be set on a substance-by-substance basis, considering the significance of the risk present and using all relevant evidence and statutory provisions. In 1983 OSHA issued a partial stay on the policy while it reviewed its criteria and process requirements for developing lists of chemicals considered candidates or priorities for regulation.[14] OSHA announced its intent to revise the Generic Carcinogen Policy in 1987, yet no substantive action was taken.[15] Despite attempts by labor groups, industry groups, and the Office of Management and Budget (OMB) to either revive or completely kill the policy, no action was subsequently taken.[7] OSHA still has the opportunity to revive this policy as an important model, moving the agency towards comprehensively regulating known and suspected carcinogens. Yet the requirements under the Benzene decision, despite attempts by OSHA to revise the policy accordingly, still remain one of the primary barriers.

OSHA's additional attempts to comprehensively and expeditiously regulate toxic chemical exposures

By the late 1980s, as OSHA approached its 20th birthday, the agency had established just 13 permanent standards covering 26 substances—efforts that significantly lagged behind progress by other organizations that evaluate health data and set exposure limits. For example, by 1987 the ACGIH had set TLVs for 168 additional substances that were not regulated by OSHA.[16] ACGIH also revised downward 234 of the roughly 450 TLVs from the 1969 list that OSHA adopted into law in 1971 based on more recent evidence of harm at lower exposure levels.[16]

Similarly, over this same period the National Institute for Occupational Safety and Health (NIOSH) had developed and published Recommended Exposure Limits (RELs) for 160 substances.[16] Unfortunately, NIOSH is not a regulatory body and its standards are not legally enforceable. While the OSHAct directs OSHA to use NIOSH recommendations in the promulgation of new or revised health and safety standards, OSHA has acted on only a handful of NIOSH's recommendations.

In 1989 OSHA issued the Air Contaminants Standard, in which it promulgated 212 additional PELs and 164 updated PELs based for the most part on ACGIH's TLVs.[17] Yet in 1992, the US 11th Circuit Court of Appeals vacated the standard because OSHA had failed to establish that each regulated substance posed a significant risk as required under the Supreme Court Benzene Decision and because OSHA did not meet its burden of establishing that the new PELs were either economically or technologically feasible.[18] OSHA's request for a rehearing was denied, and a request for an appeal to the Supreme Court was rejected by the US Solicitor General.[19] As a result, in June 1993 OSHA revoked the updated PELs,[19] and thus the PELs reverted back to the levels set prior to issuance of the Air Contaminants Standard.

Despite OSHA's efforts to regulate chemicals more broadly through the Generic Carcinogen Standard and the Air Contaminants Standard, the majority of current workplace health standards remain woefully out of date and workers are being legally exposed to chemicals at levels known to cause harm. To date, OSHA has issued roughly 30 permanent health standards for toxic substances, a small fraction of the chemicals used in commerce today. The last permanent health standard that

OSHA established was the hexavalent chromium standard in 2006.

At the end of a long regulatory battle, the PEL in the final hexavalent chromium rule was five times less protective than the limit OSHA had initially proposed. An examination into the industry-funded data that were used as the primary basis for the revised PEL suggests that the data were analyzed in such a way as to cover up evidence that very low levels of chromium can cause cancer.[20] As a consequence, the final standard considered it "acceptable" that from one to nearly five workers for every 100 workers exposed to hexavalent chromium at the new PEL over the course of their working life will die of lung cancer.[20,21] While many occupational health experts argue that OSHA's updated hexavalent chromium standard is one of the least protective health standards passed in recent years, much can be learned about failures in our system of regulating worker exposures to toxic substances by examining what many consider a success story: the methylene chloride standard.

The methylene chloride rule: Delays and regrettable substitutions through substance-by-substance, risk-based regulation

Over 60 years ago, methylene chloride (also known as dichloromethane) was introduced as a replacement for more toxic and flammable solvents.[22] Its non-flammability and strong solvent capability contributed to the broad use of methylene chloride in a variety of products and processes. It was widely used in paint removers, degreasing agents, adhesives, and aerosol propellants. It was also used as a blowing agent in flexible urethane foams, as a process solvent in the manufacture of pharmaceuticals and food products, and as a fumigant for grains and fruits.[23] While overall use of methylene chloride has declined in recent years, it is still used in most of these applications today.[24]

Like the vast majority of legal exposure limits, the exposure limit for methylene chloride was established in 1971 based on a 1946 ACGIH threshold limit value (500-ppm 8-hour time-weighted average, or TWA). This initial exposure limit was established to protect workers from methylene chloride's ability to irritate the skin and eyes as well as to affect the central nervous system.[25] By the mid-1970s scientific evidence revealed that levels of methylene chloride far below the 500-ppm limit produced levels of carboxyhemoglobin (COHb) that robbed the blood of its ability to deliver oxygen, which in turn could cause heart disease or aggravate preexisting heart disease.[26] Based on this evidence, in 1975 the ACGIH lowered the recommended threshold limit value to 100 ppm, and in 1976 the National Institute for Occupational Safety and Health established a REL (8-hour time-weighted average) of 75 ppm.[25,26] Yet OSHA did not update its own standard until pressure mounted based on even more troubling evidence of the chemical's carcinogenicity from the National Toxicology Program (NTP).

In February 1985, NTP published its results from two animal carcinogenicity studies on methylene chloride.[27] Based on its two-year inhalation study using rats, NTP found "some evidence" for males and "clear evidence" for females of the carcinogenicity of methylene chloride for mammary gland cancers.[27] NTP's second inhalation study examining effects in mice revealed "clear evidence" of the carcinogenicity of methylene chloride for lung and liver cancers among both males and females.[27]

Labor petitions and OSHA (finally) sets a standard

The NTP toxicological studies prompted review and action on methylene chloride exposure across a number of federal regulatory agencies, including OSHA. Yet OSHA's response was not of its own accord, but rather was instigated by a petition from labor. In July 1985, The United Auto Workers (UAW) used the NTP study results to petition OSHA to issue a hazard alert and an emergency temporary standard for methylene chloride.[25] The petition, which was subsequently joined by six other unions, also called for OSHA to begin work on a permanent standard requiring a radical reduction in allowable workplace exposure levels for methylene chloride.[25]

In April 1986, NIOSH published a *Current Intelligence Bulletin* on methylene chloride in which it recommended methylene chloride be regarded as a "potential occupational carcinogen."[23] The foreword of the report stated, "Although the potential for methylene chloride induced cancer in humans has not been determined, the probability of a population of exposed workers developing cancer

could be decreased by reducing exposure. Therefore, NIOSH recommends that occupational exposure to methylene chloride be controlled to the lowest feasible limit."[23] This recommendation mirrored the original OSHA Generic Carcinogen Standard that called for action before evidence of harm in humans.

Sixteen months after labor's call for action and NIOSH's recommendation to reduce exposures, OSHA denied the petition for an emergency standard, but agreed to launch a permanent standard-setting process.[25] A few days later, in November 1986, OSHA announced its Advanced Notice of Proposed Rulemaking to revise the occupational health standard for methylene chloride.[25]

After multiple delays—and 12 years after NTP's studies sounded the alarm—OSHA finalized its methylene chloride rule.

After multiple delays—and 12 years after NTP's studies sounded the alarm—OSHA finalized its methylene chloride rule. The standard, which went into effect April 10, 1997 for most industries, reduced the legal exposure limit from 500 to 25 parts per million in air over an 8-hour workday and established a short-term exposure limit of 125 ppm for 15 minutes.[28] It also established requirements for exposure monitoring, worker training, engineering controls, designation of restricted areas, spill and leak prevention, and medical surveillance for high-risk employees.[28] The standard made clear that if engineering controls and workplace practices did not reduce methylene chloride to an acceptable level, workers must use full face-piece supplied-air respirators because methylene chloride vapors penetrated standard filter cartridge respirators.[28] The updated standard was based primarily on the NTP results showing the carcinogenic effect of methylene chloride in mice, with support from a variety of occupational epidemiologic studies demonstrating increased risk of cancers of the biliary tract/liver, prostate gland, and brain, as well as suggestive evidence for an effect on cardiovascular mortality.[29-32]

Since the Benzene Decision, and despite the Supreme Court's broad interpretation of significant risk—the threshold for implementing any regulatory action—OSHA has steadfastly interpreted significant risk as one extra case of cancer or other health consequence per 1,000 workers over the course of a working life (45 years).[33] In the case of the methylene chloride standard, the residual lifetime risk of cancer at the new PEL was 3.6 per 1,000 workers.[34] Thus even after OSHA established more stringent exposure limits, a significant number of deaths as a result of cancer caused by methylene chloride exposure were still to be expected. OSHA acknowledged in the rule itself that a significant risk remains at 25 ppm, but the PEL was considered what was currently "feasible" (an issue addressed further below).[35]

Thus, workers who assume that exposures at the new PEL are no longer dangerous are sadly mistaken. OSHA's residual cancer risks for workers are orders of magnitude greater than risks EPA "accepts" for the broader public. This essentially translates into acceptance of a large number of illnesses and deaths among workers while society is willing and able to prevent these same outcomes among the general public.[12]

Want to delay and derail worker health protections? Debate the nuances of risk assessment

Delays in finalizing the methylene chloride standard came in many forms, but all were due in part to continued science policy debates that were different from those the 1981 Generic Carcinogen Policy sought to alleviate. The new debates were rooted in the requirement of the Benzene Decision to demonstrate the significance of methylene chloride's risk to workers through risk assessment.

Risk assessment is a tool that uses modeling and prediction to evaluate the potential for exposure to a chemical hazard to cause disease. It requires numerous assumptions and judgments about exposures, human behavior, and how a chemical moves through and is metabolized by the body to exert its toxic effect. Because of uncertainties in these assumptions, risk assessments conducted by different scientific groups can result in widely different results.[36] On top of this, political and financial interests can also influence the risk assessment process.[37]

Methylene chloride is still used in paint stripping formulations.

Political and financial interests can also influence the risk assessment process.

OSHA's risk-assessment-based standard-setting process also limits a comprehensive understanding of risks and prevention opportunities because the preventability of the exposure is rarely considered in establishing "acceptable" exposure levels. This one-chemical-at-a-time risk assessment doesn't evaluate the possibility of cumulative or interactive exposures or effects. Thus, as practiced, risk assessment uses highly uncertain data to arrive at a single estimate at the expense of a broader, more nuanced understanding of risk.[38]

In developing the methylene chloride rule, there was extensive industry testimony and comments on narrow technical issues like these: Which animal model is the most representative of methylene chloride's mode of action in humans? Is there a documented physiological mechanism or mechanism(s) that demonstrates methylene chloride's carcinogenic effect? What pharmacokinetic model best represents how methylene chloride is metabolized in animals versus in humans? Extensive resources and time were spent soliciting and responding to comments critiquing the validity of scientific knowledge and assumptions OSHA made in its final risk assessment.[12] Then, in 1995, after OSHA had closed the record and proposed its updated methylene chloride rule, the Halogenated Solvents Industry Alliance introduced a handful of new studies that it had sponsored.

The studies were in effect, industry's last-ditch effort to downgrade methylene chloride's cancer risk. In summarizing the studies, the executive director of the Halogenated Solvent Industry Alliance stated that this new evidence showed that mice "are uniquely sensitive at high exposure levels to methylene chloride–induced lung and liver cancer, and . . . other species, including humans, are not at similar risk."[39] OSHA has a responsibility to examine and consider all available evidence to justify its decisions whether to regulate. As a consequence, OSHA reopened the record to receive and respond to comments about the study.

The studies were found to have significant problems in design and conduct which limited the validity of the results.[34] OSHA ultimately rejected these arguments and the proposed standard was left intact. Yet more time had been lost and more workers had been exposed to a cancer-causing chemical. Given the high burden OSHA faces to

implement permanent health standards for chemicals, this strategy of "manufacturing uncertainty" has worked extremely well in delaying actions.[37]

The primacy of engineering controls: technological feasibility trumps preventing hazards at their source

OSHA was also required to demonstrate that the methylene chloride standard could be met "to the extent feasible," as defined in the OSHAct. Feasibility has two components: (1) technological feasibility; and (2) economic feasibility. The analyses needed to demonstrate feasibility, along with the process of responding to public comments, are further reasons that it took so long to finalize the methylene chloride standard. For a standard to be considered "technologically feasible," OSHA must demonstrate that industry can meet the PEL either through the application of existing control technology or through new and improved technologies not fully developed.[40,41]

Thus the courts saw a role for OSHA standards to stimulate innovation as a "technology-forcing" authority.[42,43] The courts even noted that such technology forcing could adversely affect laggard companies that were not adopting technologies to appropriately protect workers. These court decisions were consistent with the industrial hygiene hierarchy of controls that places substitution as the most effective means to protect workers, followed by engineering controls, administrative controls and as a last resort, personal protective equipment. But despite these health-protective interpretations of technological feasibility, it is the more recent debates over economic feasibility that have stymied regulatory actions.

While the agency could consider innovation as reducing long-term costs of compliance, OSHA is often constrained in examining economic feasibility as a result of economic reviews conducted by OMB, and also by the Regulatory Flexibility Act, the Paperwork Reduction Act, and the Small Business Regulatory Enforcement Fairness Act. The latter act requires that OSHA convene and gather input from a Small Business Advocacy Review Panel that comprises several Small Entity Representatives, officials from the Small Business Administration's Office of Advocacy, and officials from OMB's Office of Information and Regulatory Affairs. OSHA officials noted that the agency "increased flexibility of compliance in response to comments made by the Small Business Administration and small businesses, themselves—OSHA gave small employers more time to implement the standard's requirements; eliminated a requirement for written compliance plans; and altered training requirements." A report by the Center for Progressive Reform has found that the requirement to comply with these laws significantly delays regulation without producing any clear benefits to industry or health.[44]

As a result of these review requirements, OSHA interpreted its feasibility analysis with caution. This was in part to avoid costly challenges by industry that would require significant human and economic resources of an already resource-constrained agency. In the case of methylene chloride, rather than designing a regulation that stimulated research and technological innovation to eliminate the use of the chemical, the standard relied on less protective hazard control approaches, such as engineering controls (e.g., using ventilation equipment to remove the offending agent to the outdoors).[45,28] These controls are standard in most of our current regulatory approaches that seek to manage risk—that is, reduce exposure to the chemical of concern rather than reduce the intrinsic hazard of the substance by investing in strategies that discover, design, and adopt safer alternatives.

The unintended consequences of chemical-by-chemical, agency-by-agency approaches to chemicals management

Our failure to advance a worker health and safety system that incentivizes the development and design of safer chemistries can result in continued harm to workers when employers seek substitutes for regulated chemicals. Although OSHA expected industries to use engineering controls to comply with its methylene chloride standard, in fact many companies abandoned the use of methylene chloride due to the perceived costs of these controls.[46]

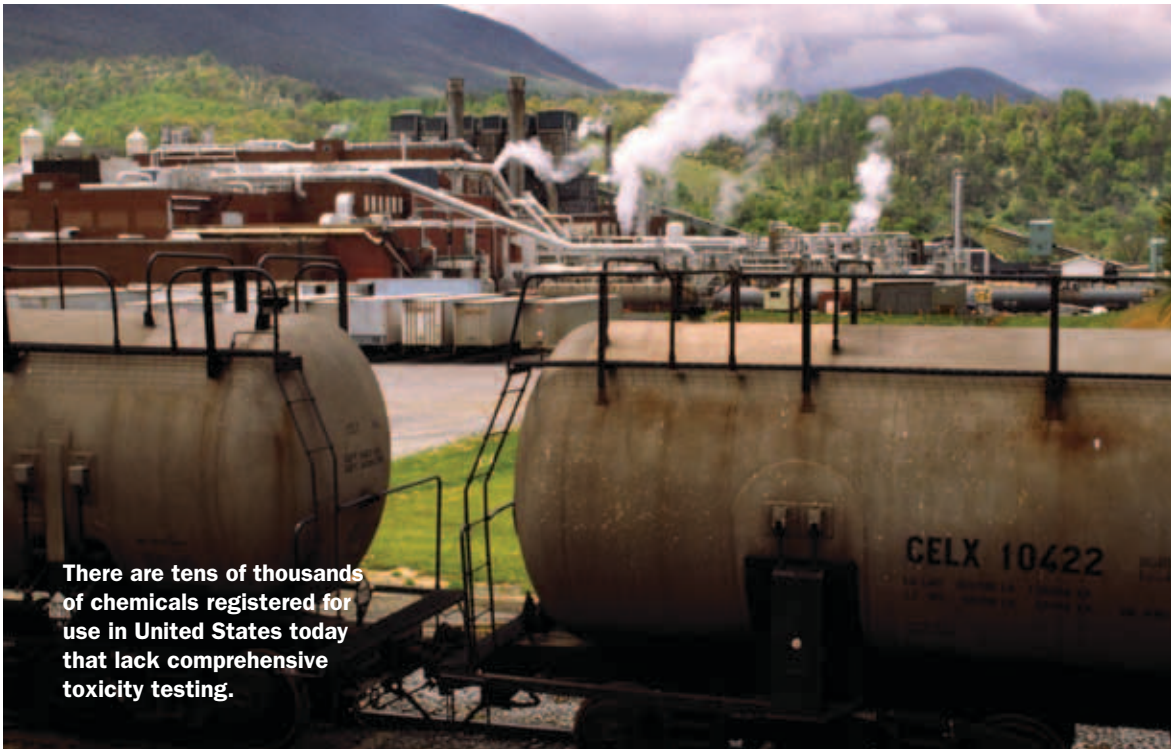
OSHA was not the only federal agency that affected employers' use of methylene chloride. The Food and Drug Administration (FDA), the Consumer Product Safety Commission (CSPC), the Department of Housing and Urban Development (HUD), and the Environmental Protection Agency

(EPA) all issued actions responding to the NTP studies and epidemiologic literature about methylene chloride's potential carcinogenicity. The FDA issued a final rule on June 29, 1989 banning methylene chloride in cosmetic products, primarily hair sprays.[47] The CPSC fell short of issuing a final rule regarding methylene chloride, but issued a "statement of interpretation and enforcement policy" requiring that by September 14, 1988, all manufacturers, importers, packagers, and private labelers of consumer products must indicate on all products that inhalation of methylene chloride has produced cancer in laboratory animals and must specify relevant use precautions.[48] HUD issued restrictions on using methylene chloride during residential de-leading. EPA undertook its own risk assessment of methylene chloride and in May 1985, determined that the chemical was a probable human carcinogen.[25]

EPA's subsequent actions were primarily stimulated by the 1990 Clean Air Act Amendments (CAAA), and resulted in contradictory outcomes. One component of the CAAA required EPA to phase out ozone-depleting chemicals by 2000. In 1994, EPA determined that methylene chloride was one of the many "acceptable" chemical substitutes for a number of industrial applications, even though the Agency acknowledged concerns about its toxicity.[49] In the ensuing years, EPA also set restrictive air emissions through technology standards for dozens of hazardous air pollutants, including methylene chloride, as part of its regulatory obligation under Title III of the CAAA. Thus, while EPA obligated industries to eliminate their use of ozone-depleting chemicals (which could involve switching to methylene chloride), the agency's actions to reduce hazardous air pollutant emissions sent another message to employers to reduce or eliminate methylene chloride use.

From the point of view of many employers, engineering controls to reduce methylene chloride exposures were not a feasible means for regulatory compliance, given the array of federal agency actions. For example, employers could not simply vent methylene chloride vapors to the outside because of EPA's new and more restrictive emission standards. If occupational health regulations restrict methylene chloride emissions *inside* where it affects workers, and environmental regulations restrict venting emissions *outside* because of air quality protections, a reasonable solution might be to replace methylene chloride altogether.

And that's just what many companies did. In response to methylene chloride regulations as well



There are tens of thousands of chemicals registered for use in United States today that lack comprehensive toxicity testing.

as regulations associated with EPA's ban on ozone-depleting chemicals, chemical companies and equipment manufacturers identified a new market for a broad array of old and new alternatives, including substitute chemistries, mechanical and equipment innovations, as well as modernized manufacturing processes.[50]

There are many examples of companies that successfully transitioned to using safer alternatives to methylene chloride and often experienced financial benefits as a result.[50] Yet, there are also tragic cases of companies that fell prey to the opportunistic marketing of replacement chemicals that were largely untested and unregulated—such as 1-bromopropane.

Substituting an untested chemical for a bad one: the tragic mistake called 1-bromopropane

In the early to mid-1990s, 1-bromopropane, also known as *n*-propyl bromide, was used primarily as an intermediate in the production of a range of chemicals. By the mid- to late 1990s, as EPA's and OSHA's methylene chloride regulations as well as bans on the use of specific ozone-depleting solvents began to take effect, 1-bromopropane blasted onto the scene as an alternative to methylene chloride. It was introduced and marketed as a non-flammable, non-toxic, fast-drying and inexpensive solvent that was effective in a variety of applications, such as refrigeration, metal cleaning, and vapor and immersion degreasing applications, as well as in adhesive resins.[1,51,52] 1-bromopropane became a favored replacement solvent in some applications because it worked well, it was a quick, drop-in substitute, and there were no regulations governing workplace or environmental emissions and minimal toxicity testing to suggest any hazard.[53,54]

Despite some signals as early as 1981 that 1-bromopropane was mutagenic, no comprehensive toxicity testing of the chemical had been conducted.[2,55] A broader literature on the hazards of 1-bromopropane began to emerge in 1998. That year, the first report of the neurotoxicity of 1-bromopropane from animal studies was published.[53] A year later, the first case report of neurotoxicity in a worker was published.[56] In that case report, a 19-year-old worker who used 1-bromopropane for metal degreasing and cleaning had developed progressive weakness in his legs and right hand, had difficulty swallowing, and at the time of admission to the hospital in February 1998 could no longer stand without assistance.[56]

One worker after another who used a 1-bromopropane-based spray solvent in a job manufacturing cushions similarly experienced the neurotoxic effects of 1-bromopropane.[1,3] For many of these workers, symptoms persisted for years, and some of these workers also experienced reproductive effects, which unfortunately were some of the earliest signals of reproductive harm from the chemical.[1,3,57,58] Many cushion-manufacturing employers had recently introduced 1-bromopropane as an alternative to methylene chloride.[1,59]

Prompted by cases of sick workers, NIOSH launched a series of health hazard evaluations at a number of cushion-manufacturing workplaces that used 1-bromopropane during the period 1998-2000, and recommended enhancing engineering controls to reduce exposure levels.[58,60,61] In 2003, and on the basis of limited data, NTP's Center for the Evaluation of Risks to Human Reproduction concluded that 1-bromopropane is toxic to the developmental and reproductive health of animals.

At the request of OSHA in 1999, NTP also studied the carcinogenicity of 1-bromopropane and found evidence of carcinogenicity.[62,51] In an unpublished analysis by a former Director of Health Standards at OSHA, the NTP results reveal that 1-bromopropane is roughly four times as potent a carcinogen as methylene chloride.[63]

Yet to date, neither EPA nor OSHA has established regulations to minimize health risks from exposure to 1-bromopropane. In 2006, the ACGIH set a time-weighted average TLV for 1-bromopropane at 10 ppm. As of late 2010, NIOSH is in the process of establishing a REL for 1-bromopropane.

On May 9, 2010, OSHA published its regulatory review of the methylene chloride standard. While none of the comments submitted highlighted the problems of substituting 1-bromopropane for methylene chloride, OSHA's final report did acknowledge potential health hazards with some substitutes: "The use of substitutes for MC [methylene chloride] has increased in certain industries. These substitutes may pose their own health hazards. Therefore, based on public comments, OSHA

will consider putting out guidance recommending that, before a substitute for MC is used, the toxicity of that substitute should be checked on the EPA and NIOSH websites."[24] While such guidance would be a step forward, it remains to be seen whether OSHA will pursue these hazard communication efforts.

More than a decade to regulate one chemical? At what cost?

While OSHA finally prevailed in finalizing the methylene chloride rule, this accomplishment came at a cost to worker health due to regulatory delays and our substance-by-substance system of regulation. The high burden on OSHA to demonstrate significant risk on a chemical-by-chemical basis opens the door for scientific challenges (with or without merit) that delay preventive actions. Regulation of one chemical without thinking about alternatives opens the door for unregulated chemicals to be used in substitution.

While substitution is the preferred approach to protect not only workers but also the broader public from chemical hazards, it is dangerous to pick substitutes without a thorough overhaul of our system to manage the safety of chemicals in commerce. Designed correctly, chemical regulations can stimulate scientific research and technological innovation.

Yet as things currently stand in the United States, employers are left to their own devices to find alternatives to newly regulated chemicals. Such employers can easily fall prey to chemical sales personnel who are eager to sell them a promising substitute that is considered "safe" simply because no testing has proven it hazardous. Given that complete basic toxicological screening data is available for only a small percentage of the tens of thousands of chemicals listed as being in commerce in the United States, stories like 1-bromopropane will be played out again and again until new approaches to comprehensively manage these hazards are identified.

OSHA estimated that the permanent methylene chloride standard would reduce exposure-related deaths by at least 97 percent for more than one-quarter of a million US workers, and prevent the deaths of 34 workers per year on average.[64] Thus the 12 years that it took to enact the standard (not including the additional time for small businesses to comply with the regulation) and the decision not to issue an emergency standard (as originally recommended by labor) inadvertently resulted in continued exposures to workers that caused or will cause an estimated 408 deaths. Moreover, by OSHA's own estimates, for each year that the new standard was delayed, as many as 30,000 to 54,000 workers may have suffered central nervous system and cardiovascular system damage.[64] Clearly, lengthy rule-making processes are not healthy for workers.

...stories like 1-bromopropane will be played out again and again until new approaches to comprehensively manage these hazards are identified.

The road not taken: Toxics use reduction and a comprehensive chemicals policy

While OSHA debated the mechanisms of action of methylene chloride and their relevance to humans, agencies in Massachusetts were implementing a pioneering new approach to reducing chemical hazards—toxics use reduction (TUR). Under the 1989 Toxics Use Reduction Act, manufacturers using more than 10,000 pounds per year (less for chemicals of high concern) of some 900 chemicals are required to undertake a yearly accounting of how those chemicals enter, are used in, and are released from their facility as waste (liquid or solids that are captured and transferred offsite) or emissions (e.g., releases to air, water or ground). Every two years, the firms are required to undertake a planning process to identify alternatives to reduce or eliminate those chemicals. In reviewing alternatives, firms are required to include workers and consider environmental, consumer, and occupational health hazards to ensure that risks are not shifted. Firms pay a small fee on chemical use that funds the regulatory program but also funds voluntary, confidential technical assistance and training, and research support at the Toxics Use Reduction Institute at the University of Massachusetts Lowell.

Many leading-edge firms are undertaking their own efforts to prioritize chemicals of concern and find safer alternatives.

This model of regulatory requirements to understand chemical use and opportunities for prevention (without any requirement to act), coupled with support to firms to institute changes, has led to significant results in just the first 10 years of the program: an 80 percent reduction in chemical emissions; a 67 percent reduction in chemical waste; and a 40 percent reduction in toxic chemical use, while saving firms millions of dollars.[38]

The TUR approach focuses on alternatives and solutions to toxic chemical concerns, even though perfect information is not available. For example, while the US EPA has struggled to finalize a risk assessment on trichloroethylene (TCE), a suspect carcinogen widely used in degreasing, Massachusetts has reduced the use of this chemical by 95 percent in degreasing operations by testing alternatives, which have been evaluated for safety, to ensure they work as effectively as TCE.

One example of the success of the TUR approach took place at Crest Foam, a small polyurethane foam manufacturer. The company eliminated the use of 190,000 pounds per year of methylene chloride by installing a foaming process that uses carbon dioxide instead of trichlorofluoromethane (CFC-11) or methylene chloride. The alternative is not only more efficient and less costly than methylene chloride, but also saved the company tens of thousands of dollars in permitting and emission control equipment costs.[65]

While the TUR model demonstrates that a solutions-based approach to chemical hazards can reduce risks and save money, it does not entirely eliminate the roadblock of quantitative risk assessment. A lengthy debate about these challenges in the European Union led, in 2007, to an entirely new chemicals policy called REACH—Regulation, Evaluation, and Authorization of Chemicals. REACH requires manufacturers and importers of chemicals to provide to authorities information on chemical toxicity, uses, and exposure; and to inform chemical users of hazards and prevention measures. In addition, REACH requires companies to seek permission to continue to use chemicals of high concern. While REACH is still in the early years of implementation, it is an effort to address the challenges outlined in this paper, in order to more effectively understand and prevent chemical hazards.

Following the passage of REACH, several US states have initiated their own comprehensive chemicals policies. While they differ in nature, they focus on prioritizing the universe of chemicals into lists of higher and lower concern, requiring or encouraging the shift to safer alternatives, and disclosing the chemical ingredients and toxicity of products.

Indeed, many leading-edge firms are undertaking their own efforts to prioritize chemicals of concern and find safer substitutes. While some firms are considering the lifecycle impacts (that is, including the impacts to workers, consumers and the environment of upstream production and downstream disposal) of substitutes, many others are still focused only on direct hazards to consumers.

In 2009, the US EPA released principles for reforming the US federal toxics law, the 1976 Toxics Substances Control Act (TSCA), a law that was originally seen as a response to the limits of the OSHAct for protecting workers from toxic exposures. While TSCA has been criticized for the high burdens it places on EPA to gather hazard data and take action, for new chemicals the law authorizes EPA to collect data and prevent exposures when a substance "may present an unreasonable risk or substantial exposure"—even before that substance has been manufactured. This worker health provision has provided some added measure of protection for workers, though new chemicals on the market since 1980 represent less than 5 percent by volume of the total on the market today.

As Congress begins to debate the new Safe Chemicals Act, introduced in the House in June 2010, it is imperative that worker health considerations be front and center. Indeed, while the law includes only some limited reference to substitution, there are several provisions that specifically address worker health. Nonetheless, given the eight-year reform process in Europe leading to REACH, and the six-year process that led to the original TSCA, it is unlikely that changes to federal chemicals policy will occur any time soon.

Despite attempts by OSHA administrators in the early days of the Agency, our regulatory system for protecting workers from toxic substances remains broken. OSHA's current administrator, David Michaels, clearly recognizes these failures. As he stated in a July 19, 2010 general memo, "OSHA's process for issuing regulations is unworkable . . . we must develop ways to issue standards more quickly, but we must also explore alternatives to hazard-by-hazard standard setting. . . . We can not wait for a long-term solution to this long-standing problem: we must ensure the protection of workers currently exposed to well-recognized chemical hazards for which we have an inadequate or no PEL."[66]

The experience of the methylene chloride standard demonstrates several lessons that can inform future regulatory reforms designed to anticipate rather than react to harm from toxic hazards in the workplace. First, we need a system of regulating toxic substances in this country that is comprehensive—that gathers information on the toxicity and uses of all chemicals; that prioritizes chemicals of highest concern; and provides research and support to implement safer alternatives. As the example of 1-bromopropane demonstrates, some employers will seek out substitute chemicals for newly regulated ones (particularly if these are "drop-in" substitutes), and there is nothing to hinder them from choosing an untested, unregulated alternative.

Rather than working around this problem by encouraging employers to reduce exposure levels through engineering controls, OSHA needs to tap into its technology-forcing authority to incentivize and support the innovation necessary to design, market, and install feasible, inherently safer alternatives. Real worker health protections require moving beyond our current model, which simply manages risk, and towards a model that more fundamentally reduces the potential for exposure to toxic chemicals through planning and design.

The long history of the methylene chloride standard also shows us that it is possible to issue protective regulations based on the weight of the evidence at any one time. OSHA relied on early warnings of harm from animal studies and did not delay acting to protect workers until conclusive evidence from epidemiologic studies emerged. Yet there were delays. It took OSHA over a decade to issue this one permanent health standard. Meanwhile tens of thousands of workers remained exposed to levels of methylene chloride known to cause harm, and hundreds of workers will meet or have met an early death. Reasons for these delays are numerous and include manufactured uncertainties and a broad range of time-intensive obligations set forth by the OSHAct, Congress, the courts and the Executive Office of Management and Budget.

Yet one obligation in particular, the requirement of the Supreme Court's Benzene Decision to demonstrate the significance of methylene chloride's risk to workers through risk assessment, offered a forum for the politicization of science that continues to plague rule-making processes to this day. While OSHA ultimately "won" the risk and economic assessment game in the case of methylene chloride and was able to meet its various legal and administrative obligations while keeping intact a rule to better protect workers, the extensive resources spent on dueling scientific and economic assessments could have been used to help small and medium-sized businesses identify and implement safer alternative chemicals—stimulating innovation and saving lives.

It thus appears that the Benzene Decision stands firmly in the way of a more efficient and more effective rulemaking process on toxics in workplaces. Or does it? The challenge facing occupational health policy is to think about toxic substances differently. We need to identify leverage points that better address the entire system of chemicals uses and alternatives, and so protect workers, consumers and the environment.

We need to identify leverage points that better address the entire system of chemicals uses and alternatives, and so protect workers, consumers and the environment.

CASE STUDY 5 — **TIMELINE**

YEAR	EVENT
1971	OSHA adopts ACGIH's 8-hour time-weighted average (TWA) 500 ppm as the Permissible Exposure Limit (PEL) for methylene chloride (interim standard). The exposure limit was originally established in 1946.
1975	ACGIH lowers its Threshold Limit Value (TLV) for methylene chloride from 500 ppm to 100 ppm.
1976	NIOSH recommends reducing the 8-hour TWA for methylene chloride from 500 ppm to 75 ppm.
1980	(January) OSHA issues its Generic Carcinogen Policy.
1980	(July) The Supreme Court issues what is now known as the Benzene Decision, requiring OSHA to make a determination that a workplace is unsafe due to the presence of a "significant risk" to workers, and that this risk can be eliminated or lessened by the promulgation of a standard or change in a standard.
1981	OSHA revises its Generic Carcinogen Policy to be more consistent with the Supreme Court's Benzene decision.
1983	OSHA issues a partial stay on its Generic Carcinogen Policy, which remains in effect today.
1985	(February) NTP reports bioassay results showing clear evidence of methylene chloride's carcinogenicity in mice and rats.
1985	(May) EPA's risk assessment on methylene chloride determines the chemical is a "probable human carcinogen."
1985	(July) UAW and others petition OSHA to issue an emergency temporary standard, develop guidelines for handling methylene chloride, and initiate rulemaking, for a permanent standard.
1986	(April) NIOSH publishes its Current Intelligence Bulletin, classifies methylene chloride as potential occupational carcinogen and recommends control of exposures to the lowest feasible level.
1986	(November) OSHA denies petition for a current standard and days later initiates rulemaking on a permanent standard.
1988	CPSC issues a "statement of interpretation and enforcement policy" requiring hazard labeling for consumer products containing methylene chloride.
1987	OSHA issues its Air Contaminants Standard updating and/or establishing PELs for nearly 400 chemicals.
1989	FDA issues final rule to ban methylene chloride in cosmetic products.
1992	US 11th Circuit Court of Appeals vacates the Air Contaminants Standard because OSHA failed to establish that each regulated substance posed a significant risk and that the new PELs were either economically or technologically feasible.
1994	EPA determines that methylene chloride is an acceptable chemical substitute for ozone-depleting chemicals targeted for phase-out. In the years that follow, EPA also sets restrictive air emission technology standards for methylene chloride.
1997	OSHA's final methylene chloride rule is issued, lowering the permissible exposure limit to 25 ppm and sets a short-term exposure limit is 125 ppm for 15 minutes.
1998	OSHA's methylene chloride rule is amended to support temporary medical removal protection benefits and start-up dates for compliance for specific applications.
1998	First cases of neurological illness occur in workers using 1-bromopropane as a substitute for methylene chloride.
1998–2000	NIOSH launches a series of health hazard evaluations in cushion manufacturing companies using 1-bromopropane.
2003	NTP concludes that 1-bromopropane is toxic to the developmental and reproductive health of animals.
2009	NTP issues draft technical report demonstrating evidence of carcinogenicity of 1-bromopropane in mice and rats.

Acknowledgments

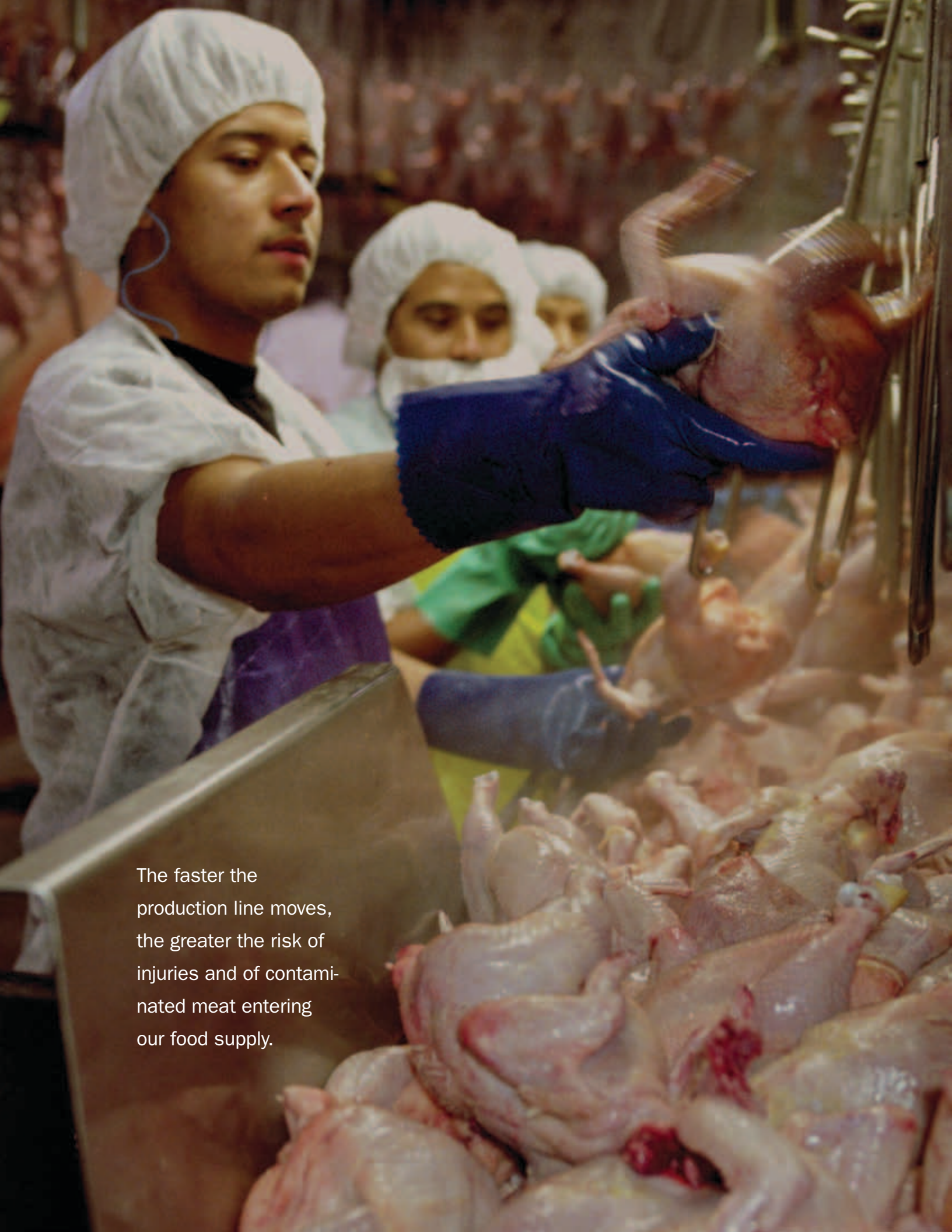
We are deeply grateful to Dr. Adam Finkel (University of Pennsylvania), who was instrumental in both the design and review phases of this case study, given his experience as OSHA Director of Health Standards when the methylene chloride standard was issued and his current research and analysis of the hazards associated with 1-bromopropane. We also thank Dr. Cora Roelofs (University of Massachusetts Lowell) who also helped to review this case study and whose science policy research on methylene chloride over the last decade is featured prominently here.

References

1. Ichihara G, Miller JK, Ziolkowska A, et al. Neurological disorders in three workers exposed to 1-bromopropane. *J Occup Health.* 2002;44:1-7.
2. Ichihara G. Neuro-reproductive toxicities of 1-bromopropane and 2-bromopropane. *Int Arch Occup Environ Health.* 2005;78(2):79-96.
3. Majersik JJ, Caravati EM, Steffens JD. Severe neurotoxicity associated with exposure to the solvent 1-bromopropane (n-propyl bromide). *Clin Toxicol (Phila).* 2007;45(3):270-6.
4. Ashford NA. Government Regulation of Occupational Health and Safety. In BS Levy, DH Wegman (Eds.), *Occupational Health: Recognizing and Preventing Work-Related Disease and Injury* (4th edition). Philadelphia: Lippincott Williams & Wilkins. 2000. 211-236.
5. Occupational Safety and Health Administration. *Regulations (Standards -29 CFR)*. Available at: *http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910*. Accessed: May 9, 2010.
6. Ruttenberg R, Bingham E. A comprehensive occupational carcinogen policy as a framework for regulatory activity. *Ann N Y Acad Sci.* 1981;363:13-20.
7. Robinson JC, Paxman DG. OSHA's four inconsistent carcinogen policies. *Am J Public Health.* 1991;81(6):775-780.
8. U.S. Department of Labor, Occupational Safety and Health Administration. Identification, Classification, and Regulation of Potential Occupational Carcinogens. *Federal Register*. January 22, 1980;46:5013.
9. U.S. Department of Labor, Occupational Safety and Health Administration. Identification, Classification, and Regulation of Potential Occupational Carcinogens. *Federal Register*. January 22, 1980;46:5004.
10. U.S. Department of Labor, Occupational Safety and Health Administration. Identification, Classification, and Regulation of Potential Occupational Carcinogens. *Federal Register*. January 22, 1980;46:5201-5217.
11. Industrial Union Dep't v. American Petroleum Institute. 448 U.S. 607. 1980.
12. Finkel A. *There is No "War" on Occupational Cancer*. President's Cancer Panel, Industrial Exposures & Cancer Public Meeting. East Brunswick, NJ 2009. Available at: *http://scienceblogs.com/thepumphandle/2008/09/presidents-panel-examines-cancer-and-the-environment.php*. Accessed: July 15, 2010.
13. U.S. Department of Labor, Occupational Safety and Health Administration. Identification, Classification, and Regulation of Potential Occupational Carcinogens; Conforming Deletions. *Federal Register*. January 21, 1981;46(13):5878-5882.
14. U.S. Department of Labor, Occupational Safety and Health Administration. Identification, Classification and Regulation of Potential Occupational Carcinogens; Partial Stay. *Federal Register*. January 4,1983;48:241-243.
15. U.S. Department of Labor, Occupational Safety and Health Administration. Carcinogen Policy. *Federal Register*. April 27, 1987;52(80):14528.
16. Robinson JC, Paxman DG, Rappaport SM. Implications of OSHA's reliance on TLVs in developing the air contaminants standard. *Am J Ind Med.* 1991;19(1):3-13.
17. U.S. Department of Labor, Occupational Safety and Health Administration. Air Contaminants. *Federal Register*. January 19, 1989;54:2332-2983.
18. American Federation of Labor and Congress of Industrial Organizations, et al. v. Occupational Safety and Health Administration Department of Labor (AFL- CIO v. OSHA), 965 F.2d 962 (11th Cir.). 1992.
19. U.S. Department of Labor, Occupational Safety and Health Administration. Air Contaminants. *Federal Register*. June 30, 1993;58:35338-35351.
20. Michaels D, Monforton C, Lurie P. Selected science: an industry campaign to undermine an OSHA hexavalent chromium standard. *Environ Health.* 2006;5:5.
21. Scientific Knowledge and Public Policy Project. *Hexavalent Chromium Case Study*. Available at: *http://www.defendingscience.org/case_studies/Chromium-Case-Study.cfm*. Accessed: August 20, 2010.
22. Halogenated Solvents Industry Alliance I. *White Paper on Methylene Chloride*. March, 2008. Available at: *http://www.hsia.org/white_papers/dcm%20wp.htm*. Accessed: March 28, 2010.
23. National Institute for Occupational Safety and Health. *Current Intelligence Bulletin 46: Methylene Chloride*. Department of Health and Human Services, Centers for Disease Control and Prevention. April 18, 1986. Available at: *http://www.cdc.gov/niosh/86114_46.html*. Accessed: March 29, 2010.
24. Office of Evaluation and Audit Analysis. *Regulatory Review of 29 CFR 1910.1052: Methylene Chloride*. Occupational Safety and Health Administration, Directorate of Evaluation and Analysis. February 2010. Available at: *https://iforms.osha-slc.gov/dea/lookback/MC-lookback-Feb-2010-final-for-publication-May-2010.pdf*. Accessed: August 26, 2010.
25. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Exposure to Methylene Chloride; Final Rule (Section III: Events Leading to the Final Standard). *Federal Register*. January 10, 1997;62:1496-1500.

26. National Institute for Occupational Safety and Health. *Criteria for a Recommended Standard: Occupational Exposure to Methylene Chloride*. Report No:76-138. March 1976. Available at: *http://www.cdc.gov/niosh/76-138.html*. Accessed August 20, 2010.
27. National Toxicology Program. *Toxicology and Carcinogenesis Studies of Dichlormethane (Methylene Chloride) (CAS No. 75-09-2) in F344/N Rats and B6C3F1 Mice (Inhalation Studies)*. Report No:306 (NIH Publication No: 86-2562). Department of Health and Human Services, Public Health Service, National Institutes of Health. 1986. Available at: *http://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr306.pdf*. Accessed June 5, 2010.
28. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Exposure to Methylene Chloride; Final Rule. *Federal Register*. January 10, 1997;62:1494-1601.
29. Ott MG, Skory LK, Holder BB, et al. Health evaluation of employees occupationally exposed to methylene chloride. *Scand J Work Environ Health.* 1983;9 Suppl 1:1-38.
30. Lanes SF, Cohen A, Rothman KJ, et al. Mortality of cellulose fiber production workers. *Scand J Work Environ Health.* 1990;16(4):247-51.
31. Gibbs GW, Amsel J, Soden K. A cohort mortality study of cellulose triacetate-fiber workers exposed to methylene chloride. *J Occup Environ Med.* 1996;38(7):693-7.
32. Heineman EF, Cocco P, Gomez MR, et al. Occupational exposure to chlorinated aliphatic hydrocarbons and risk of astrocytic brain cancer. *Am J Ind Med.* 1994;26(2):155-69.
33. Finkel AM, Ryan PB. Risk in the Workplace: Where Analysis Began and Problems Remain Unsolved. In MG Robson, W Toscano (Eds.), *Risk Assessment for Environmental Health.* San Francisco, CA: John Wiley & Sons, Inc. 2007. 187-237.
34. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Exposure to Methylene Chloride; Final Rule (Section VII: Significance of Risk). *Federal Register*. January 10, 1997;62:1560-1563.
35. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Exposure to Methylene Chloride: Final Rule (Section X: Summary and Explanation of the Final Standard). *Federal Register*. January 10, 1997;62:1571-1600.
36. Bailar JC, 3rd, Bailer AJ. Risk assessment—the mother of all uncertainties. Disciplinary perspectives on uncertainty in risk assessment. *Ann N Y Acad Sci.* 1999;895:273-85.
37. Michaels D. *Doubt Is Their Product: How Industry's Assault on Science Threatens Your Health*. New York: Oxford University Press. 2008.
38. Tickner J, Wright S. Primary prevention of chemical contamination. *New Solutions.* 2002;12(4):425-433.
39. Moore M. OSHA reopening file on methylene chloride. *Rubber and Plastics.* November 13, 1995;5.
40. Society of the Plastics Indus., Inc. v. OSHA, 509 F. 2d 1301, 1308 (2nd Cir.) 1975.
41. Am. Iron & Steel Inst. v. OSHA, 577 F. 2d 825 (3d Cir.) 1978.
42. Latin HA. The feasibility of occupational health standards: an essay on legal decisionmaking under uncertainty. *Northwestern University Law Review.* 1983:583-631.
43. Ashford NA, Caldart CA. Chapter 3. The Occupational Safety and Health Act of 1970. In *Technology, Law, and the Working Environment*. Washington DC: Island Press. 1996. 91-192.
44. McGarity T, Steinzor R, Shapiro S, et al. *Workers at Risk: Regulatory Dysfunction at OSHA*. Center for Progressive Regulation. February 2010.
45. Roelofs CR. *Losing Controls: the Case for a Preventive Industrial Hygiene (Dissertation)*. University of Massachusetts Lowell. 2001.
46. Roelofs CR, Ellenbecker MJ. Results of the Massachusetts methylene chloride end-users survey. *Appl Occup Environ Hyg.* 2003;18(2):132-7.
47. Department of Health and Human Services, Food and Drug Administration. Cosmetics; Ban on the Use of Methylene Chloride as an Ingredient of Cosmetic Products. *Federal Register*. June 29, 1989;54:27328-27342.
48. Consumer Product Safety Commission. Labeling Certain Household Products Containing Methylene Chloride; Statement of Interpretation and Enforcement Policy. *Federal Register*. September 14, 1987;52:34698-34703.
49. Environmental Protection Agency. Protection of Stratospheric Ozone. *Federal Register*. March 18, 1994;59: 13044-13161.
50. Roelofs CR, Ellenbecker MJ. Source reduction for prevention of methylene chloride hazards: cases from four industrial sectors. *Environ Health.* 2003;2(1):9.
51. U.S. Department of Health and Human Services, National Toxicology Program. *Abstract for TR-564 - 1 Bromopropane (CASRN 106-95-4) Toxicology and Carcinogenesis Studies of 1-bromopropane (CAS No. 106-954-5) in F344 Rats and B6C3F1 Mice (Inhalation Studies)*. November 19, 2009. Available at: *http://ntp.niehs.nih.gov/index.cfm?objectid=4E0C03A9-F1F6-975E-79F1E370B9027815*. Accessed: July 2, 2010.
52. Ichihara G, Yu X, Kitoh J, et al. Reproductive toxicity of 1-bromopropane, a newly introduced alternative to ozone layer depleting solvents, in male rats. *Toxicol Sci.* 2000;54(2):416-23.
53. Yu X, Ichihara G, Kitoh J, et al. Preliminary report on the neurotoxicity of 1-bromopropane, an alternative solvent for chlorofluorocarbons. *J Occup Health.* 1998;40:234-235.
54. California Department of Health Services, Hazard Evaluation System and Information Service. *1-Bromopropane (n-Propyl Bromide)*. July, 2003. Available at: *http://www.cdph.ca.gov/programs/hesis/Documents/bpropane.pdf*. Accessed: May 2, 2010.
55. Barber ED, Donish WH, Mueller KR. A procedure for the quantitative measurement of the mutagenicity of volatile liquids in the Ames Salmonella/microsome assay. *Mutat Res.* 1981;90(1):31-48.
56. Sclar G. Encephalomyeloradiculoneuropathy following exposure to an industrial solvent. *Clin Neurol Neurosurg.* 1999;101(3):199-202.
57. Center for the Evaluation of Risks to Human Reproduction. *NTP-CERHR Monograph on the Potential Human Reproductive and Developmental Effects of 1-Bromopropane*. NIH Publication No: 04-4479. U.S. Department of Health and Human Services, National Toxicology Program. October, 2003.

58. Harney JM, Nemhauser JB, Reh CM, et al. *Health Hazard Evaluation Report: HETA 99-0260-2906, Marx Industries, Inc., Sawmills, North Carolina*. Report No: HETA-99-0260-2906. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health. 1999. Available at: *http://www.cdc.gov/niosh/hhe/reports/pdfs/1999-0260-2906.pdf*. Accessed April 3, 2010.
59. Engel E. *Hazard Alert – 1-Bromopropane*. North Carolina Department of Labor. Available at: *http://www.ahfa.us/uploads/documents/1bphazardalert.pdf*. Accessed: April 3, 2010.
60. Reh CM, Mortimer VD, Nemhauser JB, et al. *Health Hazard Evaluation Report: HETA-98-0153-2883, Custom Products, Inc., Mooresville, North Carolina*. Report No: HETA-98-0153-2883. Department of Health and Human Services, National Institute for Occupational Safety and Health. 1998. Available at: *http://www.cdc.gov/niosh/hhe/reports/pdfs/1998-0153-2883.pdf*. Accessed April 3, 2010.
61. Harney JM, Hess J, Reh CM, et al. *Health Hazard Evaluation Report: HETA-2000-0410-2891, STN Cushion Company, Thomasville, North Carolina*. Report No: HETA-2000-0410-2891. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health. 2000. Available at: *http://www.cdc.gov/niosh/hhe/reports/pdfs/2000-0410-2891.pdf*. Accessed April 3, 2010.
62. Directorate of Health Standards, U.S. Occupational Safety and Health Administration. *Nomination of 1-Bromopropane (1-BP) and 2-Bromopropane (2-BP) for Testing by the National Toxicology Program.* December 199. Available at: *http://ntp.niehs.nih.gov/ntp/htdocs/Chem_Background/ExSumPdf/Bromopropanes.pdf*. Accessed: August 20, 2010.
63. Finkel AM. *Highlights of Testimony: OSHA Rulemaking Hearing on Modifications to the Hazard Communication Standard ("HazCom")*. March 5, 2010. Available at: *http://peer.org/docs/osha/3_5_10_Finkel_TLV_testimony.pdf*. Accessed: May 25, 2010.
64. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Exposure to Methylene Chloride; Final Rule (Section VIII: Summary of Final Economic Analysis) *Federal Register*. January 10, 1997;62(7): 1563-1571.
65. Commonwealth of Massachusetts, Executive Office of Environmental Affairs, Office of Technical Assistance. *Toxics Use Reduction Case Study: Crest Foam Eliminates Use of Methylene Chloride in Manufacturing Process* March 1997. Available at: *http://www.p2pays.org/ref/20/19157.htm*. Accessed July, 2, 2010.
66. Michaels D. *Memo to colleagues: OSHA at Forty: New Challenges and New Directions*. Occupational Safety and Health Administration, Department of Labor. July 19, 2010. Available at: *http://scienceblogs.com/thepumphandle/OSHA_at_Forty.pdf*. Accessed: August 5, 2010.



The faster the production line moves, the greater the risk of injuries and of contaminated meat entering our food supply.

CASE STUDY 6

Safe Food from Safe Workplaces:
Protecting Meat and Poultry Workers

Molly M. Jacobs, David Kriebel, Joel Tickner

"The line is so fast there is no time to sharpen the knife. The knife gets dull and you have to cut harder. That's when it really starts to hurt, and that's when you cut yourself. I cut my hand at the end of my shift, around 10:30 at night.... I went to the clinic the next day at 11:00 am. They gave me stitches and told me to come back at 2:30 before the start of my shift to check on the stitches. They told me to go back to work at 3:00. I never stopped working."

—A pork processing plant worker at Tar Heel Plant in Bladen, NC, 2003[1]

"We come in different sizes, but the hooks and the cutting table are the same for everybody. The short ones have to reach more, and they hurt their backs and shoulders. The tall ones have to stoop down more, so they hurt their backs and shoulders. Everybody walks out of the plant hurting at the end of the shift."

—A poultry processing plant worker in Rogers, Arkansas, 2003[1]

"The difference I have found among working in multiple plants is the way we are treated by the supervisors. They [the supervisors] do not train you to do the work, but they still expect you to work. When supervisors talk to you, they scream at you and insult you, using obscenities. There is no respect for the workers."

—A meatpacking worker in Nebraska, 2009[2]

SLAUGHTERING AND PROCESSING beef, lamb, pork, and poultry for our food supply are inherently dangerous jobs.[3] Turning a 1,250-pound steer or a five-pound chicken into cuts sold in the marketplace is physically demanding work undertaken in a difficult and hazardous work environment. Workers use sharp hooks and knives while standing on floors made slippery from blood, fat, fecal matter, and other bodily fluids. Unpredictable and violent reactions from animals before slaughter pose constant physical threats to workers. Heavy suspended carcasses of beef traveling along a fast-moving automated line can slam a worker to the floor. Down the line, processing workers stand for long periods of time working closely together while making thousands of repetitive cuts each shift. The noise is deafening and temperatures in the plants range from hot and humid on the killing floors to near freezing in the processing rooms. Pathogens can infect workers, and chemicals from decomposing animal waste, disinfectants, or gases such as ammonia used for refrigeration can prove deadly.

Over a century ago, Upton Sinclair's *The Jungle* used narrative rather than statistics to describe

injuries among meatpacking workers in the Chicago stockyards, "Of the butchers and floorsmen, the beef-boners and trimmers, and all those who used knives, you could scarcely find the person who had use of his thumb; time and time again the base of it had been slashed, till it was a mere lump of flesh."[4] Decades later, when the Occupational Safety and Health Act (OSHAct) became law in 1970, the meat and meat products industry was designated by the new Occupational Safety and Health Administration (OSHA) for priority attention as part of the agency's efforts to target those industries having the highest rates of occupational injuries.[5] The creation of OSHA in 1970, earlier trade union organizing in the 1930s, and creation of the National Labor Relations Act in 1935 brought improved conditions for meatpacking workers for many years.[1] These gains were lost, however, beginning in the 1980s with a variety of changes in the industry, and by 1991, nearly one out of every two workers was either injured or made ill by the work.[6]

Today, reported illness and injury rates in meatpacking workers are more than double that of U.S. manufacturing as a whole while rates among poultry processing workers are 30 percent higher.[7,a] However, known flaws in our occupational illness and injury surveillance methods make it difficult to know the extent of current health concerns among these workers.[3]

Despite the inherent dangers of the work, injuries and illness among workers engaged in animal slaughtering and meat processing tasks can be avoided. Comprehensive employee safety education and training, safeguards on machines and equipment, personal protective equipment, reducing line and work speed, employee involvement in decisions that affect workplace health and safety, as well as prompt and appropriate medical management to prevent smaller injuries from becoming more serious or chronic conditions, are just a few of the practices that, if implemented, can keep workers healthy on the job.

ABOUT THIS CASE STUDY

Hazards in the meat and poultry slaughter and processing industry are well known and predictable, and solutions to preventing these harms are feasible. Why then is this industry still beset by sickness and injuries? Over the last decade historians, investigative journalists, government oversight committees, occupational health scientists, and human rights and labor organizations, among others, have examined this very problem. This case study provides an analysis and synthesis of this body of work and reveals that solutions to protect the health and safety of meat and poultry production workers cannot be decoupled from the complex intersection of power relations on the plant floor, regulatory agencies with inadequate resources and power, and the perverse economics of our industrial meat production system, in which narrow profit margins drive business decisions that impact workers and consumers alike.

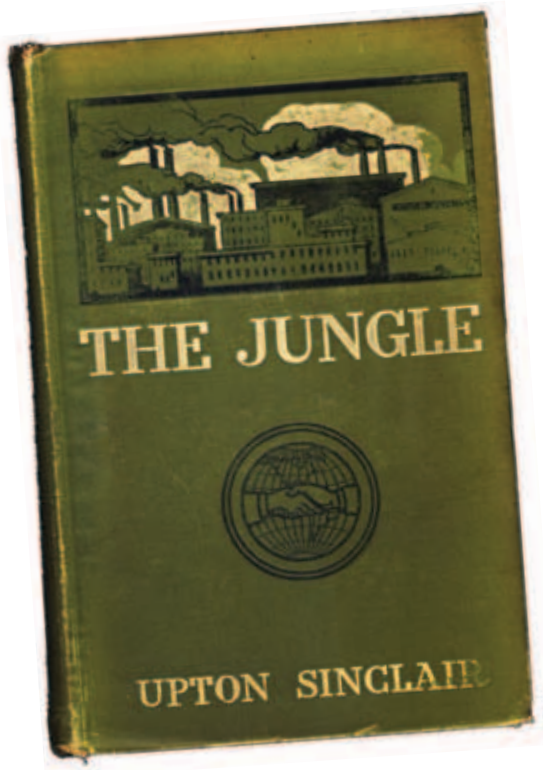
A brief review of history: Have we come full circle and back to Sinclair's *The Jungle*?

Failing to connect the dots: safe food comes from safe workplaces

Upton Sinclair's 1906 novel *The Jungle* exposed the dehumanizing labor conditions and unsanitary environment of the meatpacking industry.[8] In horrific detail from the Chicago stockyards, Sinclair's writings made clear the connections between unsafe working conditions and an unsafe food supply. The resulting public outrage and outcry to transform the industry resulted in inspections that confirmed Sinclair's assertions: some packing establishments were continuously unsanitary; meat processing methods themselves were hazardous and unclean, producing meat products simply unfit for human consumption; workers had high rates of tuberculosis; and conditions in the stockyard and in the plants were a significant public health threat to the largely immigrant population that worked there and lived nearby.[9]

Within months, President Teddy Roosevelt and Congress intervened with the passage of two consumer protection laws in 1906: the Pure Food and Drug Act and the Meat Inspection Act. Together the laws sought to safeguard the meat supply for human consumption by increasing the US

a *Based on 2009 Bureau of Labor Statistics non-fatal injury and illness incidence data using the North American Industry Classification System (NAICS) codes: 31-33 (manufacturing), 311611 (animal (except poultry) slaughtering), and 311615 (poultry processing).*



"Of the butchers and floorsmen, the beef-boners and trimmers, and all those who used knives, you could scarcely find the person who had use of his thumb; time and time again the base of it had been slashed, till it was a mere lump of flesh." —Upton Sinclair, *The Jungle*

Department of Agriculture's (USDA) oversight and also prohibiting the sale of adulterated or fraudulently labeled food (and drugs)—an act considered punishable by fines and jail time.[10]

Despite Sinclair's attempts to connect the health and safety of production workers with the integrity of the food landing on the public's dinner table, no parallel reforms were enacted to improve workplace conditions. Years later, Sinclair expressed disappointment about the result: "I aimed at the public's heart, and by accident, I hit it in the stomach. . . . My main concern had been for the fate of the workers, and I realized with bitterness that I had been made into a 'celebrity', not because the public cared anything about the sufferings of these workers, but simply because the public did not want to eat turbercular beef."[11]

Shifting power on the plant floor: the labor movement improves health and safety

Improvements for workers did arrive decades later due to the growing voice and power of the organized labor movement. Beginning in the 1930s, wages, working hours, and conditions for meat slaughter and processing workers started to improve as a result of the unionization of their workplaces.[12] While these jobs were still dangerous and difficult, master bargaining unit contracts helped to balance the power structure to ensure that workers' health and safety were better protected. Unionization helped to bring safety procedures and programs to curtail some workplace dangers: union stewards enforced the placement of safety devices on cutting equipment; the presence of shop stewards and a grievance system helped to slow production speed to decrease accidents; and union sick leave provisions allowed those injured in the course of work to take time off to prevent small injuries from turning more serious.[12]

Technological and corporate restructuring: new hazards and all too familiar injustices

As technological advances and changes in corporate structure and practices reshaped the nature of the meat slaughter and processing industry, conditions for workers worsened.

Between the 1950s and 1970s, power tools and automated lines helped to mechanize and speed up some of the slaughtering and meat-cutting tasks. As a consequence, more workers were used further down the line in the processing departments, where job duties became simplified.

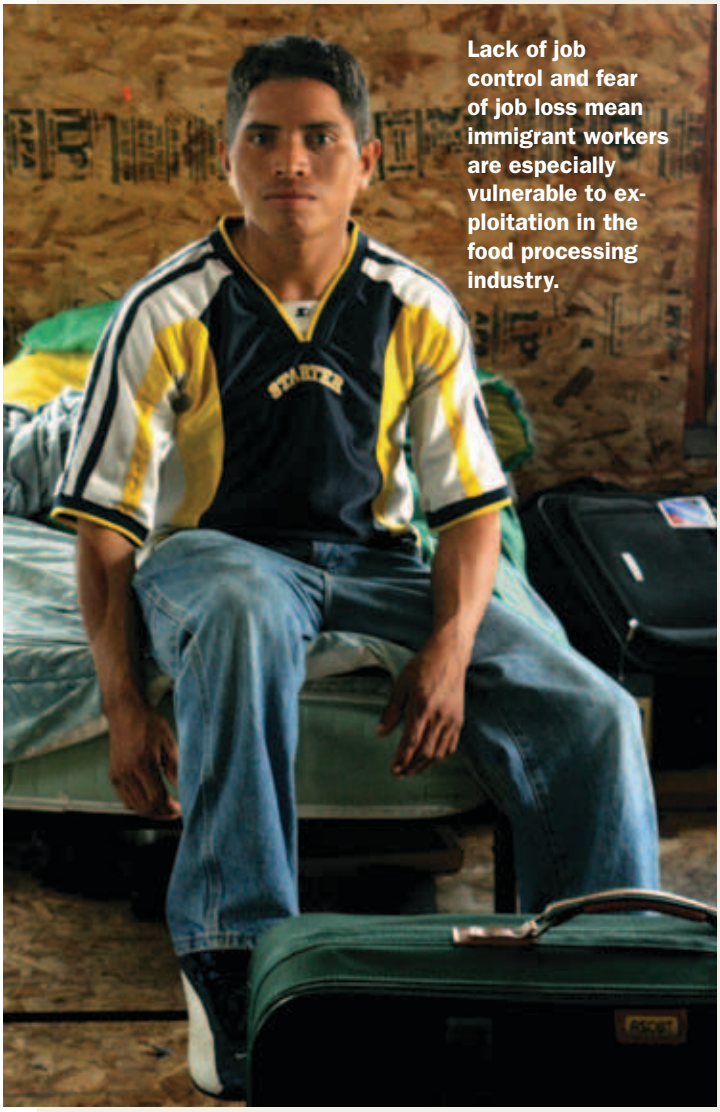
While improving productivity and reducing the hazards in some tasks, new machine pacing and a production line approach created more repetitive work tasks than had been typical of the industry in prior years.[12] Workers still used sharp knives, but rather than doing tasks that required making a number of different cuts at different angles, allowing the body to shift positions, processing workers were now making the same cut over and over again.

"I aimed at the public's heart, and by accident, I hit it in the stomach."

Together with technological restructuring of the industry, changes in corporate structure and practices transformed the industry into the one we see today. Over the past 40 years, meat slaughterers

Vulnerable immigrant workers often suffer in silence

While their countries of origin have changed over the decades, immigrant workers still dominate the workforce in many meat and poultry plants, as they did in the time of *The Jungle*.[3] These workers hold a variety of immigration statuses, and some are undocumented and without current permission to work in the United States. Despite the fact that all immigrant workers—independent of immigration status—are protected by national workplace rights standards, many are afraid to voice concern about unsafe working conditions or prefer to avoid navigating what is often seen as a complex and costly array of procedures to vindicate their rights when they are harmed.[1]



Lack of job control and fear of job loss mean immigrant workers are especially vulnerable to exploitation in the food processing industry.

The acute risk of immediate deportation acts as a very strong disincentive for immigrant workers to raise concerns about workplace hazards or personal injury. As one poultry worker told Human Rights Watch in 2003, "They have us under threat all the time. They know most of us are undocumented—probably two-thirds. All they care about is getting bodies into the plant. My supervisor said they say they'll call the INS [Immigration and Naturalization Service] if we make trouble."[1]

Similar fear is felt among immigrant workers and US-born workers who are working legally. Most workers depend on having a job to support their families, and some may also have undocumented relatives or friends whom they want to protect.[1] As reported by Nebraska Appleseed in 2009, a survey of 455 workers on Nebraska's meatpacking disassembly lines revealed that workers' basic fear of losing their jobs—apart from immigration concerns—was the main reason they refrained from reporting injuries, and that less that half (44 percent) remembered receiving information about how to use the workers' compensation system in the event of an injury.[2]

Lack of job control and fear of job loss are easily exploitable circumstances. As a consequence, reports abound of abusive supervisors who scream, humiliate, and threaten employees in order to meet their productivity quota.[1,2,16] If injured or concerned about mistreatment, these vulnerable and marginalized populations feel they have nowhere to turn, as immigrant workers often feel that an employer's human resource and medical staff have only the company's interest in mind. As stated by one Nebraska meatpacker, "It's sad to not know who to complain to, because even the doctors and nurses are on the company's side."[2] This is especially true in non-unionized plants, where immigrant worker centers are taking an increasingly important role in protecting the rights of these workers.

Companies remain dependent on hiring workers who are more willing than many US residents to work for low pay in extremely difficult and hazardous conditions in an industry plagued with rapid employee turnover.[17]

and processers began consolidating and moving their slaughterhouses to more rural communities.[13] The rules of efficiency had changed, and meat that was once further processed by wholesalers and retailers nearer to final markets was now processed at the plant. Broken and boned carcasses were cut into primal and subprimal cuts, packaged in vacuum-packed plastic, and shipped in boxes.[13] With narrow margins, industry profits depended on maximizing the volume of animals that could be processed. Plant size increased and along with it, the speed of processing and thus the number of animals that could be processed each day. For example, Smithfield's Tar Heel plant in North Carolina—now the largest hog-processing facility in the country—can slaughter, cut, pack, and ship more than 32,000 hogs a day.[14] Tyson's 54 poultry processing plants conduct similar operations for 42.5 million chickens per week.[15]

Industry consolidation meant that fewer independent small firms were operating. According to the Government Accountability Office (GAO), in 2005 the top four meatpacking companies slaughtered, processed, and packaged roughly 80 percent of the beef in the United States;[b] the top four pork producers controlled nearly 70 percent of the market; and the poultry industry was somewhat less concentrated, with the top five companies maintaining over 50 percent of the market share.[3]

Significant changes in the relations between organized labor and employers came along with this industry consolidation and the movement of processing to rural locations away from union centers. By the end of the 1980s, union membership among meat workers had fallen to 21 percent, compared to 46 percent during the 1970s and 1980s.[6] With the decline of union membership, wages declined and employee turnover increased.[3]

The flow of new labor—often to rural areas without a sufficient population to fully staff large processing plants—drew upon those with limited job options, who lacked either the skills or resources to find more desirable jobs, or relied upon company recruitment of new immigrants.[1,3] By 1994, one-third of production and sanitation workers in meatpacking plants were foreign-born non-citizens—a proportion that would continue to increase in the coming years.[3] While these workers were provided with jobs that paid more than those in their homelands, US employers benefited from a flow of low-wage workers, and consumers reaped the benefits of low prices.

OSHA inspections and a Congressional investigation in 1987 revealed that official government statistics underestimated the severity of what was really happening inside these facilities as a result of underreporting by employers.

The extent of current injury, illnesses, and dangerous working conditions revealed

Amidst the technological and corporate restructuring that occurred within the meat and poultry industry, it is not surprising that injury and illness rates increased. Between 1981 and 1991, the injury and illness rate rose 45.5 percent.[6,18] More concerning though, was the rise in illness rates in particular: more than a five-fold increase from 1981 to 1991.[12] This increase was probably driven by work-related musculoskeletal disorders (MSDs) of the nerves and muscles in the wrist, arms, neck, and back. MSDs are counted as "illnesses" by the Bureau of Labor Statistics, but include a spectrum of overuse or repetitive strain injuries that result in often permanently debilitating conditions such as tendinitis and carpal tunnel syndrome. MSDs are an extremely frequent occurrence in the meat slaughter and processing industries. By the late 1980s, MSDs occurred at a rate approximately 75 times that for industry as a whole.[19]

OSHA inspections and a Congressional investigation in 1987 revealed that official government statistics underestimated the severity of what was really happening inside these facilities as a result of underreporting by employers. In 1987, OSHA levied an unprecedented fine on Iowa Beef Processors, Inc. (IBP, now a subsidiary of Tyson Foods) of $2.59 million for what an OSHA official

b *In 2008 the Department of Justice and 16 states challenged the merger of JBS and the National Beef Packing Company, two of the top four beef packing companies in the United States. These actions led the companies to abandon the deal.*

Carpel tunnel syndrome is an all too common injury among meat packing and poultry processing workers.

described as "the worst example of under reporting injuries and illnesses ever encountered."[12]

Testimony by representatives of the United Food and Commercial Workers International Union (UFCW) during Congressional hearings revealed that the IBP plant in Dakota City, Nebraska, maintained two injury logs: one maintained by the plant nurse and another version reported to OSHA. Copies of the original logs revealed that during a three-month period in 1985, 1,800 workplace injuries were recorded. Yet the version submitted to OSHA for the same time period included only 160 injuries.[20]

Testimony during these hearings provided disturbing accounts regarding the deteriorating, difficult, and dangerous working conditions that meatpacking workers faced and also described how employers often turned their backs on workers if they became injured. Many of the dangers were unchanged from Upton Sinclair's day:

> *In less than 10 years at the plant, my work on the kill floor left me with permanent hearing loss and four additional injuries. Three of these were knife cuts because they didn't issue protective gloves to their workers back then. My fourth injury was due to the same slippery floors that continue to maim workers at the plant today—a meat cart slipped, causing a meat hook to grab me and rip my back open clear to the spine.*[21]

Yet another frequent occurrence—also a throwback to the turn of the century—was evidence of disregard for workers' health and wellness. Testimony provided accounts of workers sent back to work while still injured, and foremen ignoring workplace dangers and using fear to manage employees who voiced dissent about hazardous working conditions or their health.[20] As one worker commented:

> *I was even instructed to run that machine, on occasion, when there was an ammonia leak in the area. When your eyes begin watering so badly you can't see, then you know the job is unsafe. But the foreman would just say, "You will go back over there. You will run that machine, or you will be fired."*[22]

In the UFCW's review of the 1,800 injury and illness reports, extensive MSDs caused by repetitive strain were identified: "scores of workers whose illnesses are described as numbness in the left hand, locking and tingling of fingers, pain in shoulder going into fingers."[23] A survey by the UFCW estimated that 70 percent of all plant employees demonstrated symptoms consistent with MSDs.[24]

In 1988, IBP was fined another $3.1 million under the OSHAct's general duty clause for failing to keep the workplace safe from hazards associated with repetitive motions.[25]

The emergence of ergonomic solutions

In 1988, IBP reached a settlement with OSHA and the UFCW which substantially reduced IBP's combined fines of more than $5 million in exchange for establishing long-term programs aimed at addressing the high rates of MSDs. Such an approach centered on using ergonomic controls: changes in the work environment such that work stations and tasks are designed to fit the worker, rather than the other way around. For the next three years at its 15

union and non-union plants, IBP agreed to: (1) identify workplace hazards; (2) prevent such hazards using work station and tool redesign, work practice controls, personal protective equipment, and the implementation of administrative controls; (3) use medical management to reduce the incidence and severity of MSDs through early identification and treatment; and (4) educate and train employees to actively participate in the prevention of MSDs.

According to one UFCW health and safety representative, the work on ergonomic solutions that began with IBP during the late 1980s and early 1990s greatly improved health and safety practices throughout the meat and poultry slaughter and processing industry.[26] Greater automation, adjustable work stands, lower conveyer belts, and mechanical assists are now commonplace in most state-of-the-art plants. These design changes are a double win for industry: they not only prevent MSDs, they improve employee productivity.[26] With less strain, workers can perform tasks with greater ease. When workers are free from suffering from an injury on a job, they can work more efficiently. Yet even among plants heralded as having model ergonomic programs, health researchers

A Worker's Grueling Day

by Franco Ordonez[29]

Celia Lopez felt lucky when she was hired at the House of Raeford Farms turkey plant in Raeford, North Carolina. But after six years, the 44-year-old mother of three said she feared the "hands that take care of my family" were ruined. At the [*Charlotte*] *Observer*'s request, Lopez recounted a typical day:

- **6:45 a.m.** – Lopez walks through the gate of the sprawling plant. She's struck by the pungent smell of ammonia. She punches her timecard and puts on her gear—rubber boots, apron, hairnet and two pairs of gloves. She rushes to position. Workers must be at their posts before the production line starts. No excuses.
- **7 a.m.** – The line starts. Lopez begins by grabbing and placing turkey breasts on plates to be weighed. Each plate must weigh between 6 and 6-1/2 pounds. She grabs meat with her right hand and uses her left to hold the plate, then pushes the turkey along the line. She'll repeat this process hundreds of times an hour.
- **9:30 a.m.** – If Lopez needs a bathroom break, she must wait until a supervisor finds someone to replace her on the line. This can take minutes or hours—if approved at all. "Bathroom breaks are a privilege, not a necessity," she said her bosses told her. If granted, she has 10 minutes to remove her gear, use the facilities and return.
- **11 a.m.** – Lunch.
- **11:30 a.m.** – Back on the line. She has processed hundreds of pounds of meat. The line is moving fast; workers struggle to keep pace, she says. Conversation is minimal.
- **2 p.m.** – Break. She looks for a wall to press her back against and stretch her muscles.
- **2:30 p.m.** – The next two hours are the hardest—the piles of meat seem endless, she says. Her back cramps, pain spreading to her shoulders, arms and hands. She is exhausted from standing. Sometimes she feels dizzy.
- **4 p.m.** – She punches out. She changes out of her work clothes, washes her face and leaves.
- **4:30 p.m.** – She arrives home and takes a shower. "The meat smell gets stuck in your skin," she says.
- **About 7 p.m.** – She helps cook dinner for her family. Grasping a spoon is hard, she says. She uses two hands to carry a dinner plate. Basic tasks take longer because of the pain. "It's like ants crawling through my hands, up my arms," she says.
- **9 p.m.** – She takes two ibuprofen pills before rubbing her hands with alcohol and lotion—a nightly routine.
- **9:30 p.m.** – She goes to bed.
- **Midnight to 2 a.m.** – Lopez frequently wakes up, hands cramping. She squeezes her fists each time the pain is worse. She swallows more ibuprofen.
- **5 a.m.** – Her alarm sounds. The line starts in two hours. "Sometimes I cry. I just pray to God that he will show me the way."

— Reprinted with permission from the Charlotte Observer

continue to document an excess prevalence of an array of MSDs compared to that among other workers from the same community.[27]

The hazard control techniques mentioned above are simply one component of a multi-faceted ergonomic management program that includes the voluntary guidelines established by OSHA in 1993.[28] Yet because in 2001 Congress and President George W. Bush repealed OSHA's newly issued mandatory ergonomic standard, which would have legally required employers to implement specific ergonomic hazard control programs, an employer has discretion as to what elements of an ergonomic program to implement. Reduced line speed is rarely one of them.

Today, only USDA, not OSHA, specifically regulates line speed. But USDA assesses permissible line speeds with respect to food safety considerations, not worker safety.

Line speed: pain for workers, contaminated meat for consumers, and profit for employers

Line speed, in combination with staffing levels on the line and the rotation (or non-rotation) of workers during their shifts, is directly related to the number of repeat motions workers make in a day. In 2009, the non-profit law and policy center Nebraska Appleseed issued a report revealing that among a representative sample of Nebraska meatpackers, line speed and having an adequate number of staff on the line were the biggest concerns for workers: 73 percent stated that line speed had increased in the past year.[2]

Why quicken the speed of the line? Line speed is directly related to profits. The faster the line, the more product produced, and the greater the profits. As a 2004 Human Rights Watch report stated, "Profit margins per chicken or per cut of meat are very low, often a few pennies a pound, so competitive advantage rests on squeezing out the highest volume of production in the shortest possible time."[1] Managers tell workers that the plant loses money every second the line is slowed or stopped.[1]

Workers often know when inspectors or visitors are at the plant, as revealed by multiple workers surveyed by Nebraska Appleseed. "When a visitor comes they slow it down and when they leave they speed it up."[2] "It would be good if they maintained an adequate number of workers on the line and the same line speed as when inspection visits take place."[2]

Today, only USDA, not OSHA, specifically regulates line speed.[3] But USDA assesses permissible line speeds with respect to food safety considerations, not worker safety.[3] As long as USDA inspectors can certify that the meat product is uncontaminated, line speed can increase with no concern for effects on worker health and safety. When line speeds are fast due to production pressures, the probability of human error or accidental contamination greatly increases.

USDA's own procedures to correct contamination include reducing line speed so that employees can exercise better caution and have the time necessary to sanitize tools.[30] Yet contaminated meat and poultry sicken thousands of people each year.

Based on the latest data from the Centers for Disease Control and Prevention, in 2007, 691 individuals became sick after eating contaminated chicken and 667 individuals were sickened by eating contaminated beef.[31] Yet the degree of underreporting is known to be significant—an estimated 38-fold in the case of *Salmonella*, and 20-fold for *E.coli 0157:H7*.[32] Meat recalls are a common occurrence these days. In the first six months of 2010, multiple incidents resulted in the recall of over 6.1 million pounds of beef due to *E. coli O157:H7* contamination.[33]

Now the list of virulent *E. coli* strains is expanding. In August 2010, 8,500 pounds of hamburger were recalled after three people were made violently ill by consuming meat that was traced to Cargill and to a specific production lot.[34] Investigators tracked the likely source of the illnesses to *E. coli 026*, a strain that is legally allowed in beef sold to the public.[34] USDA and industry officials will undoubtedly debate the merits of giving this new bacterial strain "illegal" status, but will a focus on these downstream effects really correct the upstream causes at the point of slaughter and production that are affecting workers and consumers alike?

In 1996, the Pathogen Reduction Act was passed, allowing USDA to issue a new "risk-based" system of inspection that made the slaughter and processing industry, rather than USDA inspectors, responsible for identifying and fixing food safety hazards—the Hazard Analysis and Critical Control Point (HACCP) system. HACCP is considered a vast improvement over USDA's former "poke and sniff" inspectional system in which inspectors relied on their sense of sight, smell and touch to identify contaminated meat and thus were unable to identify invisible bacteria or infection. Yet under the HACCP system, the role of USDA inspectors was changed to providing oversight over industry's own inspectors.

Slowing or stopping production is a disincentive for addressing problems of potentially contaminated meat. HACCP also prescribes methods for the decontamination of meat using expensive technologies (e.g., carcass rinsing, ozonation, and irradiation among others) rather than fixing problems at the source. In 2001, a GAO report reviewed the effectiveness of this inspection system during a pilot stage and surveyed USDA inspectors and veterinarians working at poultry and meat slaughter and processing establishments. Sixty percent of those surveyed stated that line speed was too fast to ensure product safety.[35] While USDA inspectors still provide oversight, they are discouraged from stopping production lines when they suspect contamination. A USDA memo in 2002 stated that inspectors would be held responsible for halting production unless there was clearcut evidence of product contamination.[36]

It's unclear whether this USDA internal policy still holds true today. Nevertheless, if action is not taken when an inspector suspects a problem, the odds are greatly increased that one piece of contaminated meat can contaminate machinery and other products.[36]

Coming full circle: attempts to fix food safety neglect worker health

As a result of the public's growing concern over food recalls and associated illness outbreaks, in 2009 President Obama vowed to "upgrade our food system for the 21st century."[37] While such food system reforms are crucially needed, the focus of these efforts is consumer health—once again, neglecting the health of workers, just as in the day of Sinclair Lewis's *The Jungle*. Ironically, the President even referred to the time of *The Jungle,* noting that many of the nation's food-safety laws "have not been updated since they were written in the time of Teddy Roosevelt."[37] Yet, only when we succeed in making the connection that healthy food is produced by healthy workers will we find ourselves with a safer, healthier food system.

A meat cutter in a packing plant in Baltimore, Maryland.

Improving coordination between USDA and OSHA

USDA inspectors have a daily presence at many meat and poultry slaughter and processing facilities. With proper cross-training and agency coordination, these federal safety inspectors could help to im-

prove workplace safety as part of their duties to protect consumer safety.

The first step in such an approach has already been taken, although it took a terrible tragedy to compel the agencies to act. In 1991, a fire claimed the lives of 25 poultry plant workers in Hamlet, North Carolina, many of whom could not escape because the owner locked the plant doors based on a suspicion that workers were stealing product.[38] While a USDA poultry inspector knew of the routinely locked doors and reported to the owner that his actions were in violation of safety codes, he did not report the incident(s) to OSHA.[3] Lives likely would have been spared if only the USDA inspector had reported this violation.

In response to this accident, USDA and OSHA revised an existing memorandum of understanding (MOU) between the two agencies in 1994.[3] The MOU established a process and framework for: (1) training USDA meat and poultry inspection personnel to improve their ability to recognize serious hazards within the meat and poultry industry; (2) reinforcing procedures for meat and poultry inspection personnel to report unsafe and unhealthy working conditions to which workers are exposed; (3) instituting new procedures for USDA's meat and poultry inspection personnel to refer serious workplace hazards affecting plant employees to OSHA; and (4) coordinating possible inconsistencies between OSHA's job safety and health standards and USDA's sanitation and health standards.[39] Through the MOU, USDA inspectors are not expected to replace OSHA inspectors. With improved training and a clear referral system, USDA inspectors are to be able to recognize serious workplace hazards and report them to OSHA and to plant management.

OSHA could have more effective enforcement if USDA inspectors routinely alerted OSHA to potential safety hazards.

According to a 2005 GAO report, while OSHA has put together training materials for USDA inspectors, only one such training has occurred. The 2005 report revealed that over an 11-year period since the MOU was signed, USDA inspectors made 31 referrals to OSHA, 26 of which resulted in an OSHA inspection.[3] However, 31 referrals in hundreds of facilities where inspectors are often present each and every day indicates an underutilized system of coordination.

The GAO report revealed that USDA officials cited three primary reasons for the failure of the referral system: (1) workplace hazards are not the focus of their inspections; (2) inspectors often deal with hazards by working directly with plant management; and (3) USDA inspectors don't want to be a part of any resulting inspection—which might put them at risk of being cited for violations, such as not wearing their personal protective equipment.[3]

OSHA could accomplish more effective enforcement of critical safety and health standards with more routine USDA signaling of the need for inspections. It's clear that better coordination between these two federal agencies is still badly needed and represents a major opportunity.

Improving prevention: new approaches beyond enforcement are needed

As the current OSHA administrator David Michaels has described, enforcing compliance with OSHA regulations is intended to have a strong preventive purpose. "The credible threat of enforcement makes most employers think twice about cutting back on preventive maintenance, training or investments in safer working conditions. The fear of a serious citation and heavy fine should make employers consider the consequences of cutting corners on safety to meet a deadline. And the threat of strong enforcement can encourage employers to seek out a safety consultant or use the free services of our On-Site Consultation Program."[40]

While employers are required to comply with OSHA rules, they do not have to demonstrate compliance unless they are inspected. In 2009, OSHA inspected 97 poultry plants and 139 meatpacking plants. These inspection rates correspond roughly to inspecting one out of six poultry plants and one out of eleven meatpacking plants.[c,41,42]

c *Rates derived from OSHA inspection data and US Census county business pattern data for NAICS codes 311611 and 311615.*

Limited resources are an endemic problem confronting OSHA's system of enforcement. Among the criteria OSHA uses to identify high-priority plants for the limited number of inspections it can conduct each year are high rates of injury and illness and the severity of injuries or illnesses. Yet, just as in 1987, it is still difficult for OSHA to rely on the available data to set these priorities because of their questionable reliability.[3,43]

Underreporting of injury and illness data: a continued problem

From 1991 to 2001 the reported injury and illness rates in the meat and poultry slaughter and processing industry fell by 50 percent.[44] More recent trends from 2003 through 2009 also show steady declines (see Figure 1). In 2009, non-fatal injury or illnesses impacted roughly one in 14 workers in the meat and poultry slaughter and processing industries (6.9 percent[d]).[7] While lower than in years prior, this injury and illness rate is still 60 percent higher than that for all manufacturing industries combined.[7] In addition, 2009 Bureau of Labor Statistics (BLS) data reveal that the slaughtering and processing of meat (excluding poultry) had the highest incidence rate of severe cases—those that resulted in days away from work, restricted work activity, or job transfer.[45,e]

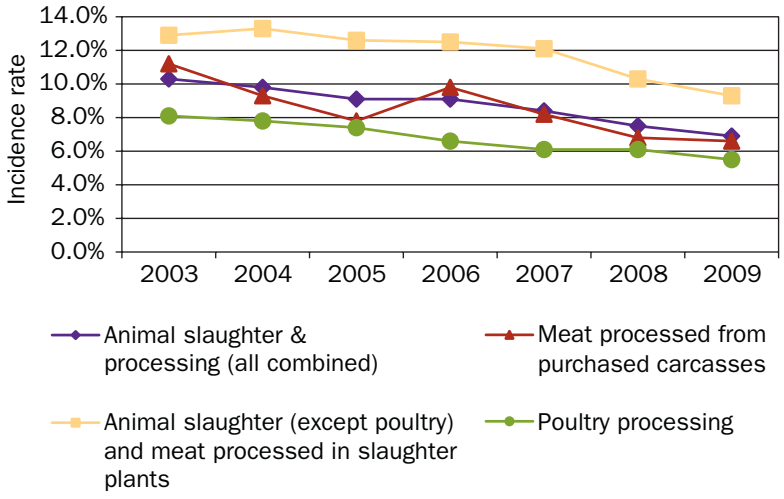
Industry representatives describe the trends of declining workplace injury and illness rates as evidence that their operations are safer for workers.[44] It is likely that plants which have successfully instituted voluntary multi-faceted ergonomic programs have experienced improvements in some areas. Yet, just as Congressional hearings in 1987 revealed underreporting of injuries and illnesses, today's investigators find evidence of similar problems.

Investigative journalists from *The Charlotte Observer* reported in 2008 that while the House of Raeford's poultry slaughter and processing plant in Greenville, South Carolina, claimed a five-year safety streak with no lost-time accidents, multiple cases were identified in which injured workers were brought back to work hours after surgery, or supervisors and/or plant nursing staff dismissed employees' requests to see physicians when their pain became too much to bear.[46] By getting workers back to work even though they are still injured and in pain, an installation the size of the Greenville plant can save hundreds of thousands of dollars in workers' compensations costs.[47] In addition, the plant is more likely to avoid an OSHA inspection because with no lost-time accidents it appears as though injuries are of the less severe variety.

In another House of Raeford plant in West Columbia, South Carolina, the company reported zero MSDs from July 2003 to April 2007. However, journalists from *The Charlotte Observer* found 12 employees who worked at the plant during the same time who said they suffered pain brought on by MSDs; indeed, two of them reported having surgery for carpal tunnel syndrome at company expense.[46] This company reports some of the industry's lowest illness rates and thus as of 2008 was rarely inspected by OSHA.[46]

While company officials dispute allegations of underreporting or mistreating ill or injured workers, a 2009 GAO report substantiates concern for the underreporting of work-related injuries and illnesses in meat and poultry industries.[43] The report stated that many employers did not

FIGURE 1
Reported rates of nonfatal occupational injuries and illness in meat and poultry slaughter and processing industries, 2003–2009.



Source: Bureau of Labor Statistics, Table 1—Incidence Rates—Detailed Industry Level, 2003–2009. Available at: http://www.bls.gov/iif/oshsum.htm. Accessed: October 29, 2010.

d NAICS code 31161 (animal slaughtering and processing).

e NAICS code 311611 (animal (except poultry) slaughtering).

Safe working conditions and a safe food supply both require that workers have a voice in controlling hazards.

report workplace injuries and illnesses for fear of increasing their workers' compensation costs or hurting their chances of winning contracts. The report also revealed that workers stated they did not report job-related injures for fear of being fired or disciplined, or for fear of jeopardizing rewards based on having low injury and illness rates.

UFCW recently compared injury and illness data among its unionized meat and poultry plants to BLS data overall and showed that rates among unionized plants were consistently higher.[26] These data support what the GAO report and other health and safety experts contend: when workers are less fearful about employer retaliation if they report their workplace injury or illness, they are more likely to report.

Yet OSHA's own recordkeeping policies are also part of the problem of underreporting. In January 2002, OSHA's revised injury and illness recordkeeping rule went into effect.[48] This new rule changed definitions and recording criteria. While these changes are nuanced and subtle, they greatly affected how data are collected and how trends are interpreted—data after 2002 are not comparable to data from earlier periods.[12,48-51] For example, the column for recording "repeated trauma" was deleted from the workplace injury and illness log. While the original revised recordkeeping rule contained a section that added a specific illness column for MSDs, it never became effective and in 2003 the MSD column was officially eliminated.[52]

While reporting of MSDs is still required, there are no specialized recording criteria for these conditions, and thus enumerating the extent and nature of specific MSDs is impaired.[48] In addition, exacerbation of a preexisting MSD may go unrecorded given how the revised recordkeeping rule defines a new case.[49] OSHA's summary of the new rules specifies that "aggravation of a cause where signs or symptoms have not resolved is a continuation of the original case" and therefore not considered recordable.[49,53] OSHA's recordkeeping handbook further explains, "If the worker has not fully recovered and no new event or exposure has occurred in the workplace, the case is considered a continuation of the previous injury or illness and is not recordable."[48]

Therefore, if a poultry worker's pre-existing work-related tendinitis is once again exacerbated, it's likely that such a case will go unrecorded—a result easily justified under OSHA's own rule. Researchers as well as OSHA officials have reported that such recordkeeping changes have only contributed to the apparent downward trend of injury and illness rates.[12,49,50]

Recordkeeping policies: is change on the horizon?

Changes to enforce accurate injury and illness reporting may be on the horizon. Academic researchers have estimated that the magnitude of the underreporting across all industries may be extensive.[54-57] For example, one study that surveyed data from six states revealed that the BLS injury and illness statistics missed almost 340,000 lost-time

injuries during the years 1998-2002 and at a minimum, the reported statistics missed 24 percent of injury cases.[55] As a result of these academic studies and the investigative journalism of *The Charlotte Observer*, a GAO investigation was launched and legislative hearings on the underreporting of workplace injuries and illnesses were held.[46,58,43] Congress has subsequently directed OSHA to begin an enforcement initiative on recordkeeping.

Effective February 19, 2010, OSHA launched its Recordkeeping National Emphasis Program.[59] The aim of the program is to ascertain whether, and to what extent, employers are underrecording workplace injuries and illnesses. Meatpacking and poultry processing industries are targeted for this initiative. The program will also assess injury and illness among cleaning and sanitation workers—who are not employed directly by the plants in most cases—an issue that the GAO's 2005 report stated was a key contributor to the problem of incomplete data. Special procedures for assessing the scope of musculoskeletal disorders will be included.

In addition to its Recordkeeping National Emphasis Program, OSHA also held hearings in 2010 to discuss its proposed revisions to illness and injury reporting requirements. As proposed, MSDs will once again be specified on the work-related injuries and illness form and the total number of MSDs each year will be summarized.

Without accurate surveillance data, OSHA is unable to evaluate whether its hazard prevention policies and programs are being effective. While OSHA's new focus on improving recordkeeping is a step in the right direction, it is too soon to tell whether new actions will be taken or new policies will be issued to redress underreporting. Yet OSHA's enhanced actions are serving to put employers on notice to a degree not seen for over a decade.[26]

Fines for violations: signs of improvement?

If OSHA's deterrence-based system of levying penalties on non-compliant employers is to operate effectively, the economic consequences of violations must be considerably higher than the costs of avoiding compliance in the first place. Yet the OSHAct itself limits the size of fines the agency can impose. For "serious" violations, there is a $7,000 maximum. If OSHA can determine that a company's violation is "willful," far stiffer fines can be levied, up to $70,000 per violation. Penalties can be reduced based on the discretion of OSHA officials and Department of Labor attorneys after informal discussions with companies or if the cited employer challenges the citation and enters into settlement negotiations with the agency. More often than not, OSHA chooses to settle cases because it lacks the resources to litigate.[60]

Without accurate surveillance data, OSHA is unable to evaluate whether its hazard prevention policies and programs are being effective.

As reported by the investigative journalism team at *The Charlotte Observer*, from 1997 to 2007 roughly three-quarters of OSHA fines against poultry companies were lowered or eliminated. For example, in 2001, OSHA inspections at Tyson Foods in Wilkesboro, North Carolina, found more than 30 violations that involved hazards that could result in amputations, factures, or falls. The $13,000 proposed fine was dropped to less than $1,800. When *The Charlotte Observer* examined this issue further in its 2008 series, the average starting fine to the poultry industry was roughly $2,300 and fines were reduced to an average level of $1,100. The problem with such minimal fines is the perverse message they send to employers: the financial cost of ignoring the law is much lower than assuring compliance with OSHA standards.[60]

Yet very recently, there are signs that OSHA may be moving towards higher penalties and more frequent use of findings of "willful" violations. In 2010, OSHA levied its highest-ever fine on a poultry plant run by Allen Family Foods in Maryland. The $1.03 million fine was issued based on 51 violations, 15 of which were considered "willful." Also in 2010, OSHA fined the Wisconsin-based meatpacking company VPP Group LLC $369,500 for 38 violations, four of which were considered "willful." Time will tell whether these fines will have a ripple effect on the industry as a whole of making the cost of hazard prevention lower than the cost of noncompliance.

LESSONS LEARNED

There remains a significant gap between the frightening evidence of injury and illness revealed by academic researchers, journalists, labor and human rights organizations, on the one hand, and the unreliable official injury and illness statistics on the other. Questionable surveillance data cannot serve the purpose of effectively targeting limited resources to remedy workplace safety and health hazards. While OSHA's Recordkeeping National Emphasis Program and its efforts to include MSDs on workplace injury and illness log forms are important recent advances, it is unlikely that our existing illness and injury reporting system can completely capture the true injury and illness experience of workers without a major overhaul.

Second, OSHA's enforcement system will never have the resources necessary to reach all establishments. Thus, the recent trend towards increased fines for violations is crucial for OSHA's deterrence-based system of compliance to operate effectively. In addition, the MOU between USDA and OSHA, last revised in 1991, provides great potential to tap the presence of USDA inspectors to enhance protections in the meat and poultry slaughter and processing industries. Yet over the last 20 years, results from this interagency agreement are meager and warrant reexamination.

Third, real improvements in the health and safety of meat and poultry slaughter and processing workers can be realized only when the unequal power dynamics on the plant floor are remedied. Workers' lack of job control and fear of job loss, especially among immigrant workers, are easily exploitable circumstances. New procedures and practices are needed to improve the capacity of workers to identify, report, and prevent workplace hazards.

OSHA has taken preliminary steps towards rulemaking efforts requiring a workplace safety and health prevention program, the Injury and Illness Prevention Program (I2P2), which has real potential for protecting all workers, including those that are most vulnerable. Yet where there are serious imbalances of power between managers and workers—such as in some meatpacking and poultry processing facilities and especially among non-unionized plants—simply establishing a pro forma workplace health and safety committee or a worker complaint system may not be enough to guarantee real employee empowerment and real protections. Therefore, another critical component of addressing these power imbalances to establish safer conditions lies in workers' right to organize unions, effective union representation, and workers' centers.

Lastly, the disconnect between the health of meat and poultry slaughter and processing workers and the safety of the meat landing on the public's table must be addressed. In the absence of an OSHA ergonomics standard, OSHA or its research partner, the National Institute for Occupational Health and Safety (NIOSH) should have more influence in the evolution of food safety decisions by USDA that are having an impact on workers, such as limits on line speed.

Through OSHA as well, speed of work should be specifically addressed, slowed, and regulated. Protection of workers in the meat and poultry slaughter and processing industries requires slowing down production—as well as improving the capacity of workers to be active participants in comprehensive workplace health and safety processes to address workplace dangers, when they arise. In order to protect workers where health and safety interventions such as slowing line speed may impact productivity and profits, increased regulation may be the only way to level the playing field and ensure that all establishments operate similarly and safely for both workers and consumers.

Only when we embrace the notion that healthy food comes from healthy workers will we achieve a safer, healthier food system.

Only when we embrace the notion that healthy food comes from healthy workers will we achieve a safer, healthier food system.

CASE STUDY 6 — **TIMELINE**

YEAR	EVENT
1906	Upton Sinclair's novel *The Jungle* exposes worker health and food safety hazards in the meatpacking industry in Chicago.
1906	US government passes the Pure Food and Drug Act and the Meat Inspection Act—laws to safeguard the public from adulterated meat.
1943	US Department of Labor finds that injuries and accidents are causing absence from work in the meatpacking industry at a rate double the national average for manufacturing.
1943	Labor organizations secure their first national contracts.
1950s–1970s	Automation and mechanization transform most meat slaughter and processing plants.
1960s–1980s	Iowa Beef Processors, Inc. (IBP), begins a corporate transformation that changes the face of the entire industry. The meat slaughter and processing industry becomes consolidated. Plants move to more rural communities and the size of individual establishments dramatically increases.
Late 1980s	Union membership in meat slaughter and processing plants falls to 21 percent compared to an average membership rate of 46 percent during the 1970s and 1980s.
1987	Inspections by OSHA and a Congressional hearing find significant underreporting of workplace injuries and illness by IBP. Testimony by members of the UFCW reveals that original injury and illness logs during a three-month period in 1985 report 1,800 cases, yet only 160 were reported to OSHA. UFCW estimates that 70 percent of workers in this plant have symptoms consistent with MSDs. The company is fined $2.59 million.
1990	OSHA issues its ergonomic program management guidelines for the meatpacking industry.
1991	Injury and illness rate among meat slaughter and processing workers reaches 45.5 percent—a 40 percent increase compared to the 1981 rate. There is a five-fold increase in the illness rate in particular between 1981 and 1991.
1991	A fire claims the lives of 25 poultry plant workers, many of whom could not escape because the plant door was locked by the employer. USDA inspectors knew of the locked door, and this prompts a new MOU between OSHA and USDA to improve worker health and safety training among USDA inspectors and to establish a clear referral system to OSHA to follow up on specific concerns.
1996	USDA codifies the Pathogen Reduction Act and its Hazard Analysis and Critical Control Point (HACCP) system, allowing the majority of product safety inspections to be conducted by industry inspectors, rather than USDA.
2001	The US Government Accountability Office reviews a pilot HACCP system and finds that 60 percent of USDA inspectors and veterinarians surveyed by the GAO believe that line speed is too fast to ensure product safety.
2001	Congress and President George W. Bush repeal OSHA's ergonomic standard.
2001	Reported injury and illness rates for meat and poultry slaughter and processing workers fall by 50 percent between 1991 and 2001.
2002	OSHA implements revisions to its injury and illness recordkeeping rule.
2003	OSHA officially deletes the MSD column from its injury and illness reporting log.
2004	Human Rights Watch publishes an influential report, *Blood, Sweat, and Fear: Worker' Rights in U.S. Meat and Poultry Plants,* detailing conditions and vulnerabilities in meat and poultry industries that violate workplace health and safety regulations and principles of human rights.

YEAR	EVENT
2005	GAO issues a report on the meatpacking industry and finds that more effort is needed to protect the health of these workers and that true injury rates are likely higher than reported rates. The report finds that efforts are needed to improve the validity of injury and illness statistics.
2008	*The Charlotte Observer* publishes its series, "The Cruelest Cuts," detailing human rights and worker health and safety abuses in the poultry industry. The series, in combination with evidence from academic studies, prompts a GAO investigation and legislative hearing about underreporting of workplace injuries and illnesses—statistics that help to target OSHA's inspections.
2009	Nebraska Appleseed publishes its notable report, *The Speed Kills You,* which documents meat-packing safety and workplace conditions from the perspective of workers in one of the country's largest meat processing states.
2009	OSHA inspects roughly one in six poultry slaughter and processing plants and roughly one in 11 meat slaughter and processing plants.
2009	OSHA launches its Recordkeeping National Emphasis Program to improve the reporting of injury and illness. The meat and poultry slaughter and processing industry is a target for the program.
2010	OSHA holds hearings on the agency's proposal to reinstate MSDs on injury and illness log forms.
2010	OSHA's highest-ever fine to a poultry slaughter and processing plant for 51 violations, 15 of which were considered "willful," is issued for $1.03 million.

Acknowledgments

We wish to acknowledge several organizations for their substantial reporting on this topic, namely Human Rights Watch, Nebraska Appleseed Center for Law in the Public Interest, and *The Charlotte Observer*. We are also grateful to Darcy Tromanhauser and Norm Pflanz at Nebraska Appleseed as well as Jackie Nowell at the UFCW who spoke with us at length and reviewed this case study.

References

1. Human Rights Watch. *Blood, Sweat, and Fear: Workers' Rights in U.S. Meat and Poultry Plants*. 2004. Available at: *http://www.hrw.org/en/reports/2005/01/24/blood-sweat-and-fear*. Accessed: August 20, 2010.
2. Nebraska Appleseed. *"The Speed Kills You". The Voice of Nebraska's Meatpacking Workers*. October 2009. Available at: *http://www.neappleseed.org/docs/the_speed_kills_you_ne_appleseed_100709.pdf*. Accessed: August 20, 2010.
3. U.S. Government Accountability Office. *Workplace Safety and Health: Safety in the Meat and Poultry Industry, While Improving, Could be Further Strengthened*. Report No:GAO-05-96. January 2005. Available at: *http://www.gao.gov/products/GAO-05-96*. Accessed: August 20, 2010.
4. Sinclair U. *The Jungle*. New York, NY: Modern Library. 1906 (republished 2006). 116.
5. CC Gjessing, TF Schrenborn, A Cohen (Eds.). *Participatory Ergonomic Interventions in Meatpacking Plants*. Report No:94-124. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute of Occupational Health and Safety. 1994. Available at: *http://www.cdc.gov/niosh/94-124.html*. Accessed: September 20, 2010.
6. MacDonald JM, Ollinger ME, Nelson KE, et al. *Consolidation in U.S. Meatpacking*. Report No:AER785. U.S Department of Agriculture, Economic Research Service. March 1999. Available at: *http://www.ers.usda.gov/Publications/AER785/*. Accessed June 20, 2010.
7. Bureau of Labor Statistics. *Table 1—Incidence Rates of Nonfatal Injuries and Illnesses by Industry and Case Types, 2009*. 2010. Available at: *http://www.bls.gov/iif/oshwc/osh/os/ostb2435.pdf*. Accessed: October 29, 2010.
8. Sinclair U. *The Jungle*. New York, NY: Modern Library. 1906 (republished 2006).
9. Unti B. *The Jungle: Upton Sinclair's Roar is Even Louder to Animal Advocates Today*. March 10, 2006. Available at: *http://www.hsus.org/farm/news/ournews/the_jungle_roar.html*. Accessed: June 20, 2010.
10. Law MT. *History of Food and Drug Regulation in the United States*. February 4, 2004. Available at: *http://eh.net/encyclopedia/article/Law.Food.and.Drug.Regulation*. Accessed: June 20, 2010.
11. Sinclair U. *The Brass Check: A Study of American Journalism*. Long Beach, CA: (Originally published by the author). 1920. 47.
12. Horowitz R. "That was a dirty job!" Technology and workplace hazards in meatpacking over the long twentieth century. *Labor: Studies in Working-Class History of the Americas*. 2008;5(2):13-25.
13. Azzam AM, Anderson DG. *Assessing Competition in Meatpacking: Economic History, Theory and Evidence*. United States Department of Agriculture, Packers and Stockyards Program. May 1996. Available at: *http://archive.gipsa.usda.gov/pubs/packers/rr96-6.pdf*. Accessed: June 20, 2010.
14. United Food & Commercial Workers Union and world's largest hog slaughterhouse in North Carolina now getting along after long worker unionization campaign. *UFCW News*. August 24, 2010. Available at: *http://www.wnylabortoday.com/index.php?src=news&refno=1274&category=State-National%20Labor%20News*. Accessed October 15, 2010.
15. *Tyson Foods*. Available at: *http://en.wikipedia.org/wiki/Tyson_Foods*. Accessed: October 15, 2010.
16. Ordonez F, Hall K, Alexander A. A boss's view: keep them working. *Charlotte Observer*. February 12, 2008. Available at: *http://www.charlotteobserver.com/poultry/*. Accessed: August 20, 2010.
17. Grey MA. Immigrants, migration, and worker turnover at the Hog Pride pork packing plant. *Hum Organ*. 1999;58(1):16-27.
18. Personick ME, Taylor-Shirley K. Profiles in safety and health: occupational hazards of meatpacking. *Monthly Labor Review*. 1989;January:3-9.
19. Sheridan PJ. Meatpackers move to cut injury rates. *Occupational Hazards*. 1991;May:81-85.
20. U.S. House of Representatives, 100th Congress. *Underreporting of Occupational Injuries and Its Impact on Workers' Safety, Hearings Before a Subcommittee of the Committee on Government Operations*. 1987. p24.
21. U.S. House of Representatives, 100th Congress. *Underreporting of Occupational Injuries and Its Impact on Workers' Safety, Hearings Before a Subcommittee of the Committee on Government Operations*. 1987. p22.
22. U.S. House of Representatives, 100th Congress. *Underreporting of Occupational Injuries and Its Impact on Workers' Safety, Hearings Before a Subcommittee of the Committee on Government Operations*. 1987. p52.
23. U.S. House of Representatives, 100th Congress. *Underreporting of Occupational Injuries and Its Impact on Workers' Safety, Hearings Before a Subcommittee of the Committee on Government Operations*. 1987. p33.
24. U.S. House of Representatives, 100th Congress. *Underreporting of Occupational Injuries and Its Impact on Workers' Safety, Hearings Before a Subcommittee of the Committee on Government Operations*. 1987. p23.
25. Associated Press. U.S. fines meatpacker $3.1 million over injuries. *The New York Times*. May 12, 1988. Available at: *http://www.nytimes.com/1988/05/12/us/us-fines-meatpacker-3.1-million-over-injuries.html*. Accessed at: September 15, 2010.

26. Nowell J. Director of Safety and Health, United Food and Commercial Workers International Union. *Personal Communication.* October 29, 2010.
27. Lipscomb HJ, Epling CA, Pompeii LA, et al. Musculoskeletal symptoms among poultry processing workers and a community comparison group: Black women in low-wage jobs in the rural South. *Am J Ind Med.* 2007;50(5):327-38.
28. Occupational Safety and Health Administration. *Ergonomics Program Management Guidelines for Meatpacking Plants.* 1993 (reprint). Available at: *http://www.osha.gov/Publications/OSHA3123/3123.htm*. Accessed August 15, 2010.
29. Ordonez F. A Worker's Grueling Day. *Charlotte Observer*. February 13, 2008. Available at: *http://www.charlotteobserver.com/poultry/*. Accessed: August 20, 2010.
30. U.S. Department of Agriculture, Food Safety and Inspection Service. *Public health risk-based inspection system for processing and slaughter - technical report*. April 18, 2008. Available at: *http://www.fsis.usda.gov/OPPDE/NACMPI/Feb2008/Processing_Slaughter_Tech_Rpt_041808.pdf*. Accessed: September 1, 2010.
31. Surveillance for foodborne disease outbreaks—United States, 2007. *MMWR Morb Mortal Wkly Rep.*59(31):973-9.
32. Mead PS, Slutsker L, Dietz V, et al. Food-related illness and death in the United States. *Emerg Infect Dis.* 1999;5(5):607-25.
33. Flynn D. How goes peak E.coli season? *Food Safety News*. July 26, 2010. Available at: *http://www.foodsafetynews.com/2010/07/how-goes-the-e-coli-season/*. Accessed August 31, 2010.
34. Neuman W. Beef recall intensifies fight for tighter rules. *The New York Times*. September 2, 2010. Available at: *http://www.nytimes.com/2010/09/03/business/03beef.html*. Accessed September 8, 2010.
35. U.S. Government Accountability Office. *Food Safety. Weaknesses in Meat and Poultry Inspection Pilot Should be Addressed Before Implementation*. Report No:GAO-02-59. December 2001. Available at: *http://www.gao.gov/products/GAO-02-59*. Accessed: October 15, 2010.
36. Public Citizen. *USDA Tells Inspectors to Give Deference to Meat Companies, Stop Production Lines Only in Certain Circumstances*. October 2, 2002. Available at: *http://www.citizen.org/documents/fieldinstructions.pdf*. September 1, 2010.
37. Eggen D. Obama Targets Food Safety. President Announces New Leaders, Group to Upgrade Laws. *The Washington Post*. March 15, 2009 Available at: *http://www.washingtonpost.com/wp-dyn/content/article/2009/03/14/AR2009031401600.html*. Accessed: September 15, 2010.
38. Associated Press. Food plant fire kills 25; exits blocked; disaster: chicken workers in North Carolina are trapped in a facility that had never been inspected for safety. Another 40 workers hurt. *Los Angeles Times*. September 4, 1991. p. A4.
39. *Memorandum of Understanding between The U.S. Department of Labor, Occupational Safety and Health Administration and The U.S. Department of Agriculture, Food Safety and Inspection Service*. 1994. Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=MOU&p_id=262*. Accessed: September 2, 2010.
40. Michaels D. *Remarks to the American Bar Association, Occupational Safety and Health Law Committee, Coronado California.* March 10, 2010.Available at: *http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2137*. Accessed: September 15, 2010.
41. U.S. Census Bureau. *County Business Patterns* 2010. Available at: *http://www.census.gov/econ/cbp/index.html*. Accessed September 15, 2010.
42. U.S. Department of Labor, Occupational Safety and Health Administration. *Inspection Data*. 2010. Available at: *http://www.osha.gov/pls/imis/industry.html*. Accessed September 10, 2010.
43. U.S. Government Accountability Office. *Workplace Safety and Health: Enhancing OSHA's Records Audit Process Could Improve The Accuracy of Worker Injury and Illness Data*. Report No:GAO-10-10. October 15, 2009. Available at: *http://www.gao.gov/products/GAO-10-10*. Accessed September 15, 2010.
44. American Meat Institute. *AMI Fact Sheet: Worker Safety in the Meat and Poultry Industry*. February 2009. Available at: *http://www.meatami.com/ht/a/GetDocumentAction/i/47110*. Accessed: September 15, 2010.
45. Bureau of Labor Statistics. *Table SNR02: Highest Incidence Rates of Nonfatal Occupational Injury and Illness Cases with Days Away from Work, Restricted Work Activity, or Job Transfer, 2009*. 2010. Available at: *http://www.bls.gov/iif/oshwc/osh/os/ostb2424.pdf*. Accessed: October 29, 2010.
46. Hall K, Alexander A, Ordonez F. The cruelest cuts. The human cost of bringing poultry to your table. *The Charlotte Observer*. February 10, 2008. Available at: *http://www.charlotteobserver.com/poultry/*. Accessed: July 22, 2010.
47. Hall K, Ordonez F, Alexander A. Pain behind safety streak. *Charlotte Observer*. February 15, 2008. Available at: *http://www.charlotteobserver.com/poultry/*. Accessed: September 15, 2010.
48. Occupational Health and Safety Administration. *OSHA Recordkeeping Handbook*. 2005. Available at: *http://www.osha.gov/recordkeeping/handbook/index.html#1904.12*. Accessed: October 15, 2010.
49. Friedman LS, Forst L. The impact of OSHA recordkeeping regulation changes on occupational injury and illness trends in the US: a time-series analysis. *Occup Environ Med.* 2007;64(7):454-60.
50. Whitmore B. OSHA recordkeeping: "how we got to this point". *New Solut.* 2008;18(4):493-7.
51. U.S. Department of Labor, Bureau of Labor Statistics. *Recordkeeping Changes Affect the Occupational Injury and Illness Data*. Available at: *http://www.bls.gov/iif/osh_notice01.htm*. Accessed: September 10, 2010.
52. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational Injury and Illness Recording and Reporting Requirements. *Federal Register*. June 30, 2003;68:38601-38605.
53. U.S. Department of Labor, Occupational Safety and Health Administration. Available at: *http://www.osha.gov/recordkeeping/RKside-by-side.html*. Accessed September 15, 2010.
54. Rosenman KD, Kalush A, Reilly MJ, et al. How much work-related injury and illness is missed by the current national surveillance system? *J Occup Environ Med.* 2006;48(4):357-65.
55. Boden LI, Ozonoff A. Capture-recapture estimates of nonfatal workplace injuries and illnesses. *Ann Epidemiol.* 2008;18(6):500-6.

56. Smith GS, Wellman HM, Sorock GS, et al. Injuries at work in the US adult population: contributions to the total injury burden. *Am J Public Health.* 2005;95(7):1213-9.
57. Leigh JP, Marcin JP, Miller TR. An estimate of the U.S. Government's undercount of nonfatal occupational injuries. *J Occup Environ Med.* 2004;46(1):10-8.
58. U.S. House of Representatives. *Hidden Tragedy: Underreporting of Workplace Injuries and Illness. A Majority Staff Report by the Committee on Education and Labor*. June 2008. Available at: *http://edlabor.house.gov/publications/20080619WorkplaceInjuriesReport.pdf*. Accessed September 15, 2010.
59. U.S. Department of Labor, Occupational Safety and Health Administration. *OSHA Notice – Injury and Illness Recordkeeping National Emphasis Program (RK NEP)*. February 19, 2010. Available at: *http://www.osha.gov/OshDoc/Directive_pdf/CPL_02_10-02.pdf*. Accessed: September 30, 2010.
60. McGarity T, Steinzor R, Shapiro S, et al. *Workers at Risk: Regulatory Dysfunction at OSHA*. Center for Progressive Regulation. February 2010. Available at: *http://www.progressivereform.org/articles/OSHA_1003.pdf*. Accessed: August 20, 2010.


naturipe
naturipe

CONCLUSIONS

Synthesis and Recommendations

APRIL 5, 2010

Explosion at Upper Branch Mine in West Virginia kills 29 coal miners

APRIL 20, 2010

Eleven men dead on Deep Horizon BP oil rig in Gulf of Mexico

JULY 14, 2010

Oven at U.S. Steel plant near Pittsburgh explodes, injuring 15 workers, at least two critically

THE SUFFERING OF WORKERS SEEMS to be front-page news nearly every day. Yet for all the disasters that appear in the headlines, far more workers die or are injured without making the headlines. And these incidents not only affect the injured workers, but greatly impact their families and communities. Every day, fourteen workers die, and each year, more than 4 million are seriously injured or are sickened by exposure to toxic agents.[1] Real change to the nation's approach to workplace safety and health is desperately needed.

But what kinds of changes? There is a risk that the eagerness to fix ineffective worker safety and health protections will lead to quick, reactive efforts to undo the failings of earlier administrations, without sufficient thought about the deeper limitations of the regulatory approach that was developed in the late 1960s and is still largely intact.

The quick response approach has three potential pitfalls: (1) it precludes broader system-level changes to occupational and environmental health; (2) it inhibits broad coalition-building that could reduce the compartmentalization of worker health, consumer health, and environmental health; and (3) it could inadvertently shift risks from one sector of society to another in the search for a solution to a problem too narrowly defined.

To fully understand the limits of our current federal worker safety and health policies and identify long-term solutions that are both viable and effective, we must step back and view broadly the systems of production within which work environments function. More inspections and more standards alone will not cure structural flaws in occupational safety and health regulations in the United States. In addition, agencies other than the Occupational Safety and Health Administration (OSHA) are also responsible for worker protections—for example, the Mine Safety and Health Administration, in the case of mine workers, and the Environmental Protection Agency (EPA) in the case of farm workers exposed to pesticides.

Our research has led to the conclusion that the most effective reforms will come through preventive redesign of workplaces, work processes, and products and not simply tighter regulation of the current way of doing business. Further, reforms to OSHA regulations need to be coupled with a new research agenda—through the National Institute for Occupational Safety and Health (NIOSH) and other science agencies—focused on more prevention-oriented research. To begin to move this process forward, we undertook the task of researching and writing a set of stories demonstrating why

and how our occupational safety and health systems are broken and identifying lessons learned that we hope can provide insights on how to fix those systems.

Six case studies: revealing where we went wrong in our systems to protect workers

The Lowell Center for Sustainable Production at the University of Massachusetts Lowell sought to use the rich history of actions and inactions regarding selected workplace safety and health policies and practices in the United States to reveal compelling evidence for national policy reforms that will lead to stronger, more effective, prevention-focused worker safety and health protections. The resulting six case studies illustrate a range of current failures in our approach to workplace safety and health.

Floor finishers, lacquer sealers and fires: safer product alternatives are the solution.

Three Vietnamese floor finishers were killed in two separate fires in Massachusetts in 2004–2005. In each case, highly flammable lacquer sealer vapors ignited and flashed almost instantly across a newly varnished floor, causing a deadly inferno. Fatal fires like these, as well as less dramatic but also serious neurological damage and other adverse health effects from floor finishing chemicals, illustrate the dangers faced by small entrepreneurial businesses staffed by immigrant laborers. Despite the challenges to creating protections for these workers, this case study has a hopeful ending. It demonstrates the power of connecting the health struggles of immigrant workers with community organizing efforts that resulted in landmark legislation in Massachusetts prohibiting highly flammable floor finishing chemicals. The story shows how grassroots organizing can lead to practices that protect workers—in this case, replacing dangerous products with safer alternatives.

© 2010 Earl Dotter

When my job breaks my back: shouldering the burden of work-related musculoskeletal disorders.

Work-related musculoskeletal disorders are a serious public health concern. Our case study on back injuries and other musculoskeletal disorders among health care workers, hotel housekeepers, and poultry processing workers illustrates how badly ergonomic injuries can disable us and affect our everyday well-being both at work and outside our work. Despite overwhelming scientific evidence on the risks and the economic costs of failure to control ergonomic hazards, OSHA was prevented from mandating comprehensive solutions. In the first months of 2001, OSHA's Ergonomics Standard was repealed with the first use and thus far the only use of the Congressional Review Act—a move made possible by a Republican Congress and the newly elected President George W. Bush. Yet a decade later, musculoskeletal disorders remain one of the leading causes of lost work time and an extremely burdensome "cost of doing business" with impacts felt throughout the economy and the health care system.

Successful initiatives in several states are highlighting at least one way forward: programs that focus first on reducing injuries in high-risk tasks such as manual patient handling and transfer in the health care and social assistance sectors, and then on tackling particularly hazardous occupations, and finally entire industries. Further, occupational safety and health management systems based on real worker participation and leadership commitment will help address ergonomic risks in those industries where the burden is heaviest.

The poison that smells like butter: diacetyl and popcorn workers' lung disease.

In 2000, a cluster of disabling and potentially fatal lung disease among workers was identified in a microwave popcorn plant in Jasper, Missouri. A few years later, additional cases were identified among workers exposed to butter flavoring chemicals while working at their food flavoring manufacturing jobs. This shocking case study raises a troubling question: how could a chemical that can destroy a worker's lungs in just a few months evade our system of chemical regulation? Workers were once again the "canary in the coal mine" for the general public whose lungs are also being damaged by the artificial butter flavoring chemical, diacetyl.

This case points out the challenges of chemical-by-chemical regulation spanning multiple agency jurisdictions, and highlights the essential role played by occupational and environmental health specialists on the front lines, detecting and minimizing harm to workers. It also illustrates the need for national comprehensive chemicals policy reform leading to safer chemicals and ensuring that risks are not transferred among workers, communities, and the environment.

Injuries are not accidents: construction will be safe when it's designed to be safe.

Every day in the United States, approximately three workers die in construction accidents.[a] And for every worker who is killed, more than 100 more suffer injuries that result in lost work time, lost wages, and a drag on productivity.[b] Investigations of construction accidents invariably find a complicated web of causal factors involved in these tragic, yet avoidable events. To manage these complex occupational hazards and protect workers adequately, the construction sector needs a more comprehensive approach than mere compliance with government standards or the sporadic application of control measures following a serious accident.

a Based on the US Bureau of Labor Statistics' total fatality cases (975) in construction, in 2008.

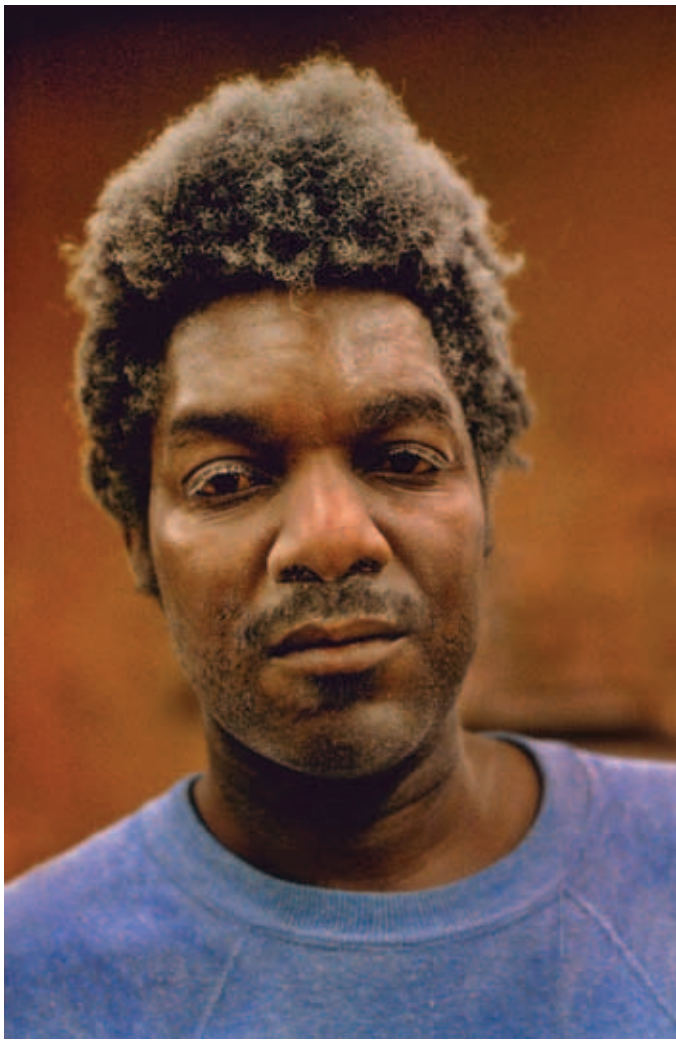
b Based on the US Bureau of Labor Statistics' total non-fatal cases (120,240) in construction, in 2008.

This case study shows the importance of implementing an occupational safety and health management system on the worksite. A commitment to a comprehensive occupational safety and health management system can break through bad habits, careless thinking, and the inertia that prevents managers and workers from making real changes in safety procedures. Further, this case study shows how vital training and community-based safety and health strategies are for the immigrant workers who are increasingly employed in this sector. Journalists have a role to play, too. When a workplace disaster happens, the reporting too often frames the problem as a tragic and inevitable accident rather than as the result of an avoidable failure in managing a dangerous human activity.[2] By redesigning workplaces to avoid hazards in the first place, we can use innovation and ingenuity to ensure workers are protected.

Regulating methylene chloride: a cautionary tale about setting health standards one chemical at a time.

OSHA's chemical-by-chemical risk-based standard setting process is so slow that years can go by between the time that it is clear that workers are being dangerously over exposed and the time that effective controls are put into place. The tortured path to OSHA's methylene chloride standard is a potent illustration of the limits of the current standard-setting process. The methylene chloride standard took more than a decade to establish. And, under the standard that was finally set, the legal exposure limit continues to allow workers to be exposed to this cancer-causing chemical at a level hundreds to thousands of times higher than is permitted for the general public.

By focusing the debate on the narrow question of exactly how risky a specific exposure level might be, OSHA and its risk-based standard setting process distracts attention from the more important question: do we need this chemical at all? Are there safer alternatives? In the case of methylene chloride, the risk debate allowed some employers to shift from methylene chloride to an untested, unregulated substitute chemical—1-bromopropane—which turned out to be a neurotoxicant, a reproductive toxicant, and possibly a more potent carcinogen than methylene chloride.



Safe food from safe workplaces: protecting meat and poultry processing workers.

Over a century ago, Upton Sinclair's novel *The Jungle* exposed the dehumanizing labor conditions and unsanitary environment of the meatpacking industry. Slaughtering and processing of meat and poultry for our food supply are inherently dangerous jobs. These hazards are well known and predictable, and solutions to preventing harms are feasible. Yet since Sinclair's time, rates of injuries and illnesses in the meatpacking industry have been notoriously high.

The long history of the meat and poultry slaughter and processing industry shows how solutions to protect the safety and health of workers cannot be addressed in isolation; eliminating hazards on the production line, providing dignity and job satisfaction to line workers, and ensuring a safe and ecologically sound food supply are all

components of the same food systems approach to this industry. The roadblocks to effective food safety practices and to healthy jobs are the same: workers with little control over their jobs on the plant floor, regulatory agencies with inadequate resources and powers, and the perverse economics of our industrial meat and food production system in which narrow profit margins drive business decisions with insufficient commitment to either working conditions or food quality.

From individual tragedy to broad understanding: some lessons learned

As we dissected these stories, each with its own long history of problem identification, scientific evidence, policy prescriptions, and often frustrating delays and setbacks, we saw some common themes. These lessons learned should lead to solutions, to fresh approaches, and to new commitments.

Important lessons for preventing workplace injury and illness:

- Both employers and employees have essential roles in making workplaces healthy.
- Clear and comprehensive laws and regulations are critical elements of worker health protections, but can be more effective when combined with other strategies such as incentives to innovate with inherently safe technologies, and campaigns that link improvement in worker health to goals like environmental protection and energy efficiency.
- Adequate resources are needed to ensure the deterrent effect of enforcement, but there is also a clear need for sufficient technical resources to help firms more effectively protect workers and communities, as well as resources to promote research and application of safer production systems and products.
- It is impractical to rely solely on federal inspectors, working to ensure compliance with hundreds of specific rules, as the primary solution to our occupational health crisis: this approach is either too expensive (if enough inspectors could be hired) or ineffective (with the current numbers of inspectors).
- Workplace health and safety and environmental protection should be viewed as two aspects of the design of sustainable systems of production. Economically, this can create efficiencies, and politically, it can help forge alliances among traditionally contentious interests.
- Globalization has not only sent many hazardous jobs overseas, it has also led to the concentration of marginalized immigrant workers in those dangerous and exhausting jobs that remain in the United States. Immigrant rights and occupational health are increasingly linked.
- Occupational and environmental health policies that focus upstream—on prevention at the source of the hazards—are not only feasible, but also protect workers' health and save money for companies and government agencies.

> ***"The whole system is clogged up like I-15. There are traffic jams, so that makes you less productive and makes you nervous. Then you hurry up because you're trying to be a productive employee. Just like how when you speed on a freeway you have less time to react, when you hurry on the job you have less time to correct that mistake."***
>
> *— An iron worker employed on one of the two major construction projects in Las Vegas where nearly a dozen construction workers died in a period of less than 17 months*

Solutions: promising directions to improve worker safety and health

We have identified seven high-priority strategies that could have important impacts on making workplaces safer. The first three are policy changes within the traditional boundaries of OSHA's activities, while the remaining four involve changes in other agencies and organizations.

1. Establish a Workplace Safety and Health Program Rule that emphasizes injury and illness primary prevention and worker participation.

Several of the case studies concluded that a key solution for preventing injury and illnesses is to improve the capacity of both employees and employers to identify and prevent workplace hazards. In response to nearly a dozen fatalities on a job site in Las Vegas, one iron worker for example identifies factors contributing to the accidents, "The whole system is clogged up like I-15. There are traffic jams, so that makes you less productive and makes you nervous. Then you hurry up because you're trying to be a productive employee. Just like how when you speed on a freeway you have less time to react, when you hurry on the job you have less time to correct that mistake."[3]

OSHA could issue a rule similar to those already in place in states such as California, requiring each employer to develop, implement and continuously evaluate a workplace safety and health prevention program. This standard has the potential to comprehensively address a range of hazards present in workplaces without establishing specific rules for each. Each employer's plan would include a set of core practices fundamental to worker safety and health to fill significant gaps in hazard prevention. These core practices—with measurable performance targets—include:

- procedures for management commitment and employee involvement (and also community involvement, where applicable) in all facets of planning, implementing, evaluating, and decision-making about the program;
- clear requirements for worksite analysis to identify and assess all hazards and their root causes;
- hazard prevention and control, including requirements to evaluate hazards and assess safer alternatives;
- requirements for employee, manager, and supervisor safety and health education and training and
- requirements for medical surveillance.

Workplace safety and health prevention plans should include subcontractors' employees, who often make up a significant fraction of the workers in an establishment.

In May 2010, OSHA took preliminary steps towards rulemaking efforts requiring workplace safety and health prevention programs, the Injury and Illness Prevention Program (I2P2). This appears to be a promising prevention-oriented policy solution to better protect workers.

2. Revamp OSHA's enforcement system by leveraging existing agency inspectional systems, as well as cross-training of inspectors, to support greater regulatory compliance by employers.

Establishing a workplace safety and health program could fill an important gap in motivating and maintaining healthy and safe workplaces, as it is clear that the threat of inspections and fines alone is simply inadequate. Yet enforcement re-

mains an important element of workplace protections. While OSHA has prioritized enhancing its enforcement efforts by hiring new compliance officers to inspect more facilities, and also by changing how penalties are calculated to increase employer fines where appropriate, there are still too many workplaces for any realistic inspection force to cover.

However, enforcement can be enhanced by leveraging the capacity and the presence of other public and private public health auditing and/or inspectional services. Whether it's the US Department of Agriculture's (USDA) Food Safety and Inspection Service inspectors in the case of meat and poultry facilities, the Joint Commission on Accreditation of Healthcare Organizations' (Joint Commission) surveyors in the case of health care facilities, or the EPA Risk Management Program auditors in the case of establishments that have large volumes of toxic chemicals on site, the presence of services like these in a broad range of other agencies provides an opportunity to integrate occupational health into existing activities with a public health focus.

Many workplaces targeted by current environmental/public health inspectional and auditing programs are reached only infrequently by OSHA. Thus, leveraging the capacity of existing inspectional and auditing programs provides the opportunity for OSHA to ensure that more facilities are complying with its regulations. As the USDA's, the Joint Commission's and EPA's inspectors, surveyors, and auditors are already skilled in public health protections, probably only minor cross-training on issues specific to occupational health is needed to allow these programs to serve as additional sets of eyes for OSHA. Further, a more coordinated approach that engages teams of inspectors, or calls for whole-facility multi-media inspections, would help ensure that hazards are not shifted from inside the plant to outside and could focus on facility-level prevention opportunities. Finally, many states have pollution prevention and manufacturing extension offices that could provide engineering support for workplace and facility design in the course of inspections.

While only OSHA has the jurisdiction to issue citations for violations, these additional inspectional/auditing services can serve as important referral sources for OSHA inspections. The USDA already has a memorandum of understanding (MOU) with OSHA to carry out these services.[4] Yet more effort is needed to realize the potential of this MOU and to establish similar MOUs with other public and private agencies.

© 2010 Earl Dotter

3. Expand occupational safety and health surveillance and enable rapid interventions when hazards are detected.

Accurate, comprehensive, and informative surveillance data are essential for ensuring that resources to protect the safety and health of workers are targeting the most at-risk workers and for evaluating whether hazard prevention policies and programs are effective. As discussed in the majority of case studies, statistics on injuries and illness collected by the Bureau of Labor Statistics (BLS) woefully undercount injuries and illnesses that are occurring in workplaces.[5,6]

OSHA is currently pursuing two important efforts to improve surveillance data: (1) its Recordkeeping National Emphasis Program will presumably help rectify deliberate underreporting by certain employers; and (2) current efforts to include musculoskeletal disorders as a reportable illness category will help reveal the true extent of these injuries. Yet beyond these activities, major surveillance gaps will still remain—gaps that severely impede not only OSHA's regulatory enforcement

"I played by the rules. I worked to support my family. This unregulated industry virtually destroyed my life. Don't let it destroy the lives of others. These chemicals that are used on food in large scale production must be tested and proper instructions and labeling supplied with their sale."

— Eric Peoples, microwave popcorn plant worker who was diagnosed with a form of fixed, obstructive lung disease resulting from workplace exposure to artificial butter flavoring chemicals

and compliance assistance activities, but also non-regulatory hazard and disease prevention efforts by NIOSH and state occupational health programs. BLS data should be supplemented by new annual national surveillance surveys or similar tools to capture data that current BLS surveillance tools were not designed to collect. Additional surveillance data collection efforts should include illnesses with long latencies such as cancer, additional injury and illness types not specified on data collection forms used by BLS (OSHA 300 logs), and the experience of workers employed by some small businesses.

Also of crucial importance is the need to expand the capacity of state and federal occupational health programs to intervene rapidly to prevent additional cases of injury or illness when hazards are identified. According to a survey by the Council of State and Territorial Epidemiologists, 34 of 50 US states have minimal to no surveillance or epidemiology capacity in occupational health.[7] And those that have the staff capacity have neither the real-time injury or illness data nor hazard surveillance tools to support occupational health officials in meeting their responsibility to identify and warn workers who are at risk, or to identify early-stage cases of disease.

Hazard surveillance tools should include a central repository of chemical use information. This need was clearly revealed in the diacetyl case study: the California Department of Health Services' Hazard Evaluation System and Information Services (HESIS) unit could not appropriately warn workers of hazards associated with diacetyl, as it had no way of finding out which workplaces used butter flavorings.[8]

4. Implement comprehensive chemicals policy reform, including both occupational and environmental hazards.

At present, the United States has roughly 15 federal agencies and many more state agencies responsible for chemicals management. As seen in the popcorn workers' lung and methylene chloride case studies, this disjointed collection of overlapping jurisdictions for managing chemicals—a system that tends to treat chemical hazards as "safe until proven hazardous"—is harming workers. This harm was poignantly described by Eric Peoples, a popcorn plant worker, "I played by the rules. I worked to support my family. This unregulated industry virtually destroyed my life. Don't let it destroy the lives of others. These chemicals that are used on food in large scale production must be tested and proper instructions and labeling supplied with their sale."[9] Nor is our chemicals management system protecting the general public or the environment.

A comprehensive approach to regulating workers' exposure to chemicals needs to move beyond OSHA's risk-based health standards—a substance-by-substance process that every OSHA administrator has recognized cannot keep pace with the rapid pace of technological change in the American workplace. Moreover, the risk of unintended consequences of regulating one chemical at a time was clearly revealed in the methylene chloride case study—some employers responded to the methylene chloride standard by switching to 1-bromopropane, an unregulated chemical that testing has now revealed may be four times more potent in causing cancer than methylene chloride.[10]

An important model for the chemicals management system needed in the United States is the European Union's policy called REACH—**R**egistration, **E**valuation, and **A**uthorization of **Ch**emicals. This policy requires that manufacturers and importers of chemicals assess chemical hazards, communicate these hazards through supply chains, and ensure safe use of chemicals rather than placing the burden on government to show that each substance is harmful before action can be taken to regulate it. Some key components are:

- Manufacturers must provide hazard, exposure, and use data on all chemicals, not only new ones, before they can be used in commerce.
- Companies have the responsibility to provide information on health and environmental effects of the chemicals they use.
- Hazard information must be communicated both up and down the supply chain.
- Substances of "very high concern" need explicit authorization for use, and a plan to substitute safer alternatives.

While efforts are underway to reform the 30-year-old US Toxic Substances Control Act, many US companies already recognize the need to understand what chemicals are in their products and to undertake necessary testing and evaluation. Several US states are also undertaking broad chemicals reforms to rapidly prioritize chemicals into higher and lower hazard categories and require safer alternatives to chemicals of concern. Proposed regulations in California, for example, will require the state to prioritize chemicals and products of concern and require that retailers and distributors evaluate safer alternatives to those substances. But none of these developments, including REACH, includes the full range of components of a Comprehensive Chemicals Policy that considers all chemicals, across all uses and jurisdictions, with the goal of promoting safer chemicals and not simply controlling the hazardous ones.

5. Promote "Prevention through Design" (PtD) to make jobs, products, and materials inherently safe.

For decades, chemists, engineers, and architects designed the materials and production processes that fuel our economy with little or no regard for the safety and health of workers. From avoidable falls among construction workers, preventable back injuries to health care workers, and neuropathy among workers exposed to 1-bromopropane, the case studies again and again reveal entirely

© 2010 Earl Dotter

avoidable harms if only our chemicals, production processes, and technologies were *designed* differently. Across the life cycle—from manufacture and construction to operation, maintenance, and disposal—fatalities, illnesses, and injuries result from hazards inherent in the way things were designed. Given that these problematic materials and processes were designed and created by humans, solutions can be also—and one of the best ways to protect workers is to design out those hazards.

NIOSH has a dedicated Prevention through Design (PtD) initiative whose mission is to "reduce the risk of occupational injury and illness by integrating decisions affecting safety and health in all stages of the design process." With current interest in greening the economy and in getting people back to work, successful implementation of PtD concepts holds great promise for breaking free of the false dichotomy of safety versus profit—it doesn't have to be a trade-off. Tools to implement PtD, including alternatives assessment and toxics use reduction planning, can be integrated into decision-making by both businesses and regulatory agencies to reduce hazards at their sources

> ***"It's sad to not know who to complain to, because even the doctors and nurses are on the company's side."***
>
> — an anonymous Nebraska meat packing worker

rather than simply managing downstream risks. PtD application at the firm level can be combined with coordinated federal agency research to identify design-oriented solutions for workplace hazards that optimize worker and environmental health. The training of chemists, engineers, designers, and business and finance professionals could include PtD as well. Federal research programs could be used to stimulate innovative research on the most cost-effective ways to design out hazards throughout the economy.

6. Expand labor/migrant labor safety and health protections. Support immigrant worker centers to develop expertise in assisting workers.

The globalization of systems of production has two distinct aspects. The export of hazardous industries is perhaps the better understood aspect. But we can see that when a hazardous and exhausting job *can't* be exported—construction, janitorial services, personal care, health care—these trades are increasingly carried out by immigrants, which creates special challenges for those who try to help them protect themselves.

New immigrant workers experience communication, legal, and cultural barriers to understanding and exercising their workplace rights. In some sectors, trade unions have been successful at organizing these marginalized workers, and this can be an important step in providing them with basic protections. Yet in many situations, unionization has been very difficult. As described in the construction case study, only 11 percent of Hispanic construction workers belong to a union. They also suffer far more fatal and non-fatal injuries and are 48 percent less likely to receive payment for medical costs from workers' compensation than their non-Hispanic white co-workers.[12] Similar needs were also revealed in the case study of meat and poultry workers. For example, less than half (44 percent) of the predominantly immigrant workforce on Nebraska's meatpacking disassembly lines remembered receiving information about workers' compensation, according to a survey by Nebraska Appleseed.[11] As described by one meatpacking employee, these populations often feel that their employer's human resources and medical staff only have the company's interest in mind, "It's sad to not know who to complain to, because even the doctors and nurses are on the company's side."[11]

Safety and health training, information, and other support can be offered through immigrant worker centers and other community initiatives to reach out to these populations. And OSHA could strengthen its ability to communicate with immigrant workers and their communities through outreach activities and additional resources devoted to working with non-English speakers. However, information alone will not be sufficient to protect workers. It must be coupled with policies and enforcement and compliance programs that ensure that the most vulnerable workers are protected from workplace hazards (considering the cumulative impacts of workplace and community hazards and stressors). By protecting those most vulnerable, all workers will be better protected.

7. Strengthen occupational and environmental health expertise and related clinical initiatives that are created by health care reform legislation.

Health care reform debates have opened many opportunities to improve health care focused on the hazards of work. If it were not for astute physicians, such as Dr. Alan Parmet in Kansas City and Dr. Phil Harber in Los Angeles, who diagnosed the first cases of lung disease in workers exposed to butter flavoring chemicals, the epidemic would have lasted longer and more workers and consumers would have been sickened.

When physicians are trained in occupational health and when effective occupational health surveillance systems are in place, workers' lives are better protected. Yet the Institute of Medicine has declared that there is a "critical shortage" of specialty-trained occupational and environmental physicians in communities, in academic medical centers, and in public health and related agencies.[13] Public health and medical curricula should

require a minimum level of competence in recognizing occupational injury and illness to enhance the capacity of future professionals. Some states, such as Massachusetts, are implementing programs to integrate occupational health into existing public health, clinical care, and worksite wellness programs.[14] Focusing these initiatives in community health centers makes sense because the low-income patients who use these centers often find themselves in the most hazardous jobs.

Taking the next steps

The challenges of protecting workers' safety and health are great, but the opportunities for broad solutions that can improve the health of workers, communities, and the environment while stimulating innovation are even greater. The case studies in this report explore multiple overlapping factors that lead to workplace injury and illness. Using these case studies, we have identified concrete steps for systems-level changes that can prevent injury and illness. None of the proposed recommendations is sufficient in and of itself. It will take multiple efforts with the engagement of a wide range of parties to effect fundamental change. Resources for participating in this ongoing dialog are available at our website: *www.sustainableproduction.org*, along with the six case studies and resources for going deeper into each of these topics.

References

1. Michaels D. OSHA at forty: new challenges and new directions. July 19, 2010. Available at: *http://scienceblogs.com/thepumphandle/2010/08/osha_at_forty_new_strategies_f.php?utm_source=combinedfeed&utm_medium=rss*. Accessed: August 5, 2010.
2. Schneider S, Check P. Read all about it: the role of the media in improving construction safety and health. *J Safety Res.*41(3):283-7.
3. Berzon A. Construction worker deaths on the strip: pace is the new peril. *Las Vegas Sun*. March 30, 2008. Available at: *www.lasvegassun.com/news/2008/mar/30/construction-deaths/*. Accessed July 15, 2010.
4. Memorandum of Understanding between the U.S. Department of Labor, Occupational Safety and Health Administration and the U.S. Department of Agriculture, Food Safety and Inspection Service. 1994. Available at: *www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=MOU&p_id=262*. Accessed: September 2, 2010.
5. Boden LI, Ozonoff A. Capture-recapture estimates of nonfatal workplace injuries and illnesses. *Ann Epidemiol.* 2008;18(6):500-6.
6. Leigh JP, Marcin JP, Miller TR. An estimate of the U.S. Government's undercount of nonfatal occupational injuries. *J Occup Environ Med.* 2004;46(1):10-8.
7. Council of State and Territorial Epidemiologists. *2009 Epidemiology capacity assessment*. 2009. Available at: *www.cste.org/dnn/Portals/0/2009EpidemiologyCapacityAssessmentReport.pdf*. Accessed: March 15, 2010.
8. Gail Bateson. Executive Director, Work Safe. Personal Communication. March 4, 2009.
9. Statement of Eric Peoples. Have OSHA standards kept up with workplace hazards? Hearing before the Subcommittee on Workforce Protections of the House Committee on Education and Labor, 110th Congress. 2007.
10. Finkel AM. Highlights of testimony: OSHA rulemaking hearing on modifications to the hazard communication standard ("HazCom"). March 5, 2010. Available at: *http://peer.org/docs/osha/3_5_10_Finkel_TLV_testimony.pdf*. Accessed: May 25, 2010.
11. Nebraska Appleseed. *"The speed kills you": The voice of Nebraska's meatpacking workers.* October 2009.
12. Dong X, Ringen K, Men Y, et al. Medical costs and sources of payment for work-related injuries among Hispanic construction workers. *J Occup Environ Med*. 2007;49(12):1367-75.
13. Institute of Medicine. *Addressing the physician shortage in occupational and environmental medicine: report of a study.* National Academy of Sciences, Washington, DC. 1991.
14. Davis L, Souza K. Integrating occupational health with mainstream public health in Massachusetts: an approach to intervention. *Public Health Rep*. 2009;124 Suppl 1:5-14.

Going to work should not be a choice between feeding your family and protecting your health.

Every day, 14 workers die on the job, and each year more than 4 million are seriously injured or sickened by exposures to toxic agents. Real change to the nation's approach to workplace safety and health is desperately needed. This report includes six case studies of systemic failures in protecting workers from injury and illness. Each case documents the history of selected workplace health and safety policies and practices and reveals lessons learned to inform more effective prevention-focused worker health and safety protections. The Synthesis and Recommendations section of the report uses these lessons learned to outline a series of strategies for real change—approaches that can protect workers while stimulating innovation in safer forms of production that can also protect the communities in which we all live.

ADDITIONAL COPIES

The full report as well as separate copies of the individual case studies and executive summary can be downloaded from the Lowell Center for Sustainable Production's website: *www.sustainableproduction.org*.

CONTACT

For inquires about the report, please contact Molly Jacobs at *mjacobs@envhealth.net*.

Lowell Center for Sustainable Production
UNIVERSITY OF MASSACHUSETTS LOWELL

Lowell Center for Sustainable Production
University of Massachusetts Lowell, 1 University Avenue, Lowell MA 01854 USA
978-934-2980 · www.sustainableproduction.org

Printed on 100% post-consumer, Process Chlorine-Free paper with soy-based inks.

PHOTOGRAPHY
Earl Dotter/EarlDotter.com

DESIGN
David Gerratt/NonprofitDesign.com