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Assessing the Accuracy of OSHA's Projections of the Benefits of New Safety Standards

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Background *In the preambles to the safety and health standards that it has issued since 1987, the Occupational Safety and Health Administration (OSHA) projected that new safety standards would prevent over 2,600 death each year. For six safety standards issued since 1990, we compare OSHA's projections of the impact of full compliance on fatalities with actual fatality changes and examine the reasons for the differences.*

Methods *We reviewed the preambles to OSHA standards and the Regulatory Impact Analyses (RIAs) prepared for them to identify the baseline and the prevention factor that the agency used to project the number of deaths that would be prevented. We used three data sources to track the relevant categories of fatalities: the Census of Fatal Occupational Injuries (CFOI), the National Traumatic Occupational Fatality program, and OSHAs Fatality/Catastrophe investigations.*

Results *For all six standards, OSHA appeared to overestimate the number of deaths prevented. The availability of CFOI led to better estimates of the fatality baseline, but the prevention factor was always overestimated, especially for standards which emphasized training.*

Conclusions *OSHA needs to develop better methods for projecting injury impacts. Research is needed to help OSHA predict the effects of behavioral requirements (e.g., training) on actual work practices and injury outcomes. For non-fatal injuries, new methods of data collection will be required.* Am. J. Ind. Med. 45:313–328, 2004.

KEY WORDS: safety; fatalities; occupational safety and health standards; prevention; Occupational Safety and Health Administration

INTRODUCTION

In the preambles to the safety and health standards that it has promulgated since 1987, the Occupational Safety and Health Administration (OSHA) projected that full compliance with the new rules would prevent over 2,600 deaths per year, 800–900 as the result of new safety standards and the remainder from health [Mendeloff, 2003]. By any measure, this would be a significant public health achievement. Questions have naturally arisen about the accuracy of these projections. The issue of accuracy is important for outside evaluators, but it is also important for the agency itself. Errors may lead to giving priority to the wrong hazards. For example, too high an estimate of effectiveness may lead to a judgment that a hazard has been adequately addressed when it has not been. Too low an estimate of effectiveness or too

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high an estimate of costs may reduce the priority given to a rule in the regulatory development process. To improve the process of priority setting, we need to pay attention to the quality of the projections that regulatory agencies make.

The costs and benefits of federal government safety and health standards have been reviewed by analysts interested in the effectiveness and efficiency of government regulation [Morrall, 1986; Mendeloff, 1988; Hahn, 1996; Heinzerling, 1998]. But these studies have relied almost exclusively on prospective estimates by the regulatory agencies of what the costs and effects would be. In contrast, few studies have tried to make retrospective estimates of what the costs and effects actually were.

On the cost side, a small number of retrospective studies have been conducted [Harrington et al., 2000]. They have found cases of both overestimates and underestimates, although the former were more common.

Studies of the accuracy of estimates of regulatory benefits are less common. For health hazards, we could examine changes in the number of workers exposed to different concentrations to find out whether the standard had been effective. However, for hazards with long latency periods, we could not easily assess whether the projected reduction in diseases had occurred.

Estimating the actual effects of safety standards seems more straightforward. It should be possible to observe whether the ex-ante estimate of the change in fatal or nonfatal injuries was on target. Of course, we still need to estimate what the level of injuries would have been without the standard, which generally requires controlling for other factors that could affect the level.

A few retrospective studies of individual OSHA standards have been carried out. A report by U.S. Congress, Office of Technology Assessment [1995] examined the validity of the techniques used for estimating the costs of OSHA standards. It noted that two safety standards had not been implemented as extensively as OSHA had projected. In compliance with the ‘‘look-back’’ provision of the 1995 Small Business Regulatory Enforcement and Fairness Act, OSHA has completed studies on two safety standards, the ‘‘lockout-tagout’’ standard [U.S. Department of Labor, Occupational Safety and Health Administration, 2000] and the grain handling standard [U.S. Department of Labor, OSHA, 2003a]. Another study examined the effects of the OSHA trench and excavation standard [Suruda et al., 2002]. However, none of these studies attempted to compare the effects with the projections OSHA made at the time the standards had been promulgated.

We attempt to compare the ex-ante projections of the effects on fatalities of full compliance with OSHA safety standards with the actual changes that occurred. We use longitudinal data from different sources and have begun with the most recent standards for which enough time has elapsed to merit an evaluation. We also investigate some of the reasons for the errors and the types of remedies that might be available. We do not attempt to examine whether the standards were worthwhile.

MATERIALS AND METHODS

Our comparison of the actual and projected numbers of injuries prevented by the standards involved several steps. A list of all OSHA safety standards was obtained from its Office of Regulatory Analysis. To limit the size of the task and to make it more relevant to current practices, we look at 11 standards promulgated since 1990 (see Table I). We omitted the three most recent standards, promulgated after 1996, on the grounds that there may not have been enough time to track their effects. We reviewed the preambles to the remaining rules as they appeared in the Federal Register. The preambles present the conclusions of the studies on the expected costs and safety effects of the standards. On the basis of this information, we excluded other standards.

TABLE I. Safety Standards Promulgated Since 1990

Date of federal register	Title	Effective date
08/06/1990	Electrical safety related work practices	12/04/1990 (with exception 08/06/1991)
11/14/1990	Safety standards for stairways and ladders used in the construction industry	01/14/1991
02/24/1991	Process safety management (PSM) of highly hazardous chemicals; explosives and blasting agents	05/26/1992
01/14/1993	Permit-required confined spaces	04/15/1993
01/31/1994	Electric power generation, transmission, and distribution; electrical protective equipment	05/31/1994 (with exception 01/31/1995)
08/09/1994	Safety standards for fall protection in the construction industry	02/06/1995
10/12/1994	Logging operation	02/09/1995
08/30/1996	Safety standards for scaffolds used in the construction industry	11/29/1996 (except for one provision)
07/25/1997	Longshoring and marine terminals	01/21/1998
12/01/1998	Permit-required confined spaces modification	02/01/1999
12/01/1998	Powered industrial truck operator training	04/27/1999

The data available for tracking fatal injuries is much better than the data available for tracking non-fatal injuries. On this basis we excluded: (a) the 1994 rule for Personal Protective Equipment for General Industry, which OSHA had projected would prevent four deaths per year; and (b) the 1990 rule on Stairways and Ladders in Construction, which OSHA had projected would prevent three deaths per year. As the data in Table II indicate, the standards we are examining were all projected to prevent at least 40 deaths per year.

We also excluded the 1994 standard on fall prevention in construction. Addressing falls from roofs and through floors in new construction, the new provisions of this standard were projected to prevent 22 fatalities per year. In addition, OSHA projected that full compliance with the existing standard would prevent another 57 deaths per year. As a percentage of the baseline number of deaths, the 22 represented only about a 15% reduction, a change that could be difficult to discern, relative to other standards with larger absolute and percentage reductions.

The omission of these three standards and the focus on standards with relatively large projected effects may make it less likely that we find cases where the effects are underestimated. However, although this is important to note, we believe that a focus on cases with bigger estimated effects is justified in a study of OSHA's accuracy: the importance of the error is larger if a projection of 60 deaths prevented is wrong by a factor of 2 than if a projected effect of three deaths is wrong by a factor of 2.

The preambles for the six remaining standards often failed to clearly explain how the estimates of safety effects were made. To find the answers, we also examined the Regulatory Impact Analyses (RIAs) that OSHA prepared for these standards and obtained the information shown in Table II.

On the basis of the preambles and the RIAs, we also identified several pieces of information which were important for our attempts to evaluate the effectiveness of the standards: the effective date for compliance with the standard; whether the standard was expected to affect all states equally; which industries (SICs) would be affected; and which injury types would be affected.

DATA

Fatal Injuries

For fatal injuries, we looked at three different data sets: the Census of Fatal Occupational Injuries (CFOI), the National Traumatic Occupational Fatality data (NTOF), and the Fatality/Catastrophe Investigation reports compiled by OSHA (FAT/CATs).

CFOI

The Bureau of Labor Statistics (BLS) carried out this census for the first time for deaths occurring in 1992. It covers all cases in which the decedent was working for pay or profit at the time of the event in a legal work activity or was present at the site as a requirement of the job. Multiple sources are examined to identify occupational fatalities. To be included, a case must be verified from two independent source documents or from a source document and a follow-up questionnaire. Many items about the causes of the deaths are collected [U.S. Department of Labor, Bureau of Labor Statistics, 2003a].

NTOF

Beginning with 1980 data, the National Institute of Occupational Safety and Health (NIOSH) has collected death certificates from all states for workers 16 years and older for whom an external cause of death was noted and where the certificate gave a positive answer to the "Injury at Work?" item. The death certificate is supposed to list the "usual" industry and occupation of the decedent. Errors in this coding, however, appear to occur in 25–40% of cases. The main information on the cause of death comes from the external source of injury code [Marsh et al., 2001].

FAT/CATs

Employers are supposed to report fatalities and some multi-hospitalization events to OSHA by telephone within 24 hr of the event. OSHA usually investigates if it has reason to believe that a violation of a safety and health standard might be involved. (For that reason, the FAT/CAT data do not include deaths due to highway motor vehicle accidents, assaults and some other significant causes of mortality.) From 1984 through early 1997, a text version of the event has been maintained in OSHA's information system (IMIS). Key words can be used to retrieve particular types of injury events.[1]

Non-Fatal Injuries

For non-fatal injuries, we looked at the Survey of Occupational Injuries and Illnesses, conducted annually by BLS [U.S. Department of Labor, Bureau of Labor Statistics, 2003b]. Prior to 1992, the Survey provided no information about the characteristics of injuries, other than if they involved days away from work, restricted work activity, or medical care. The Survey also collected information about the estimated duration of injuries with days away from work.

[1] Since mid-1990 inspection data from all states has been entered into IMIS. California did not participate before July 1987, left again in June 1989 and then returned in July 1990. Washington State began submitting data in January 1990. Michigan health reports began in October 1988; safety reports, in October 1989 [U.S. Department of Labor, Occupational Safety and Health Administration, 1993]. Because of these late entrants, we have adjusted the FAT/CAT numbers before 1991 upward on the basis of the population in those states (6% in 1990, 10% in 1989 and 5% in 1988, 11% in 1987, 17% in 1986 and earlier).

TABLE II. Costs and Effects of the Standards in This Study

			Estimate of annual effects		
Title of the standard	**Affected industry**	**Cost estimate**	**Baseline**	**Fatalities prevented**	**Injuries prevented**
Electrical safety related work practices	General industry	$90.8 million annually	235 fatalities and 7,682 non-fatal injuries	97 (41.4 %)	1,691 non-fatal (22.7 %)
PSM of highly hazardous chemicals; explosives and blasting agents	General Industry, except in three states	First 5 years, annually $888.7 million and 6–10 years, annually $405.8 million	1983–1990: 330 fatalities and 1,918 injuries/illness per year (excluding CA, NJ, and DE)	Annually, first 5 years 132 (40%) and next 5 years 264 (80%)	Annually, first 5 years 767 with 250 LWDIs (40%) and next 5 years 1,534 with 500 LWDIs (80%)
Permit-required confined spaces	General industry, (less impact in six states)	$202.4 million annually	63 fatalities; 5,931 LWDIs; 6,951 non-LWDIs	54 (85%)	5,041 LWDIs and 5,908 non-LWDIs (85%)
Electric power generation, transmission, and distribution; electrical protective equipment	Mainly, electric utility industry (SIC 491 and part of 493)	$40.9 million for the first year and $21.7 million annual cost after the first year	85.5 fatalities; 12,976.5 LWDIs	61 (69%)	1,633 LWDIs (12.6%)
Logging operations	SIC 241 (less impact in six states)	$14 million for the first year and $12.5 million annually	158 fatalities and 10,568 injuries (6,798 LWDIs; 3,770 non-LWDIs)	111 (70%)	7,398 injuries: 4,759 LWDIs; 2,639 non-LWDIs (70%)
Safety standards for scaffolds used in the construction industry	SICs 15, 16, and 17	$12.62 million annually	79 fatalities; 9,750 injuries	47 (60%)	4,455 (45.7%)

Source: Regulatory Impact Analysis Documents.

Beginning in 1992, the Survey began to collect additional information about the subset of injuries, which involved days away from work.

As the description of data sources above suggests, we have a better ability to identify and track different types of fatal injuries than we have for non-fatals. Also, OSHA projected in all of these cases (Table II) that the prevention factor for fatalities would be at least as high, if not higher, than for non-fatal injuries. As a result, we limit our analyses to fatalities.

EVALUATION DESIGNS

In order to track fatalities, we first identified the industries that, according to OSHA, were covered by the new standards and the effective date of the standards. Next, for all except the Logging Operations standard, we identified the injury types that the standards were projected to affect. As described below, we were not always able to track each effect. For the logging, confined spaces, and process safety management (PSM) standards, we were also able to use comparison groups of states that had previously adopted some or all of the elements of the new federal OSHA standard. In light of the limited number of annual observations, we do not apply statistical tests to the differences we find. For the three industry-specific standards, we did interview leading safety officials in those industries about whether other new developments might be influencing fatality rates during this period. We did examine the effect of cyclical changes (as measured by changes in the unemployment rate) on changes in the economy-wide fatality rate (as measured by NTOF and the Current Population Survey). On average, during the 1990s, a 1-point drop in the unemployment rate raised the fatality rate by about 1 or 2%. Given this small effect, we did not consider it further.

RESULTS

Electrical Work Practices for General Industry

The electrical standard for general industry became effective in late-1990. OSHA estimated that the first year costs would be $75 million, followed by recurring costs of $20 million per year. It estimated a baseline figure for electrical deaths in general industry of 235 per year and it projected that compliance with the new standard would prevent 41%, or 97, of those deaths.

Baseline

The baseline estimate came from an estimate of the number of electrocution deaths reported for general industry in the BLS Annual Survey of Occupational Injuries and Illnesses for 1980–1984. This was extrapolated to the figure of 235 for 1985[2] [U.S. Department of Labor, Occupational Safety and Health Administration, 1987]. In the final standard, OSHA explicitly excluded coverage for SICs 491 and 493 (the industries addressed by the later Electrical Power Generation standard), which would lead to a somewhat lower baseline.

We constructed an estimate of what the number of deaths before 1992 had been. In that year, CFOI became available, providing more accurate information. Figure 1 shows trends from all three data systems for private industry, except agriculture and construction, and (except for NTOF) without SICs 491 and 493. For CFOI the category is "contact with electric current." For FAT/CATs, it is the keyword "electrical." For NTOF, it is deaths with E-codes 925.2 and 925.9. For the years from 1992 through 1995, we can compare the CFOI and FAT/CAT estimates. The CFOI numbers were, on average, 25% higher. We used this adjustment figure, along with the adjustment for missing data in FAT/CATs because some states did not contribute data before 1991. Based on these "adjusted FAT/CAT" figures, we estimate that there were about 135 deaths in 1985. This is well below the OSHA baseline of 235; less than half of the difference can be accounted for by the exclusion of SIC 491 and 493. (There were never more than 30 deaths per year with the keyword "electrical" for SICs 491 and 493 in the FAT/CAT system. Even after we adjust this upward for missing states and for the potential 25% underreporting, the number is less than 50.)

Prevention factor

OSHA's contractor estimated that 89% of all electrical injuries in general industry would be covered by the standard; that 75% of all injuries "are not due to faulty equipment but are related to work practices;" and that the fraction of workers exposed to fatality risks who would undergo training required by the standard would be 73%. Finally, OSHA estimated that 85% of all electrical injuries "are not caused by human error and are therefore amenable to regulation" [U.S. Department of Labor, Occupational Safety and Health Administration, 1987]. Multiplying these four percentages together, OSHA arrived at a predicted reduction in fatal injuries of 41.4%.

The logic for the last step in this calculation is hard to follow. The major provision of the new standard, at least in terms of cost, called for training workers. It is not evident why training would be useful unless many injuries had been caused by "human error."

Nevertheless, if we look for the 41% predicted drop, what do we find? The answer depends largely on the years

[2] Note that the RIA itself was produced by U.S. Department of Labor, Occupational Safety and Health Administration [1987], 3 years before the standard was promulgated.

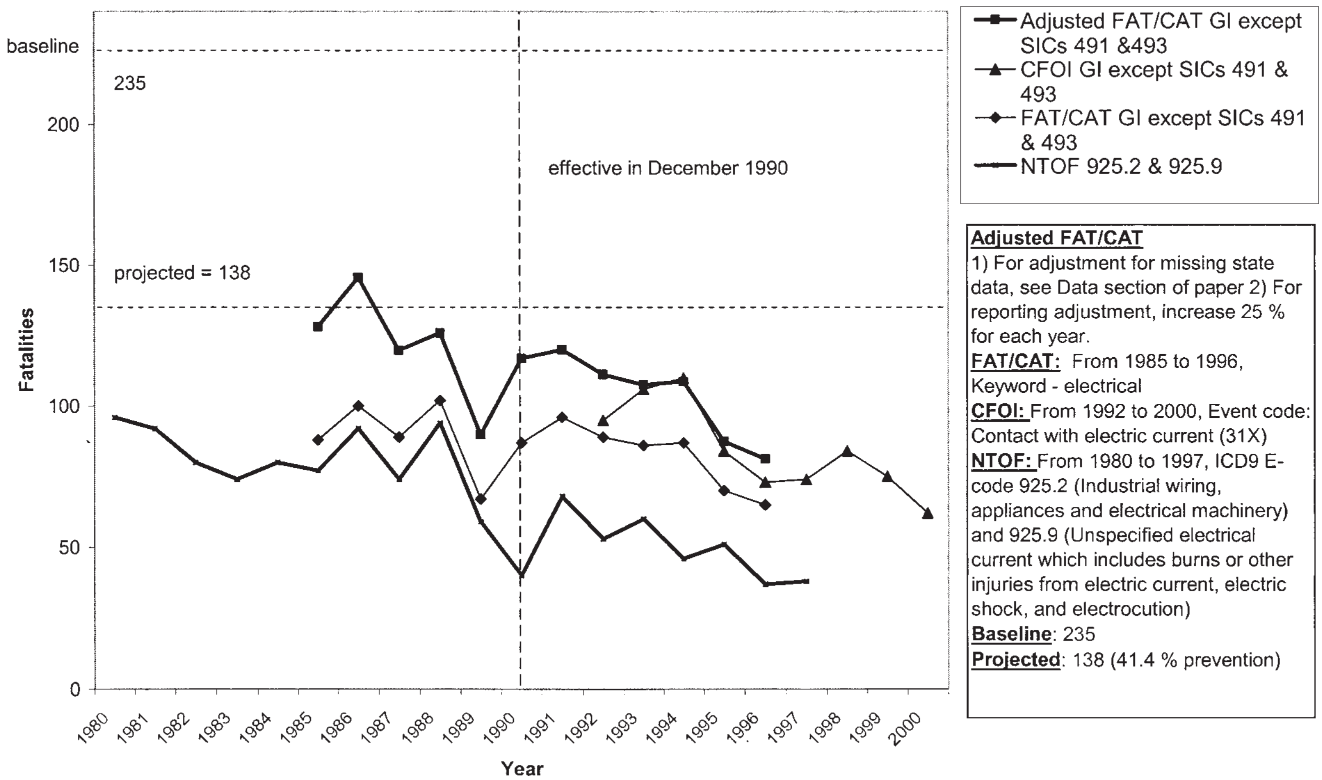

FIGURE 1. Electrical safety-fatalities in general industry.

we choose to compare. If we use 1990 as the baseline (the standard became effective in December of that year), we do not find any noticeable reduction until 1995. However, there was an unusually steep drop in deaths from 1988 to 1989 as well as further drops after 1994.

In order to see whether changes in employment might have accounted for the changes we see, we also calculated the rate for electrical fatalities, using CFOI data for the numerator and employment data from County Business Patterns for the denominator. We calculated the fatality rate in each industry sector in 1992 [U.S. Department of Commerce, 2002] and then calculated what the fatality rate for all of general industry would have been in subsequent years if the distribution of employment among sectors had remained as it had been in 1992. The resulting changes were not much different than those shown for the changes in the number of deaths and are not shown here.

Figure 1 shows clearly that the overall reduction in fatalities from the mid-1980s to the late-1990s was large—from an average of 151 in 1985–1988 to an average of 78 in 1997–2000, down 48%. Given the timing of the reductions, it seems unlikely that the 1990 OSHA rule can claim the major credit for this drop, although some role is certainly possible. However, since the baseline for this calculation is considerably lower than the baseline used by OSHA, the actual number of deaths prevented, even assuming a dominant causal role for the standard, was also considerably lower than the 97 projected deaths.

PSM in General Industry

Triggered in part by the disaster at the Union Carbide chemical plant in Bhopal, India, the PSM standard called for firms to adopt procedures to reduce the risk of releases and explosions involving chemicals and other dangerous materials. According to the RIA, implementation "will prevent the occurrence, and minimize the consequences, of significant releases of toxic substances, as well as fires, explosions and other types of catastrophic accidents."

For this standard, the RIA noted that "OSHA excluded from this final impact analysis establishments in California, Delaware, and New Jersey, where PSM statutes have already been enacted. In these three states, the compliance burden is unaffected by the federal rule." Excluding these states, OSHA estimated that the new standard would cost $889 million and prevent 132 deaths during each of the first 5 years. During the subsequent 5 years, the annual costs would drop to $406 million while the deaths prevented would double to 264. The impact was expected to grow because the proportion of establishments that had completed their self-audits would grow over the first 5 years. The standard became effective toward the end of May, 1992.

Baseline

OSHA reviewed FAT/CATs from 1983 to 1990 in the industries covered by the standard. It found 1,712 fatalities "related to process hazards covered under the OSHA standard." Next, OSHA adjusted this number upward by a factor of 1.54, due to expected underreporting of FAT/CATs. The result was an average of 330 per year from 1983 to 1990.

The major problem with the procedure is found in the first step. OSHA stated that it had extracted cases "in which the source of injury, the type of event, the environmental factor involved, or the human factor involved could be directly linked to the absence of PSM."

The use of the word "or" here is crucial. For example, the two "event codes" used were "inhalation" and "absorption." But, to be included, an accident did not have to include them. It might only have involved one of the "human factor" codes that were judged to be "related" to the standard. These included: misjudgment of hazardous situation; safety devices removed or inoperative; procedure for handling materials not appropriate to task; and several others. These human factors could be present even when an accident has nothing at all to do with chemicals or with explosions.

Yet OSHA did observe that the estimates it made were in the range of figures from the BLS Annual Survey of Occupational Illnesses and Injuries. Although that Survey's estimates of deaths have limited reliability, most of the criticisms suggested the numbers were too low [National Research Council, 1987]. To try to resolve this disparity, we reviewed the FAT/CATs since 1985. As Figure 2 shows, the annual number of deaths elicited by citing the keywords "explosion" and "fire" never totaled more than about 120. Although these categories do not capture all of the deaths related to the PSM standard, Figure 2 shows that from 1992 through 1995, when we have both FAT/CAT and CFOI data, the two data series track very closely, suggesting that the earlier FAT/CAT data may have been fairly accurate, and thus that the 51% adjustment OSHA made to account for underreporting may have been excessive.

Prevention factor

For its estimate of the prevention role that the new standard would play, OSHA relied on one of its contractors, who concluded a study of the chemical and petroleum industries with the statement that "60% of the fatalities that occurred in establishments with some elements of a (PSM) program could have been prevented and 80% of the fatalities that occurred in establishments with no program could have been prevented." A different contractor "identified a range of 16–56% reduction in both injuries and fatalities following the implementation of the OSHA standard."

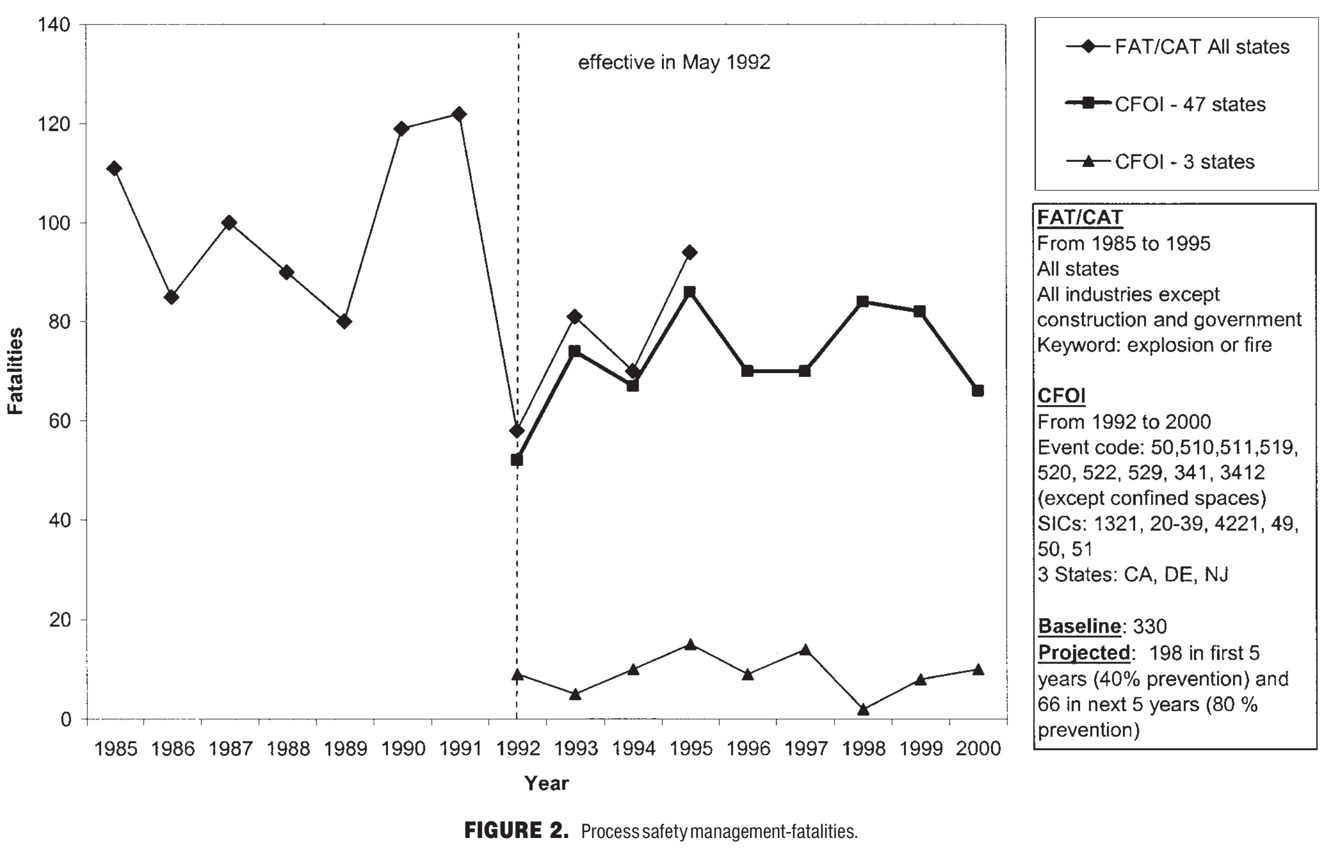

FIGURE 2. Process safety management-fatalities.

OSHA also noted that a well known organization representing many of the nation's largest firms had stated that ''Experience by ORC member companies indicates that most, if not all, process-related incidents involve a breakdown of one or more of OSHA's PSM elements. Given effective implementation and compliance with the provisions of the proposed standard, we agree with OSHAs estimate of at least an 80% reduction in serious process incidents.''

What has actually happened to deaths since the standard took effect? In Figure 2, we tracked the industries that OSHA identified as the sites of PSM-related deaths for all three of the major event types—explosions, fires, and inhalation (other than confined spaces). The FAT/CAT data (for all states) show a roughly 50% drop in explosion and fire deaths from 1991 to 1992. The standard was promulgated in February, 1992 and became effective 3 months later (1992 was a recession year, but the size of the change is far beyond anything that could be explained primarily by changes in employment).

However, the RIA, which projected a 40% average decrease in deaths for the first 5 years and an 80% decrease for the next 5 years, clearly contemplated a steadily increasing preventive effect as more firms carried out their self-audits. The CFOI data since 1992 do not show any further drop since then. The fatality trends are similar in the three states unaffected by the new standard. Because of the apparent overestimate of the baseline and the failure of the effect to grow after 1992, it is highly implausible that the PSM standard will have prevented 264 deaths per year (80% of 330) by the 10th anniversary of the standard.

Permit-Required Confined Spaces for General Industry

The safety standard for preventing injuries in confined spaces became effective in April, 1993. The general industry confined spaces standard is designed to protect workers in confined spaces from serious hazards, primarily those due to toxic or asphyxiating atmospheres. (Some other injury types were included, e.g., deaths due to engulfment.) The annualized compliance cost was projected at $202.4 million.

Baseline

OSHA estimated an annual baseline of 63 fatalities in workplaces affected by this standard. This baseline was based upon a review of FAT/CATs from 1986 to 1990, which found an average of 32 deaths per year in the affected industries. OSHA doubled this number to attempt to adjust both for underreporting and for the failure of some states to report to the IMIS.

A 1994 study by NIOSH, drawing from its NTOF database, identified 670 cases over the 10 years from 1980 to 1989 that it classified as occurring in ''confined spaces.'' Over half of the cases involved atmospheric hazards, although ''engulfment in loose material'' accounted for one-third. This average of 67 per year is close to the figure that OSHA used as the baseline, suggesting that OSHAs figure was a reasonable one.

Prevention factor

OSHAs RIA noted that six states—California, Kentucky, Maryland, Michigan, New Jersey, and Virginia—currently had permit entry rules for confined spaces. It judged that ''Despite the increased protectiveness provided by the state permit programs . . . OSHA believes that this federal standard will provide the needed additional protection to employees in these states and throughout the nation.'' Although OSHA did not omit these states from its calculations of benefits or costs, the implication here is that the impact in these states should be less because of their ''increased protectiveness.''

OSHA applied an 85% prevention rate to its baseline number, leading to a projected reduction of 54 fatalities. OSHA justified this prevention factor on the grounds that: (a) some firms seemed to have eliminated these accidents, (b) several respondents agreed that an 85% reduction seemed achievable, and (c) OSHA had used similar prevention factors in other safety RIAs.

In CFOI, we identified two event types which include most of the atmospheric deaths affected by the standard: ''inhalation in enclosed, restricted, or confined spaces,'' and ''depletion of oxygen in enclosed, restricted, or confined spaces.'' The sum of these two from CFOI for 1992 for general industry in all states was 38. For evaluating the effect of this standard, we used the two categories to compare confined space related fatalities in the six states which OSHA had stated would be less affected because of their existing standards with the effects in the other 44 states.

Figure 3 shows that from 1992 to 1993, the year the standard became effective, deaths dropped from 31 to 24 in the states that we judged more affected by the standard, and from 7 to 3 in the other six states. The trends in both groups of states were similar through 2001. From the 38 total private sector deaths in CFOI in 1992, the maximum drop came in 1999 with 12 deaths, a 68% reduction.

The reduction in deaths in confined spaces has been impressive and the OSHA standard may have contributed substantially. The main qualm is the equal or greater decline in those states that we expected to be less affected by the standard. Although it seems unlikely that deaths fell 85% (54 deaths) in response to the standard, a greater than 50% drop seems very plausible.

Electrical Power Generation

The electrical power generation standard, effective at the end of May 1994, applied primarily to the power generating

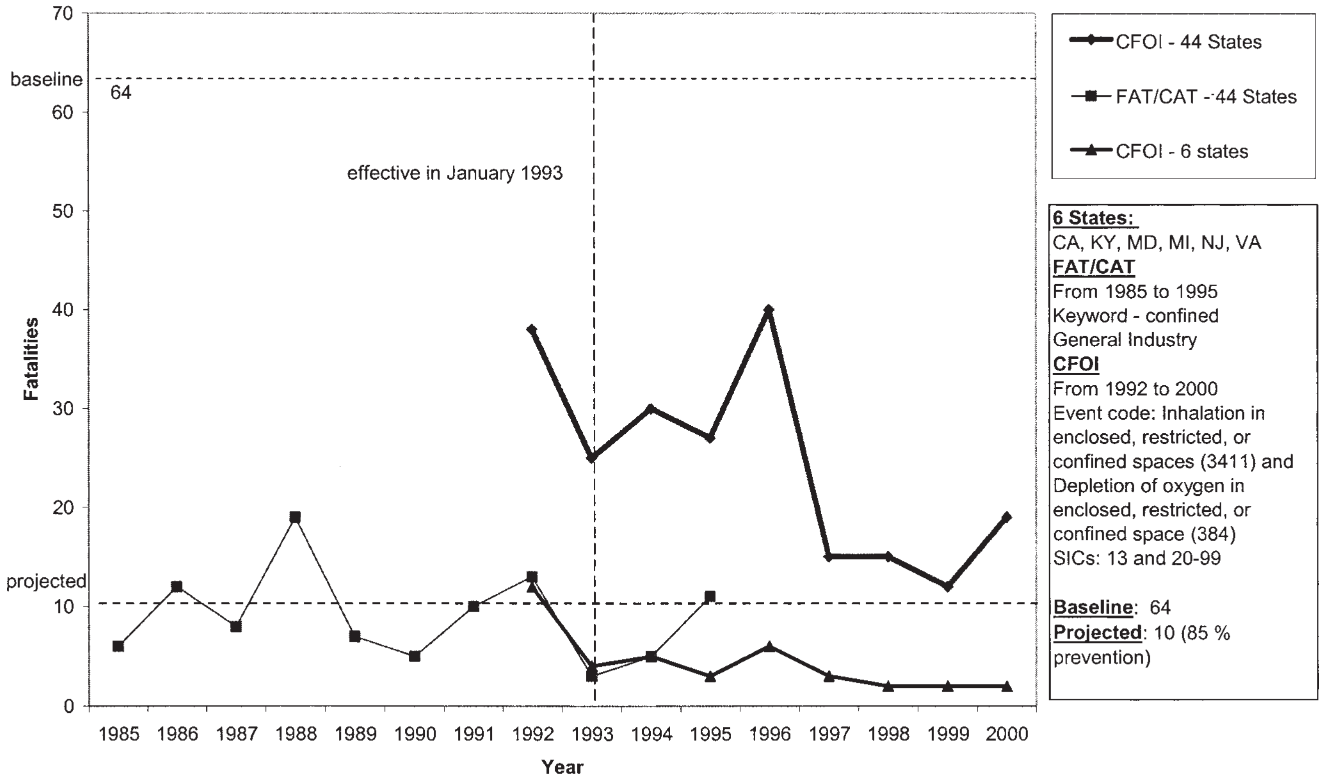

FIGURE 3. Confined spaces-fatalities in general industry.

industry (SICs 491 and 493). Although electrical injuries, like contact with electric current (CFOI event code 31X), dominate the expected fatality benefits, OSHA's estimates also included a broader set of event categories. OSHA stated that the baseline number of fatalities was 85.5 and it said that compliance with the final standard would prevent 59 of them, a 68% prevention rate.

OSHA derived the baseline here from several sources. First it looked at the annual average of fatal injuries in these two SICs that had been reported as FAT/CATs from 1988 to 1992. It doubled this number (from 39 to 78) in an attempt to take account of potential underreporting. OSHA also used the newly available CFOI data, which reported 53 private sector deaths for SICs 491 and 493 in 1992.[3]

To estimate preventability, OSHA relied heavily on data collected by the International Brotherhood of Electrical Workers, which indicated that 68% of the deaths in the electric utility industry would be preventable by full compliance with the new standard.

Our evaluation tracks deaths only in SIC 491 and 493. We applied the 68% prevention factor to the 53 deaths private sector deaths in this sector, for a predicted prevention of 36 fatalities per year. With FAT/CAT and NTOF data, we looked at electrical deaths in those industries. With CFOI, we looked both at all deaths and at only those deaths due to contact with electric current. Figures 4 and 5 show essentially the same pattern. Deaths and death rates dipped in 1993, the year the standard became effective, then went back to their pre-standard levels through 1997. From 1997 to 1999, CFOI reports that electrical fatalities fell from 25 to 12 and total fatalities fell from 44 to 29. It is hard to know how much, if any, of the post-1997 drop was due to the 1994 standard. Again, however, none of the series reveal a reduction of 36 deaths, so the prevention factor and preventive effect remain overestimated.

Logging Operations

The Logging Operations standard was promulgated in 1994 and became effective in February 1995. It expanded the set of issues covered by OSHA's existing standard for logging. OSHA reported in the Preamble to the standard that six states—California, Washington, Oregon, Michigan, Alaska, and Hawaii—had "adopted standards which provide more protection than OSHA's [pre-existing] pulpwood logging standards by covering all logging operations within their States. The standards of the five western states also contain a much higher level of detail and specification than

[3] OSHA made several additional adjustments in its final baseline. It eliminated deaths among municipal utilities in state-plan states. It reduced deaths in SIC 493 to reflect the fact that one-fourth of the employment there worked in gas, not electric utilities. Adding in electrical contractors (9.4 deaths), line-clearance tree-trimmers (8.6), and non-utility establishments (6.8) raised the total baseline to 85.5. (See Tables 3–23 in the "Economic Analysis.")

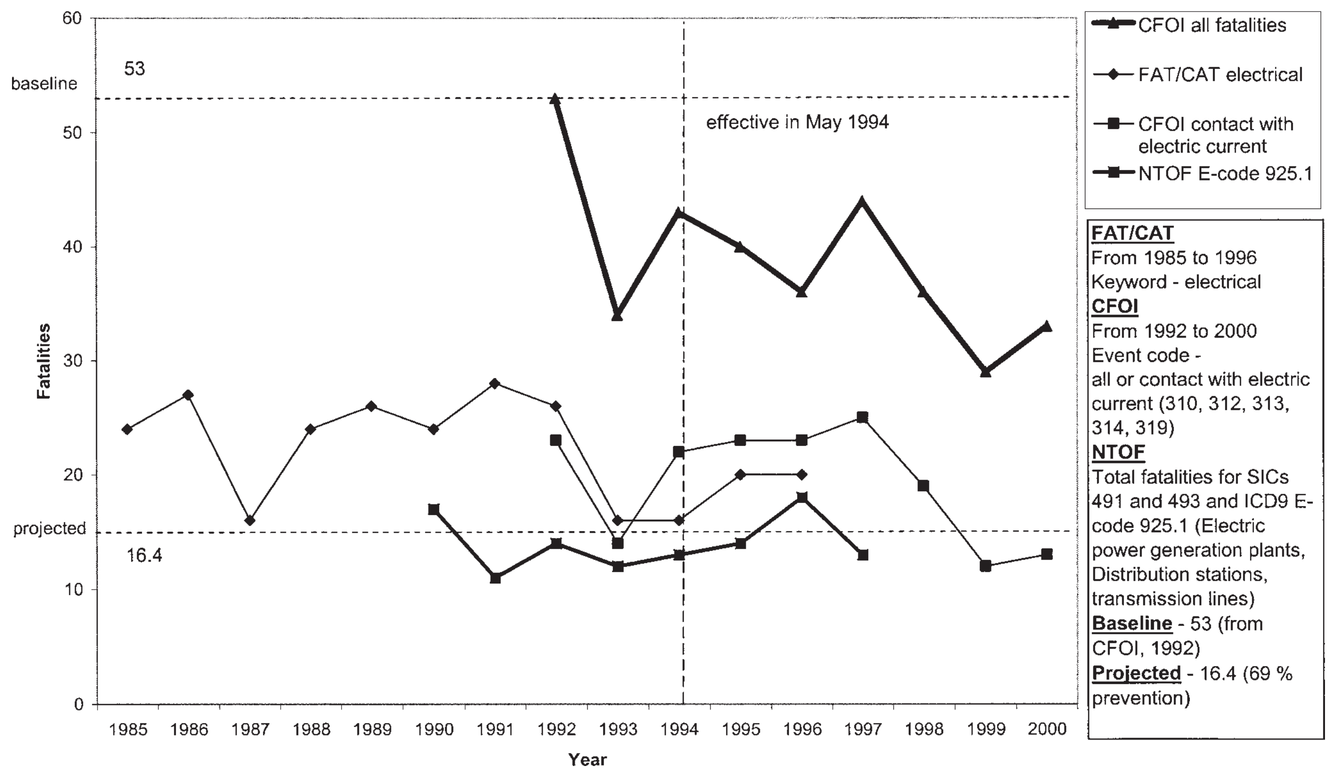

FIGURE 4. Electric power generation-fatalities in SICs 491 and 493.

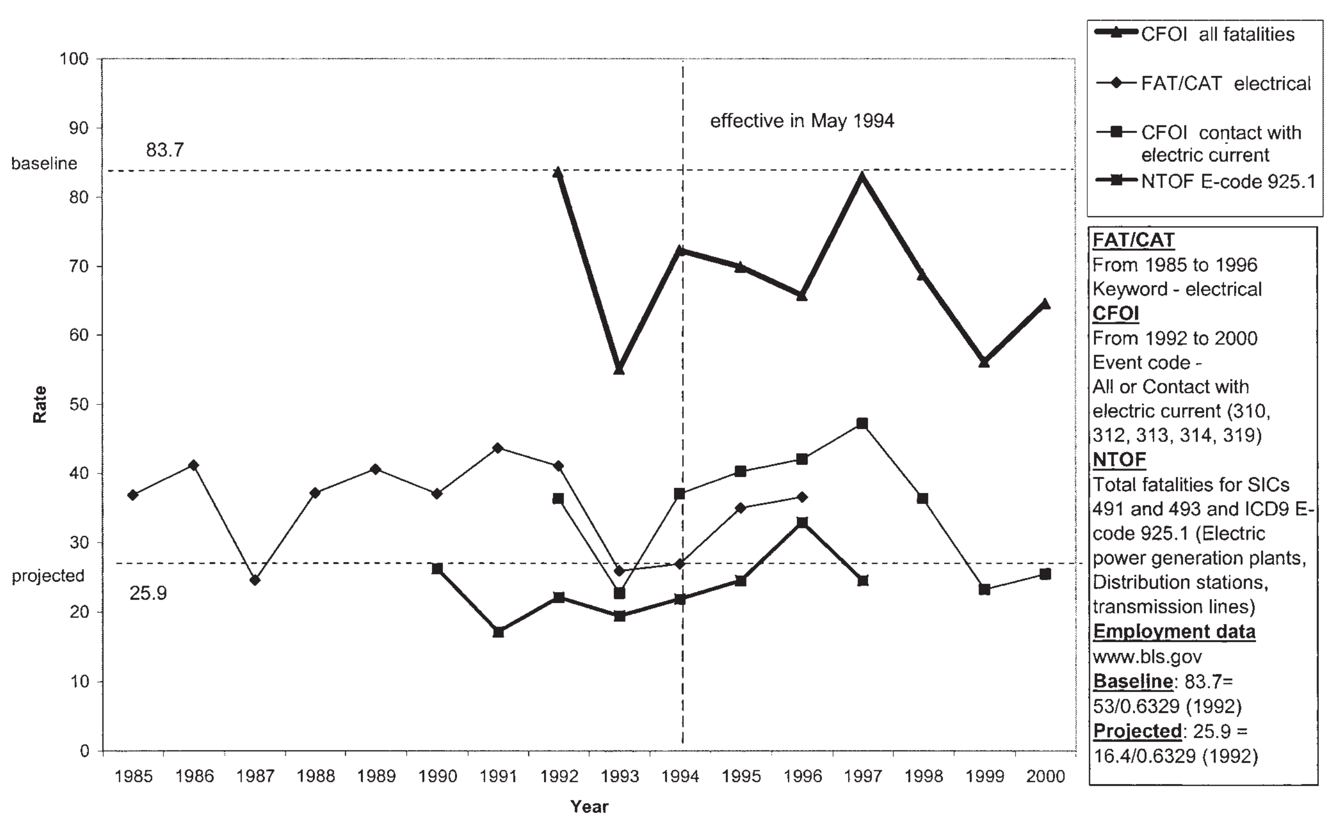

FIGURE 5. Electric power generation-fatality rate per million employees in SICs 491 and 493.

either the 1978 ANSI logging standard or OSHA's pulpwood logging standard." In its Preliminary Regulatory Impact document [U.S. Department of Labor, Occupational Safety and Health Administration, 1988], OSHA observed that the annual cost per firm to comply with the new standard "ranges from $27 in California, where firms are at a high level of compliance with their own state standard, to $452 in the South." On this basis, we would expect to find that the new standard would have bigger effects among the 44 states, which had not had their own standards. We compare the two groups of states with respect to the number of logging fatalities and fatality rate per 1,000 logging employees.

OSHA estimated that the baseline number of fatalities in SIC 241 was 158 and that compliance with the standard would reduce this number to 47, a 70% reduction. As in most other cases, OSHA did not provide a timeline for these effects. It was not clear if they would occur almost immediately following the effective date or if they would occur only after several years.

Figure 6 shows the number of deaths reported by CFOI for all states as well as separately for the six states where OSHA believed the standard would have less effect and for the 44 states where it claimed that there would have more effect. In Figure 7, we have converted these fatality numbers into fatality rates for these three categories based upon employment figures from County Business Patterns. Thus, 158 fatalities among the 58,591 workers employed in SIC 241 in 1992 in the states covered by the standard translates to a baseline fatality rate of 2.70 per thousand and a projected fatality rate of 0.80 per thousand.

Several points about these figures are worth noting.

1) Although deaths dropped in the affected states from 1992 to 1994, prior to the promulgation of the standard, they remained essentially constant in the period from 1994 through 1999.
2) Looking at fatality rates in Figure 7, we see that the national rate was quite stable. Moreover, the fatality rate in the six less affected states, already relatively low, dropped more than the rate in the other states.
3) Based on these figures, it seems that there has been no sizable drop in deaths since the new standard took effect. Based on the figures in the less affected states, it seems unlikely that some other factor was pushing deaths rates up in a way that would mask the true preventive effect of the standard. The rate has not been getting closer to the projected fatality number or rate. OSHA appears to have been overoptimistic in projecting that the logging operations standard would prevent 111 deaths per year.

Scaffolding

The scaffold standard, effective in November 1996, applied to the construction industry. Here we looked at

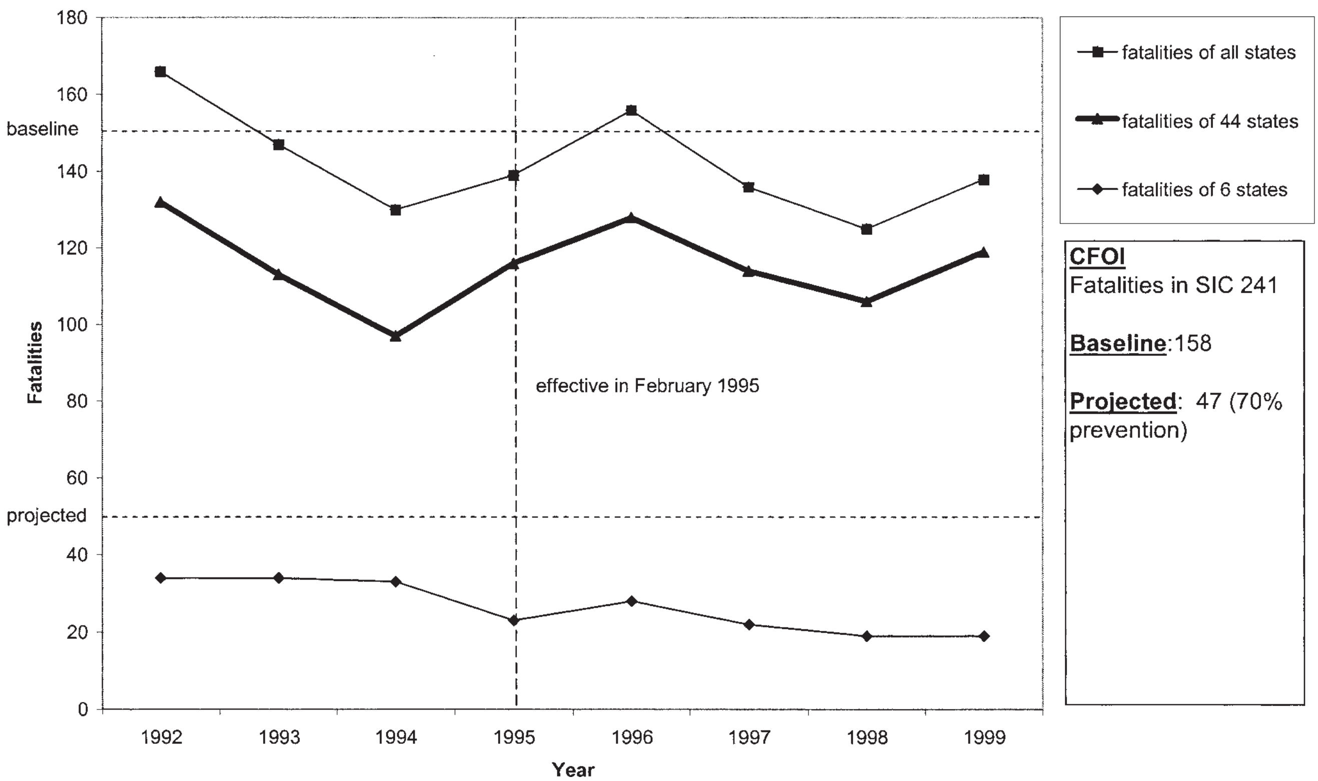

FIGURE 6. Fatalities in logging industry.

FIGURE 7. Fatality rate per 1,000 employees in logging industry.

fatalities coded by CFOI as "falls from scaffolds," FAT/CATs with the keyword of "scaffold" and NTOF-reported deaths with ICD9 E-code 881.1, "fall from scaffolding."

The 1996 scaffolding standard projected annual costs of $12.6 million per year. Over $5 million was for training workers who use scaffolds or erect or dismantle them. Almost $6 million was for scaffold inspection and about $1.5 million was for fall protection for erectors and dismantlers. Except for one provision dealing with fall protection for scaffold erectors and dismantlers, the standard's effective date was November 29, 1996.

OSHA's "Final Economic Analysis" relied for its baseline on the 1994 CFOI finding that there had been 79 scaffold-related deaths in that year. Based upon a review of FAT/CATs in 1995, OSHA identified 51 scaffold deaths. It judged that 33% of these would have been prevented by compliance with the existing standard. It also judged that all of those plus an additional 59% would have been prevented by full compliance with the new standard. Only 8%, four of the 51, were judged non-preventable. OSHA applied these percentages to the 1994 CFOI total of 79 scaffold deaths, leading to the projection that 26 deaths could have been prevented by full compliance with the existing standard and an additional 47 by full compliance with the new standard.

The standard is not limited to preventing falls from scaffolds; some provisions deal with preventing falling objects from injuring workers on scaffolds; others with avoiding contact with electrical current. However, the CFOI report showed that 72 (91%) of the 79 scaffold-related deaths in 1994 were due to falls from scaffolds. For that reason, we used the category of falls from scaffolds to track the effects of the standard. If we apply the 59% reduction factor to the 72 fatal falls from scaffolds, we get a projected reduction of 42 deaths.

Figure 8 shows that the number of these deaths was only four lower in 2000 than it had been in 1996. However, when we adjust for changes in the number of construction workers, we see in Figure 9 that there was a 21% decline in the fatality rate for falls from scaffolds from 1996 to 2000. The variability in these rates should lead us to avoid heavy reliance on any particular year to year comparison. Again, however, it seems clear that the decline in the number and rate for deaths due to falls from scaffolds in 2000 remained much smaller than the level projected by OSHA when the standard was promulgated in 1996.

DISCUSSION

In Table III, we summarize our findings about the accuracy of (a) the baseline number of fatalities; (b) the percentage of those deaths that will be prevented (the prevention factor); and (c) the overall estimate of the number of deaths prevented, which is a function of the first two. In the earlier standards, the baseline numbers were usually overestimated,

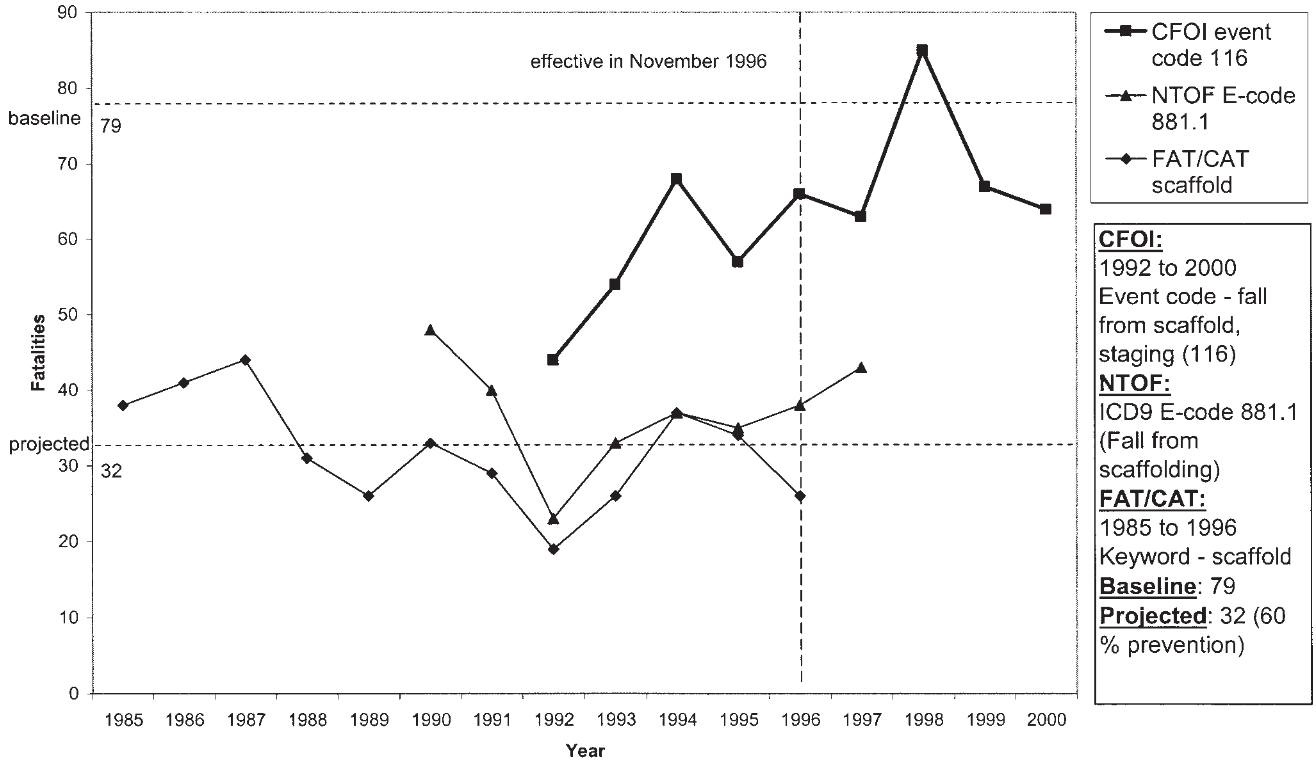

FIGURE 8. Scaffold-fatalities in construction industry.

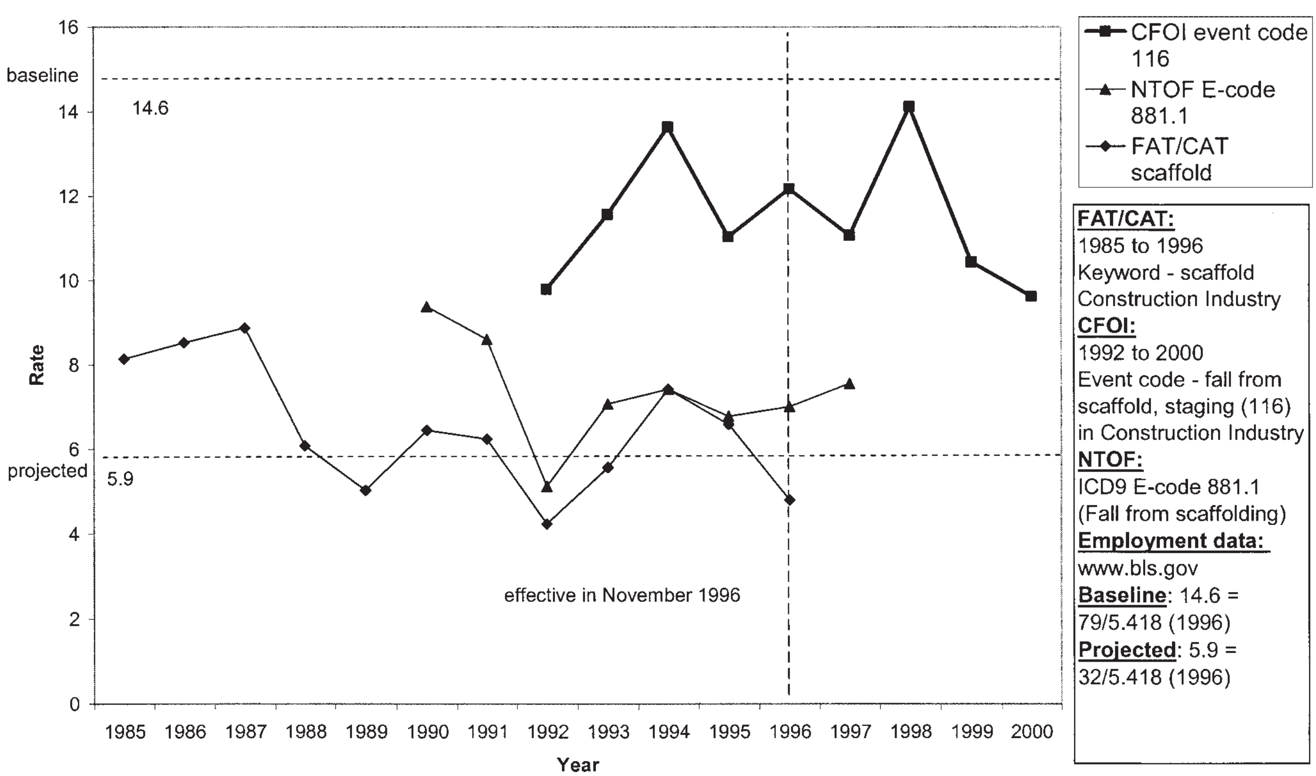

FIGURE 9. Scaffold-fatality rate per million employees in construction industry.

TABLE III. The Accuracy of the Projections of Deaths Prevented by New OSHA Safety Standards

Standard	Accuracy of baseline number	Accuracy of prevention factor	Accuracy of projection of deaths prevented
Electrical safety related work practices	Overestimated	Overestimated	Overestimated
PSM of highly hazardous chemicals; explosives and blasting agents	Overestimated	Overestimated	Overestimated
Permit-required confined spaces	Probably Accurate	Somewhat overestimated	Somewhat overestimated
Electric power generation, transmission, and distribution; electrical protective equipment	Accurate	Overestimated	Overestimated
Logging operations	Accurate	Greatly overestimated	Greatly overestimated
Safety standards for scaffolds used in the construction industry	Accurate	Overestimated	Overestimated

but subsequent use of CFOI has led to greater accuracy. Prevention factors were always overestimated, as were the total projections of the number of deaths prevented.

We need to keep in mind that the long-term trend in work fatalities and fatality rates has been downward, although that trend appears to have moderated at least since CFOI began tracking deaths in 1992. Thus, even when we do find declines in fatalities, the changes may not be the result of the new standards. Nevertheless, it is important to note that for most of our six standards, there have been notable reductions in the number of deaths occurring and that the OSHA standards may well have contributed to those reductions.

Other than controlling for employment changes, we generally did not examine other factors that might have affected deaths. However, for the three industry-specific standards (electric power generation, logging, and scaffolds), we did contact knowledgeable individuals in those industries to ask whether there had been other changes in the industry that might have had significant effects on fatalities.[4] For electric power and scaffolds, the answer was ‘‘no.’’ For logging, both respondents indicated that a major change had been a growth in the use of mechanized cutting and trimming procedures, a change, which should have reduced fatalities further. So paradoxically, the only case where we found clear evidence of technological changes that were believed to be safety-enhancing was for logging, where we see no evidence of any decline in fatalities.

Why has OSHA usually overestimated the effects? One point that OSHA staff emphasized in response to these findings was that the figures they produce should not be viewed as ‘‘predictions;’’ rather, they are estimates of what the impact would be if there were full compliance with the standard.

OSHA staff is well aware that there is not full compliance with OSHA standards. However, despite its lack of realism, the assumption of full compliance seems generally reasonable given the task that the regulatory analysts face. OSHA is required by statute to demonstrate that its standards are technologically and economically feasible, and this demonstration must be made under the assumption that there is full compliance. And if costs are estimated under this assumption, then calculations of the benefits these costs would generate should arguably use it as well.

However, there is a point at which the full compliance assumption does go beyond reasonableness. OSHA appears to assume that if a standard requires workers to avoid working in a hazardous manner or provides them training to change their behaviors, then all such unsafe behavior will be eliminated. This assumption creates the potential for estimating unrealistically large reductions in injuries. When training and work practices are major components of a standard, OSHA should be required to analyze their impacts in a more deliberative and realistic fashion.

But this admonition is a rather empty one in the absence of better scientific understanding. What, for example, can we expect to result from training? What percentage of those trained can be expected to change particular types of behavior? Without a stronger research base, these questions cannot be answered. OSHAs relatively weak commitment to research, even research applied directly to its mission, has not served it well here.

An important issue is to what extent overestimates of the prevention factor occur because the standard really was not very effective and to what extent they occur because employers did not comply with it. Both probably play some role, but the relative importance matters because the implications for policy could be quite different. Stronger enforcement could be called for if noncompliance dominates, but might not be appropriate if compliance had little preventive value. We are not able to provide further insight here. However, OSHA should examine its data on non-compliance with these standards to try to gain greater insights. It should also investigate why there appears to be variation among the standards, with less impact for the scaffold and, especially, the logging operations standards.

[4] These were Chuck Kelly, Director of Safety, Edison Electric Institute; Steve Jarvis, Director of Forest Program, Forest Resources Association; Robert H. Shaffer, Professor of Forestry Operations, Virginia Tech University; and David Glabe, Secretary of the Scaffold Industry Association.

A possible factor affecting OSHA's accuracy is the scrutiny given to its analyses by both the Office of Management and Budget (OMB) and by the courts. When such scrutiny is lacking, it is likely that the pressures to make the analysis cogent are weaker. Standards with expected costs below $100 million per year are not required to have RIAs and OMB is not required to review them. Typically, safety standards are cheaper than health standards, and less likely to be challenged and reviewed in the courts. Therefore, the small safety standards, which comprise the bulk of our sample, may represent the least well-justified analyses of impacts. Our small sample is not adequate to provide a good test, but it is suggestive that Table III indicates that the most accurate projection was for the $200 million per year confined spaces standard, while the least accurate was for the $12 million per year logging operations standard. On the other hand, low cost standards tend to be those that emphasize training requirements, whose effects, we have seen, tend to be overestimated. Therefore, it is not clear what role greater scrutiny, by itself, plays.

Steps Toward Greater Accuracy

For the objective of producing more accurate estimates, we need to inquire further into the factors that generate bad estimates and into what, if anything, might be done about them. The magnitude of the projected effect is a function of two factors: the baseline estimate and the ''prevention factor'' (i.e., the percentage of the baseline numbers that OSHA believes will be prevented).

We saw in several cases that the baseline selected by OSHA appeared to be too high. Prior to the establishment of CFOI, OSHA lacked a good source of data about fatality characteristics and incidence. Unlike CFOI, the BLS Survey provided little detail and clearly underreported deaths, especially at small establishments, which have the highest death rates. OSHA and its contractors often relied on making adjustments to the FAT/CAT numbers. We found extrapolations that ranged from 1.5 to 2.25 for establishing the baseline. Based on the limited comparison, we did for the electrical work practices standard, the low end of that range was probably more appropriate. Now that the CFOI is available, overestimates of the baseline appear to be less of a problem. CFOI provides useful information on fatality types, but it is still too imprecise to be as useful as OSHA often needs. For example, if a standard applied only to a particular type of scaffold, not all scaffolds, CFOI would probably not be able to discriminate.

More troubling are the estimates of the ''prevention factor.'' In general, we found little persuasive evidence provided to justify OSHA's calculations. In a number of cases, there are circular references to the ''prevention factors'' used for other standards, implying that if it was plausible there, it should be plausible here as well. For example, OSHA applied an 80 % effectiveness rate for the reduction of baseline fatalities and injuries in the RIA of the PSM standard because (p.v-7) ''the prevention rate is consistent with sensitivity analysis estimates used in previous regulatory analyses like the electrical work practices standard, lockout/tagout standard, and confined spaces standard.''

When a serious effort was made to estimate the effect, it generally relied upon a review of the FAT/CAT database. Reviewers would try to answer the question of whether the provisions of the new standard would have prevented the fatalities, which occurred in affected workplaces. Unfortunately, these judgments are not easy to make and depend greatly on the assumptions that the reviewer brings to the task. The case of training provisions, cited above, is probably the most egregious example. Although OSHA does often cite experiences at individual establishments, which often report dramatic reductions, it makes no effort to assess the representativeness of those experiences. In contrast, there were no references to any effort to evaluate the effects on injuries in states that had adopted similar standards in earlier years, which would potentially seem to provide a more valid basis for projecting effects. In fairness, however, we should note that good evaluations of these programs are often not easy to carry out.

We should note that in one of its more recent standards, for Powered Industrial Truck Operator Training, issued in December, 1998, OSHA stated that it ''had adopted a more conservative methodology for estimating the number of fatalities and injuries that could be prevented by the final standard'' [U.S. Department of Labor, Occupational Safety and Health Administration, 1998]. There it projected that only 11 of the annual toll of 101 industrial truck-related fatalities would be prevented by the standard. However, because OSHA also acknowledged that ''about 75% of affected establishments currently provide training that is equivalent, or nearly equivalent, to that required by the final standard,'' the degree of conservatism may be less than that implied by OSHA.

Finally, it seems clear that more attention needs to be focused on the problems of predicting the effects of new safety standards on non-fatal injuries. Here, it turns out that some of the more insightful analyses were found in older, not newer, RIAs. The reason was that they utilized data sources that OSHA and the BLS discontinued in the late-1980s. One of these, labeled Work Injury Reports, came from a program that followed-back a sample of injured workers to learn more about events related to their injuries. The Department of Labor should consider restoring this program or find other methods for obtaining better data. One method that might be considered would be to ''piggy-back'' a team of analysts onto one or two state WC data programs. OSHA could identify a set of hazards for which it was considering new standards. The analysts would review injury reports related to those hazards. Specifically, they might follow-back (by telephone or through visits) to learn the details of the injuries—for example, the specific equipment involved, the level of training, the use of personal protective equipment—in order to develop better estimates of the likely effects of the new standards.

The importance of developing better sources of data and devoting resources to analyzing them deserves a high priority. OSHA and other safety agencies face difficult analytic challenges in projecting what the consequences of new rules will be.

Some of the limitations of this study must be emphasized. First, we did not include standards where OSHA had predicted that only a small number of fatalities would be prevented. The pattern in those cases might be different. Second, we looked only at effects on fatalities, not at nonfatal injuries. Third, and probably most important, our research designs are simple and assume, on no evidence or anecdotal evidence, that controls for other influences on the fatality rate are not needed. Thus, for example, the findings may be sufficient to rule out a 70% decline, but not necessarily a 10 or 20% decline.

Despite these limitations, we believe that the pattern of findings does suggest that the likely effects are smaller than projected and that the disparities should elicit both efforts to improve the accuracy and efforts to better understand the causes of the disparities.

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REFERENCES

Hahn RW. 1996. Regulatory reform: What do the government's numbers tell us? In: Hahn RW, editor. Risks, costs, and lives saved. New York: Oxford University Press. p 208–254.

Harrington W, Morgenstern RD, Nelson P. 2000. On the accuracy of regulatory cost estimates. J Policy Anal Manage 19:297–322.

Heinzerling L. 1998. Regulatory costs of mythic proportions. Yale Law J 107:1981–2070.

Marsh SM, Layne LA. 2001. Fatal injuries to civilian workers in the United States, 1980–1995. DHHS/NIOSH Pub. No. 2001–1295.

Mendeloff JM. 1988. The dilemma of toxic substance regulation. MIT Press: Cambridge. p 53–72.

Mendeloff J. 2003. Regulatory approaches to preventing workplace injury. In: Sullivan T, Franks JW, editors. Reducing work-related disability: A reader. London: Taylor and Francis.

Morrall JF III. 1986. A review of the record. Regulation, November–December, 1986.

National Research Council. 1987. Counting injuries and illnesses in the workplace: Proposals for a better system. Washington, DC: National Academy Press.

Suruda A, Whitaker B, Bloswick D, Phillips P, Sesek R. 2002. Impact of the OSHA trench and excavation standard on fatal injury in the construction industry. J Occup Environ Med 44:902–905.

U.S. Congress, Office of Technology Assessment. 1995. Gauging control technology and regulatory impacts in occupational safety and health: An appraisal of OSHAs analytic approach. Washington, DC: Government Printing Office.

U.S. Department of Commerce, County Business Patterns. 2002. www.census.com.

U.S. Department of Labor, Bureau of Labor Statistics. 2003a. Census of fatal occupational injuries. www.bls.gov/iif/oshcfoil.htm.

U.S. Department of Labor, Bureau of Labor Statistics. 2003b. Survey of occupational injuries and illnesses. www.bls.gov.

U.S. Department of Labor, Occupational Safety and Health Administration. 1987. Preliminary regulatory impact and regulatory analysis of the proposed electrical safety-related work practices standard for general industry (29 CFR 1910, subpart S).

U.S. Department of Labor, Occupational Safety and Health Administration. 1988. Preliminary Regulatory Impact Analysis of the revisions to the pulpwood logging standard (29 CFR 1910.266).

U.S. Department of Labor, Occupational Safety and Health Administration. 1992. Final regulatory impact and regulatory flexibility analysis of the final standard for process safety management of highly hazardous chemicals (section 1910.119, subpart H).

U.S. Department of Labor, Occupational Safety and Health Administration. 1992. Final regulatory impact and regulatory flexibility analysis of the permit-required confined spaces standard (29 CFR part 1910.246).

U.S. Department of Labor, Occupational Safety and Health Administration. 1993. Final economic analysis of the electric power generation, transmission, and distribution standard (29 CFR part 1910.146).

U.S. Department of Labor, Occupational Safety and Health Administration. 1994. Regulatory Impact Analysis for the revisions to the pulpwood logging standard (29 CFR 1910.266).

U.S. Department of Labor, Occupational Safety and Health Administration. 1996. Final economic analysis of OSHAs final rule for scaffolds in the construction industry (29 CFR 1926.450–454).

U.S. Department of Labor, Occupational Safety and Health Administration. 1998. Powered industrial truck operator training. 63 FR 66237.

U.S. Department of Labor, Occupational Safety and Health Administration. 2000. Section 610 and executive order 12886 review of the control of hazardous energy sources (lockout/tagout) standard 29 CFR 1910.147.

U.S. Department of Labor, Occupational Safety and Health Administration. 2003a. "Regulatory review of OSHAs grain handling facilities standard".

U.S. Department of Labor, Occupational Safety and Health Administration. 2003b. Accident investigation file. www.osha.gov/cgi-bin/inv/inv1.