A framework for evaluating OSH program effectiveness using leading and trailing metrics

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ABSTRACT

Introduction: Many employers and regulators today rely primarily on a few past injury/ illness metrics as criteria for rating the effectiveness of occupational safety and health (OSH) programs. Although such trailing data are necessary to assess program success, they may not be sufficient for developing proactive safety, ergonomic, and medical management plans. *Methods:* The goals of this pilot study were to create leading metrics (company self-assessment ratings) and trailing metrics (past loss data) that could be used to evaluate the effectiveness of OSH program elements that range from primary to tertiary prevention. The main hypothesis was that the new metrics would be explanatory variables for three standard future workers compensation (WC) outcomes in 2003 (rates of total cases, lost time cases, and costs) and that the framework for evaluating OSH programs could be justifiably expanded. For leading metrics, surveys were developed to allow respondents to assess OSH exposures and program prevention elements (management leadership/ commitment, employee participation, hazard identification, hazard control, medical management, training, and program evaluation). After pre-testing, surveys were sent to companies covered by the same WC insurer in early 2003. A total of 33 completed surveys were used for final analysis. A series of trailing metrics were developed from 1999-2001 WC data for the surveyed companies. Data were analyzed using a method where each main 2003 WC outcome was dichotomized into high and low loss groups based on the median value of the variable. The mean and standard deviations of survey questions and 1999-2001 WC variables were compared between the dichotomized groups. Hypothesis testing was performed using F-test with a significance level 0.10. *Results/Discussion:* Companies that exhibited higher musculoskeletal disorder (MSD) WC case rates from 1999-2001 had higher total WC case rates in 2003. Higher levels of several self-reported OSH program elements (tracking progress in controlling workplace safety hazards, identifying ergonomic hazards, using health promotion programs) were associated with lower rates of WC lost time cases in 2003. Higher reported exposures to noise and projectiles were also associated with higher rates of WC cases and costs in 2003. *Impact on Industry:* This research adds to a growing body of preliminary evidence that valid leading and trailing metrics can be developed to evaluate OSH effectiveness. Both the rating of OSH efforts and the regular trending of past loss outcomes are likely useful in developing data-driven improvement plans that are reactive to past exposures and proactive in identifying system deficiencies that drive future losses.

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1. Introduction

Many occupational safety and health (OSH) personnel, workers compensation (WC) insurance carriers, and governmental regulators today rely solely on a few past injury/illness data metrics (incidence/ severity rates and experience ratings) to assess the effectiveness of OSH programs. These types of data are necessary but may not be sufficient for developing proactive safety, ergonomic and medical management plans. To build a framework for improved OSH benchmarking, it is useful to define the overall goals of an OSH program, which include primary through tertiary prevention (Brewer et al., 2007; Habeck, Hunt, & VanTol, 1998; Hunt, Habeck, VanTol, & Scully, 1993; NIOSH, 1997). OSH metrics can therefore be characterized as measures of the following activities:

- Loss Prevention (Pre-Loss)

  - Activities to protect against the occurrence of injury/illness and disability (also known as *Primary Prevention*)

- Loss Reduction (Post-Loss)

  - Activities to identify and detect injury/illness in the earliest stages when successful treatment is most likely (*Secondary Prevention*)
  - Activities to treat injuries/illnesses early to limit disability through rehabilitation and to promote timely return-to-work (*Tertiary Prevention*)

Most OSH program metrics can be further differentiated as leading or trailing. Leading metrics typically represent self-assessment ratings of a company's exposure to safety hazards or musculoskeletal disorder (MSD) risk factors and safety, ergonomic, or medical management activities. These metrics can indicate why incidents have occurred in the past and may be predictive of future losses, since they represent potential systematic causes of injury occurrence and severity (Akbar-Khanzadeh & Wagner, 2001; Amick et al., 2000, 2004; Cullen et al., 2005; Fernandez-Muniz, Montes-Peon, & Vazquez-Ordas, 2009; Habeck et al., 1998; Hunt et al., 1993; Iyer, Haight, Del Castillo, Tink, & Hawkins, 2005; Neal & Griffin, 2006; Shannon et al., 1996; Shannon, Mayrc, & Haines, 1997). Addressing leading factors may help develop more proactive OSH programs. These types of metrics may also have several drawbacks such as a potential lack of reliability, vulnerability to respondent bias, and unproven predictive validity.

Trailing metrics are typically measures of the frequency and severity of past injuries/ illnesses, such as injury rates and WC costs. These types of metrics are reflective of what has occurred, but may not necessarily be predictive of future losses. Trailing metrics also are often difficult to track effectively, due to the random variability of injury/illness rates, skewed nature of WC costs, and protracted payout of WC claims (Hashemi, Webster, & Clancy, 1998b; Hashemi, Webster, Clancy, & Courtney, 1998a; Hashemi, Webster, Clancy, & Volinn, 1997; Hauer, 1986). An additional problem with focusing solely on trailing metrics is that all remedial steps are necessarily reactive.

In summary, metrics for OSH program effectiveness can be characterized as one of four main types: leading-prevention, leading-reduction, trailing-prevention, or trailing-reduction. Aspects of this expanded evaluation framework are generalized in Table 1.

2. Methods

The specific aims of this pilot study were to compile leading and trailing loss prevention/ loss reduction metrics that could be readily used by OSH personnel to monitor program effectiveness and test the association between the metrics and standard future loss outcomes. The overall hypothesis was that all metric types (leading-prevention, leading-reduction, trailing-prevention, and trailing-reduction) would be shown to be correlated with future WC losses and that the development and use of the metrics in an expanded framework may be justifiably encouraged among OSH personnel.

2.1. Explanatory Variables

2.1.1. Survey assessments

The first step in developing leading metrics was to define the key elements of OSH loss prevention/ loss reduction programs. A number of safety and health organizations (including the United States Occupational Safety and Health Administration [OSHA], the National Institute for Occupational Safety and Health [NIOSH], and the American Industrial Hygiene Association [AIHA]), various U.S. state workers compensation bureaus (Ohio and Minnesota), and business management organizations (including the International Organization for Standardization [ISO], 1996 and the British Standards Institute [BSI], 1996) have developed models for OSH program components. Although there are distinct differences between program systems, a literature review indicated that most system components could be grouped into seven main program elements using nomenclature adapted from the OSHA Voluntary Protection Program (VPP; OSHA, 2008) and the NIOSH ergonomics program (NIOSH, 1997). These elements include: (a) Management Leadership, Commitment, and Communication, (b) Employee Participation, (c) Hazard Identification and Assessment, (d) Hazard Prevention and Control, (e) Medical Management, (f) Training, and (g) Program Evaluation. The next step was to find suitable survey instruments that could be used to assess OSH practices, policies, and procedures that captured the above essential loss prevention/ loss reduction elements. Below is a summary review of several contemporary instruments.

Hunt et al. (1993) developed a comprehensive questionnaire to evaluate a company's OSH loss prevention and loss reduction efforts for safety, ergonomics, disability management, and health promotion. The survey was used in a cross sectional study of 220 Michigan companies that found correlations between reported safety/ return-to-work practices and disability outcomes. Unfortunately, this promising survey and study was only published initially as a technical report submitted by the Upjohn Institute to the Michigan Department of Labor and was not considered during the development of the current study. The measures of organizational policies and procedures developed by Hunt et al. (1993) were later reported by Habeck et al. (1998) and Amick et al. (2000). Subsets of the measures have also been used in a number of more recent studies (Amick et al., 2004; Cullen et al., 2005; Cullen, Silverstein, & Foley, 2008; Ossmann et al., 2005; Steenstra et al., 2010; Williams, Westmorland, Shannon, & Amick, 2007).

In 1995, OSHA developed the Program Evaluation Profile (PEP, Form OSHA-195), a scored questionnaire to evaluate an employer's worksite

Table 1
Types of Metrics for OSH Programs.

	Loss Prevention (Pre-Loss) • Goal is to reduce injury/illness frequency • Focus on injury/illness causes	Loss Reduction (Post-Loss) • Goal is to reduce injury/illness severity • Focus on injury/illness disability drivers
Leading - Self-rating measures	**Leading Prevention** • Measures of a company's present/ future efforts to eliminate or prevent injuries/ illnesses • Semi-quantitative • Ratings of general safety, industrial hygiene and ergonomic management policies, practices, and procedures • Specific measures of hazards, behaviors, and controls (e.g. compliance checklists, behavior-based safety ratings, assessments of control effectiveness)	**Leading Reduction** • Measures of a company's present/ future efforts to minimize impairment and disability due to existing injuries/ illnesses • Semi-quantitative • Ratings of medical management policies, practices, and procedures (designed to ensure early detection, prompt treatment, and timely recovery)
Trailing - Measures of past injuries/ illnesses	**Trailing Prevention** • Measures of a company's past outcomes in eliminating or preventing injuries/ illnesses • Quantitative • Specific measures of injury incidence (e.g. injury/ illness rates)	**Trailing Reduction** • Measures of a company's past outcomes in minimizing impairment and disability due to injuries/ illnesses • Quantitative • Specific measures of injury disability and cost management (e.g. workers compensation case severity and costs, case progression metrics)

safety and health program. The main reason for the development of the PEP was to provide a consistent method for compliance officers to use for thoroughly documenting employers' safety and health programs in case files. LaMontagne et al. (2004) found the form was sensitive as an outcome measure for a before and after OSH intervention study involving 15 manufacturing sites. In a similar study, Barbeau et al. (2004) found the PEP appropriate for use at smaller worksites for assessing OSH program effectiveness. It is not clear whether the PEP was ever evaluated for reliability or validity since no other peer reviewed studies using the PEP were found. OSHA also developed Form 33, a benchmarking survey consisting of 25 indicators, each with a score of 0 (lowest) to 4 (highest) to evaluate a portion of the OSH program. A cross-sectional study (Akbar-Khanzadeh & Wagner, 2001) demonstrated the potential validity of Form 33 as used by the Ohio Bureau of Employment Services. A cross sectional analysis of 107 assessments that were completed by Ohio bureau consultants from 1995 to 1996 indicated that the numbers of serious and regulatory OSHA violations were significantly correlated to all 25 indicators. No additional peer-reviewed studies with Form 33 were found. Both the PEP and Form 33 questionnaires are used to evaluate only primary loss prevention OSH elements, and do not address loss reduction elements (i.e. disability management).

In 1998, as an effort to integrate the measurement of many of the existing OSH program models, researchers developed the Michigan Universal Assessment Instrument (UAI; Redinger & Levine, 1998). The survey was later released as an AIHA commercial publication (Redinger & Levine, 1999) and subsequent studies indicated the UAI had been qualitatively validated and that future studies were planned (Redinger, Levine, Blotzer, & Majewski, 2002a,b). No additional peer-reviewed studies with the UAI were found. Like the OSHA instruments, the UAI is used to evaluate mainly primary loss prevention OSH elements.

In summary, at the time the current study was being developed (2001), there were relatively few open-source tools for rating the effectiveness of safety programs for both loss prevention and loss reduction. Even fewer of these tools had been rigorously evaluated for reliability and validity. For these reasons, authors of the current study developed a new survey instrument that focused on OSH practices, policies, and procedures that captured essential loss prevention/ loss reduction elements from the OSHA VPP (OSHA, 2008) and the NIOSH ergonomic programs (NIOSH, 1997). Questions were developed to allow respondents to self-rate the extent of such OSH elements using 5-point scales. Questions were also developed to rate exposures to common MSD risk factors and safety hazards using 5-point scales. An initial survey was pre-tested using a group of OSH contacts insured by

the same WC carrier. Eight of 20 surveys mailed during late 2002 were returned. A number of survey changes were made based on completion rates and floor-ceiling effects. Questions were grouped according to related OSH program elements or type of exposure and the internal consistency of each group was ascertained using a Cronbach's alpha of 0.60 as a benchmark for sufficient relatedness of questions (Cronbach, 1951). The final survey included 51 ratings of exposure or program elements (41 loss prevention and 10 loss reduction questions) that were used in analyses. Final surveys were sent in early 2003 to 197 manufacturing companies insured by the same WC carrier and a total of 40 completed surveys were returned. Question descriptions are available in the online electronic supplementary material for this study and additional information about questionnaire development is detailed in Wurzelbacher (2006).

2.1.2. Past WC Claims

The goal in this phase was to develop trailing metrics for both loss prevention and loss reduction. WC data sets for all companies that participated in the leading phase of this study were downloaded in late 2004 from a single private insurance carrier. A series of 10 loss metrics (4 loss prevention, 6 loss reduction) provided in Table 2 were developed from 1999–2001 WC data for each company. The three-year time period was chosen to address the variability of injury/ illness rates and to provide stable indicators of past OSH performance. This model is also used in the WC industry, where experience modification factors (that are used to set insurance premiums) are based on three years of past loss data that skips the most recent year to allow proper loss development (NCCI, 2004).

A number of trailing loss prevention metrics similar to those commonly required by OSHA and reported by the U.S. Bureau of Labor Statistics (BLS; such as rates for total case incidence and rates for cases involving days away from work or restricted duty) were first generated. Since prior research indicated that MSD cases in particular may drive incidence and cost in some industries (Hashemi et al., 1997; Hashemi et al., 1998a,b), a series of MSD-related metrics were next created. All data were coded to designate entries as MSDs versus non-MSDs according to an adapted version of the BLS definition for MSDs (BLS, 2010). Finally, several trailing loss reduction metrics that are commonly collected in the WC industry and that are intended to rate past performance in detecting and treating injuries/ illnesses early to promote timely return-to-work were developed (see Table 2). Since past studies have indicated that WC costs vary by geographical state

Table 2
Trailing metrics from 1999–2001 WC data used as explanatory variables.

Metric Type	Metric	Description
Loss Prevention	WC Case Rate	• Rate of all WC cases per 100 full time employees (FTE) per year
	WC Lost Time Case Rate	• Rate of WC cases that involve lost time (indemnity) payments per 100 FTE per year
	WC MSD Case Rate	• Rate of all MSD WC cases per 100 FTE per year
	WC MSD Lost Time Case Rate	• Rate of MSD WC cases that involve lost time payments per 100 FTE per year
Loss Reduction	WC Cost per 1 FTE per Year	• Rate of all WC case incurred costs per 1 FTE per year, weighted by average cost of cases by US geographical state (UWC, 2003)
		• Incurred costs are defined to be both paid and reserved costs for medical treatments, lost time (indemnity), and other expenses
	% Costs due to MSDs	• Proportion of total incurred WC costs due to MSD WC cases
	Reporting Delay Average Days	• Average reporting delay (date of loss to the date of report) of WC cases
		• Higher delay averages may indicate potential problems with early reporting systems and employer/ employee communication systems
	% WC Cases Above $20 k	• Percentage of cases with relatively expensive total costs over $20,000
		• May represent the effectiveness of controlling high cost cases
	% Costs due to Lost Time	• Percentage of total incurred WC cost due to lost time payments
		• High percentages may indicate a lack of effective medical management practices (including return to work/ light duty etc.) to limit case disability
	% Case Open Status	• Percentage of WC cases that remain open
		• High percentages may indicate a lack of effective medical management practices to close cases in a timely manner

(Miller & Levy, 1999), all cost variables were state-weighted using published comparison data (UWC, 2003).

2.2. Outcome Variables (Future WC Claims)

Three future WC claim variables in 2003 (WC case incidence per 100 full time employees [FTE] per year, WC lost time case incidence per 100 FTE per year, and state-weighted WC cost per 1 FTE per year) were used as outcomes in this study. These variables were chosen as main outcomes because they represented some of the trailing loss metrics most commonly used by companies to track the effectiveness of their OSH programs in terms of injury/illness incidence and severity (both for worker disability and financial cost). For example, all U.S. companies are required to calculate basic injury illness incidence rates as part of completing their OSHA 300 logs (OSHA, 2010). U.S. insurance carriers also track WC cost rates as part of the process to set premiums for new policies (NCCI, 2004). In effect, all U.S. companies are judged for OSH effectiveness using at least these main outcomes. It was proposed that the utility of a new alternative metric may be determined in large part by the strength of its association to one of these standard outcomes for the incidence and severity of future injuries/illnesses.

Although 40 companies responded with completed questionnaires, only 33 complete matching WC data sets were available for downloading. This was due to the fact that several companies who responded with completed surveys did not renew WC insurance coverage with the participating carrier for the subsequent policy year and lacked complete WC data for calendar year 2003. A flow chart of the proposed association between variables for this study is provided in Fig. 1.

2.3. Statistical Analysis

Data were analyzed using a method similar to Habeck et al. (1998) that was also described by Amick et al. (2000). Each main 2003 WC claim outcome was dichotomized into high and low loss groups based on the median value of the variable (e.g., high losses ≥ the median). The mean and standard deviations of survey assessment questions and 1999–2001 past WC claim variables were compared between the dichotomized groups. Hypothesis testing was performed using F-test

with a significance level .10. All analyses were conducted in SAS version 9.2 (SAS Institute, Inc., Cary, NC).

3. Results

3.1. Survey assessments

Final leading survey completion rates were characterized by 81% of non-demographic questions having 10% or fewer missing data points. Ten percent of final questions exhibited some floor effect (mean scores less than 2 on a 5-point scale). Nineteen percent of final questions exhibited some ceiling effect (with mean scores greater than 4 on a 5-point scale). Participant companies (n = 33) were located in a total of 17 U.S. states and 8 standard industrial classifications for manufacturing (SIC codes 28, 30, 33–37, 39). The mean number of production employees at participant companies was 234 (range: 5 to 2,300). Summary statistics for outcome variables are provided in Table 3.

The results for the association analysis between explanatory variables and outcomes are provided in Tables 4–6. The leading indicators most associated (p<.05) with loss outcomes as hypothesized are summarized below.

Associated with Lower Future WC Losses:

- Hazard control tracking
  o "My company tracks progress in controlling workplace hazards"
- Health promotion programs
  o "My company has an Employee Health Promotion Program designed to improve the physical fitness of all employees"
- Ergonomic hazard identification
  o "My company gathers data to identify jobs or work conditions that are most hazardous, ergonomically-speaking, using sources such as worker reports of discomfort, injury and illness logs, medical records, or job analyses"

Associated with Higher Future WC Losses:

- Reported noise exposure (greater than 85 dBA)
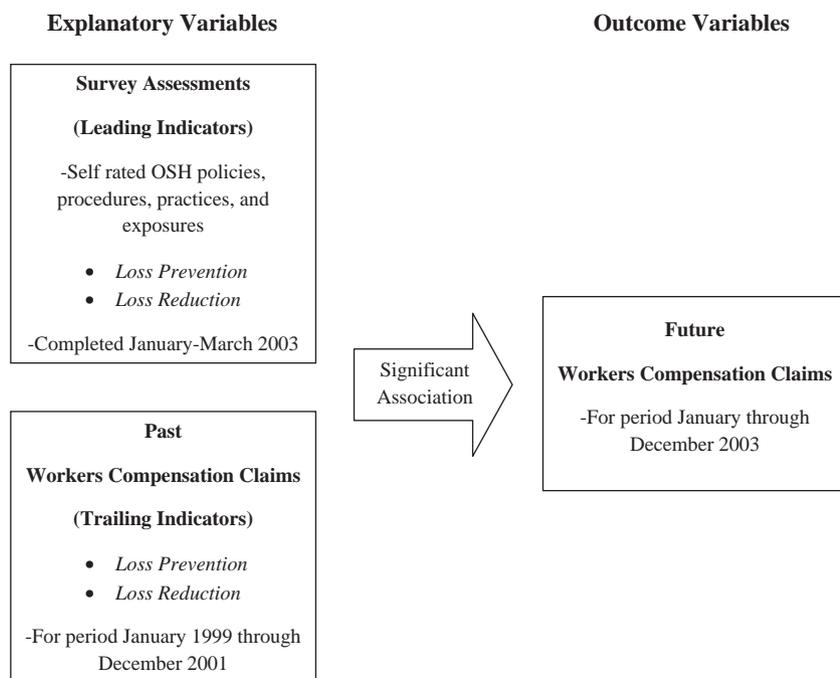- Reported projectiles exposure (eye injury potential)

Explanatory Variables   **Outcome Variables**

Fig. 1. Flow chart of the proposed association between variables for 33 companies which completed assessment questionnaires.

Table 3
Outcome metric summary statistics (n = 33).

Outcome Variable	Mean	Median	SD	Range
WC Case Rate per 100 FTE	18.4	9.0	18.8	0.5 to 78.3
WC Lost-Time Case Rate per 100 FTE	2.6	1.6	3.3	0.3 to 14.3
WC Total Incurred Cost Rate per 1 FTE	$951	$271	$1,876	$2 to $9,655

There were some additional metrics that were associated (p<.05) with outcomes in 2003, but not in the direction hypothesized. For instance, companies that reported higher greater slip, trip, and fall exposures had lower lost time WC case rates. Also companies that reported certain medical management features (e.g., work-conditioning programs and encouragement of health care providers to become familiar with job tasks) had higher WC case and lost time WC case rates.

3.2. Past WC Claims

The results for the association analysis between explanatory variables and outcomes are provided in Tables 4–6. Overall, the trailing indicator most associated (p<.05) with higher future loss outcomes as hypothesized was "WC MSD Case Rate per 100 FTE per Year (1999–2001)."

4. Discussion

4.1. Survey assessments

Several leading metrics in this pilot study were shown to be potentially usable and valid benchmarks for future OSH effectiveness. Questionnaires generally had acceptable rates of completion, and five questions were associated (p<.05) with standard future loss outcomes as hypothesized. The results of the current pilot study are consistent with those of several other researchers who demonstrated that higher self-reported primary loss prevention OSH policies, procedures, and practices correlated to lower incidence and severity of past company injury/ illness outcomes (Cullen et al., 2005; Hunt et al., 1993; Shannon et al., 1996; Shannon et al., 1997) and lower incidence and severity of future individual and company injury/ illness outcomes (Amick et al., 2000; Amick et al., 2004; Fernandez-Muniz et al., 2009; Iyer et al., 2005). Together these studies indicate that a wide variety of primary loss prevention activities (ranging from traditional safety and ergonomic approaches to wellness initiatives) are effective in reducing losses and corresponding assessment metrics for these activities should be used to optimize overall OSH programs.

In particular, the current research found that higher ratings of "hazard control tracking" ("My company tracks progress in controlling workplace hazards") and ergonomic hazard identification ("My company gathers data to identify jobs or work conditions that are most hazardous, ergonomically-speaking, using sources such as worker reports of discomfort, injury and illness logs, medical records, or job analyses") were highly associated with reduced future lost time WC rates at a company level. Conversely, this study also found that higher self-reported exposures to noise and projectiles were associated with increased company WC rates and costs. These findings are similar to Hunt et al. (1993), which indicated that higher self-ratings of "safety diligence," including "timely investigation of risks and accidents that uses problem solving for immediate correction and future prevention" were associated with 17% fewer past lost work days at a company level. Cullen et al. (2005) also found that higher safety diligence measures developed by Hunt et al. (1993) were associated with reduced past disability incidence at an organizational level for schools. Other researchers (Amick et al., 2000) determined that grouped items related to safety diligence and ergonomic practices from an employee version of the survey questionnaire developed by Hunt et al. (1993) were strong predictors of successful future return-to-work in individual carpal tunnel patients. Further, Fernandez-Muniz et al. (2009) demonstrated that self-reported primary loss prevention OSH practices and procedures predicted financial performance in a prospective multi-sector study with 455 companies. Iyer et al. (2005) determined that the self-reported level of effort applied to OSH programs was predictive of future injury/illnesses for forestry operations of a single large electricity distribution company. An interpretation of results from the above

Table 4
Means and standard deviations of explanatory variables for high and low WC case rate groups in 2003.

Metric Type	OSH Program Element	Scale Type	Metric Description	High Mean	High SD	Low Mean	Low SD	P-value
Trailing Prevention	Hazard Control	A	WC MSD Case Rate per 100 FTE per Year (1999–2001)	8.3	4.5	4.8	3.7	0.02*
Leading Prevention	Hazard Control	B	Exposure to lifting more than 75 pounds at any one time; more than 55 pounds more than 10x per day; or more than 25 pounds below the knees, above the shoulders, or at arm's length more than 25x per day	2.1	1.0	1.6	0.5	0.09*
		B	Noise (greater than 85 dBA) Exposure	3.1	1.2	1.6	0.9	0.00*
		C	Projectiles (Eye Injury Potential) Level of Control	3.7	1.3	4.4	0.6	0.06*
		C	Machinery Pinch Points Level of Control	3.5	1.3	4.2	0.7	0.08*
		D	My company controls job hazards as well as can be expected for the operations performed	3.9	0.7	4.4	0.7	0.09*
		D	In the last 3 years, my company has changed the way materials, parts, or products are transported to reduce manual material handling. (Examples might include: using mechanical assist devices)	4.2	1.0	3.3	1.4	0.05
		D	In the last 3 years, my company has changed tool designs to improve hand/body posture or reduce force. (Examples might include: pistol handle grips for knives or squeeze-grip-actuated screwdrivers)	3.6	1.3	2.7	1.4	0.06
Leading Reduction	Medical Management	D	My company has a work hardening or work-conditioning program to prepare new employees for the level of physical exertion required for particular production positions.	2.3	1.4	1.4	0.5	0.01
		D	My company's health care providers (HCP) have experience in medically evaluating and treating WMSDs.	3.9	1.1	3.1	1.5	0.08

Scale Key:
• A = injury illness rate (0 to 100+).
• B = Number of Production Employees Exposed (1 = none, 2 = some, 3 = half, 4 = most, 5 = all).
• C = Rating scale (1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent).
• D = Visual analog Likert scale anchored by 1 = Strongly Disagree, 5 = Strongly Agree.
Notes: dF = 31 for all items except for "My company has a work hardening…", where dF = 30; * indicates trend is in the direction hypothesized.

Table 5
Means and standard deviations of explanatory variables for high and low WC lost time case rate groups in 2003.

Metric Type	OSH Program Element	Scale Type	Metric Description	High Mean	High SD	Low Mean	Low SD	P-value
Trailing Prevention	Hazard Control	A	WC MSD Lost Time Case Rate per 100 FTE per Year (1999–2001)	1.9	1.9	0.9	1.0	0.08*
Trailing Reduction	Medical Management	E	WC Cost per 1 FTE per Year (1999–2001)	$1078	$1252	$476	$447	0.08*
Leading Prevention	Hazard Identification	D	My company investigates "close calls" (incidents in which employees almost were injured, but were not).	3.3	1.6	4.1	1.0	0.09*
		D	My company gathers data to identify jobs or work conditions that are most hazardous, ergonomically-speaking, using sources such as worker reports of discomfort, injury and illness logs, medical records, or job analyses.	3.1	1.5	4.0	0.9	0.04*
	Hazard Control	C	Overall, how would you rate your company's safety program?	3.5	0.7	4.1	1.0	0.09*
		C	Overall, how would you rate your company's ergonomics program?	2.6	1.0	3.4	1.1	0.05*
		D	My company maintains tools and equipment as needed for safety	4.2	0.9	4.6	0.5	0.08*
		D	My company tracks progress in controlling workplace hazards.	3.3	1.3	4.4	0.7	0.00*
		B	Airborne Pollutants (e.g. weld fume/ dust) Exposure	2.5	1.1	3.3	1.2	0.08
		B	Slips, Trips, and Falls Exposure	3.4	1.4	4.4	0.8	0.02
	Health Promotion	D	My company has an Employee Health Promotion Program designed to improve the physical fitness of all employees.	1.9	1.3	3.2	1.5	0.02*
Leading Reduction	Medical Management	C	Overall, how would you rate your company's medical management program (programs designed to prevent impairment and disability associated with injuries through early detection, prompt treatment, and timely recovery)?	2.8	1.0	3.6	1.3	0.07*

Scale Key:
• A = Injury illness rate (0 to 100+).
• B = Number of Production Employees Exposed (1 = none, 2 = some, 3 = half, 4 = most, 5 = all).
• C = Rating scale (1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent).
• D = Visual analog Likert scale anchored by 1 = Strongly Disagree, 5 = Strongly Agree.
• E = Cost rate per employee per year in US dollars (0 to unlimited).
Notes: dF = 31 for all items except for "My company investigates close calls…", where dF = 30; * indicates trend is in the direction hypothesized.

studies is that primary safety and ergonomic loss prevention activities are essential in controlling future losses and should be a basic central tracking focus of any OSH program.

The current study also indicated that a higher rating of health promotion programs ("My company has an employee health promotion program designed to improve the physical fitness of all employees") was among the indicators most associated with reduced lost time WC cases at a company level. Likewise, Hunt et al. (1993) also found that higher wellness program ratings ("the company provides wellness programs and fitness resources") were associated with lower claims at a company level, but the finding was not significant when this item was grouped with other items rating such programs. A number of more recent studies have indicated the effectiveness and high return on investment of wellness approaches (Goetzel et al., 2002; Goetzel & Ozminkowski, 2008; Henke et al., 2010; Ozminkowski et al., 2002). Some researchers have also stressed that health promotion approaches are most successful if integrated with traditional OSH

programs (Goetzel, 2005). An interpretation of these studies is that the tracking of leading indicators for wellness program activities is likely useful for promoting overall OSH effectiveness.

Other studies have indicated that higher self-reported loss reduction policies, practices, and procedures (i.e., disability management) may be linked to lower injury/ illness outcomes. For example, Hunt et al. (1993) determined that higher self-ratings of "proactive return-to-work programs" were associated with 7% fewer past lost work days at a company level. Amick et al. (2000) found that items related to disability management from an employee version of the Hunt et al. (1993) survey were associated with reduced duration of disability in individuals. The current pilot study also indicated that higher rated medical management programs ("Overall, how would you rate your company's medical management program [programs designed to prevent impairment and disability associated with injuries through early detection, prompt treatment, and timely recovery]?") were associated with lower future lost time WC rates

Table 6
Means and standard deviations of explanatory variables for high and low WC cost rate groups in 2003.

Metric Type	OSH Program Element	Scale Type	Metric Description	High Mean	High SD	Low Mean	Low SD	P-value
Leading Prevention	Hazard Control	B	Burn Injury Potential Exposure	2.8	1.3	2.1	0.9	0.06*
		B	Projectiles Exposure (Eye Injury Potential)	3.2	1.3	2.4	0.9	0.04*
		B	Machinery Pinch Points Exposure	3.2	1.3	2.4	1.0	0.07*
		B	Slips, Trips, and Falls Exposure	3.5	1.4	4.2	1.0	0.09
Leading Reduction	Medical Management	C	My company encourages health care providers to become familiar with the job tasks of company employees, either through plant walkthroughs or review of job hazard reports	4.4	0.9	3.4	1.6	0.04
		C	My company has a work hardening or work-conditioning program to prepare new employees for the level of physical exertion required for particular production positions.	2.2	1.4	1.5	0.6	0.08

Scale Key:
• B = Number of Production Employees Exposed (1 = none, 2 = some, 3 = half, 4 = most, 5 = all).
• C = Rating scale (1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent).
Notes:
• dF = 31 for all items except for "My company has a work hardening…" where dF = 30.
* indicates trend is in the direction hypothesized.

at a company level, but to a lesser extent than primary prevention. However, the current study also indicated that certain loss reduction metrics (e.g., work-conditioning programs and encouragement of health care providers to become familiar with job tasks) were associated with higher future WC losses. A possible explanation for these unexpected results is that companies that required aggressive medical management activities may also have had greater injury/ illness exposures in general than companies that did not report such controls. Due to the small sample size of this pilot study, exposure varied among companies. Additional larger studies with comparison groups stratified according to company size and detailed industry type are needed to further investigate this finding.

In summary, an interpretation of the results from the current research and those studies described above is that survey-based ratings of loss prevention and loss reduction efforts within a company are useful because such assessments can be predictive of future losses. Therefore, if overall OSH system deficiencies can be identified upstream, an improvement plan can be developed to offset potential downstream injuries and illnesses. Recent OSHA emphasis (United States Federal Register, 2010b) on the development of safety and health programs based on VPP elements may lead to a greater use of such leading program metrics in the future.

4.2. Past WC Claims

Only one trailing metric from 1999–2001 (WC MSD Case Rate per 100 FTE per Year) was shown to be strongly associated ($p < .05$) with 2003 WC outcomes as hypothesized. An interpretation is that the control of MSDs may have been of particular importance to the overall success of the OSH program for the sampled manufacturing companies. The tracking of such MSD measures provides actionable intelligence beyond standard loss rates and could likely be expanded in many companies. For example, identifying MSD case trends provides a method for developing a reactive ergonomic improvement plan to reduce or eliminate the company exposures that have led to past MSDs. Recent OSHA proposals (United States Federal Register, 2010a) to differentiate MSD in injury/illness recordkeeping logs may cause the tracking of such potentially predictive metrics to become more commonplace in the future.

The finding of the current pilot study that past injury/illness metrics correlated with future injury/ illness outcomes is consistent with other research. For example, Iyer et al. (2005) determined that prior injury/ illness incidence rates and the self-reported level of effort applied to OSH programs were both predictive of future injury/illnesses for a large single company. The WC insurance industry model is also based on the notion that past performance in preventing losses predicts future loss performance. However, predictive trending using past loss data often involves advanced statistical modeling (Hauer, 1992; NCCI, 2004; Schmid, 2009; Wood, 2005) that may not be appropriate for many OSH practitioners. Other researchers have suggested that the usefulness of simple trailing metrics to rate OSH effectiveness may be limited due to the random variability of injury/illness rates (Hauer, 1986). The current study indicates that even simple trailing metric trending may still be useful, especially if companies differentiate the type of injuries/illnesses occurring (e.g., MSDs), and also utilize leading metrics to identify OSH program weaknesses.

4.3. Limitations

There were several study design limitations associated with this research, including a small sample size and study population, limited matching within the sample, and possible selection biases of companies. To test the possibility that there may have been systematic differences affecting participation, respondent companies were compared versus non-respondents for several factors. For example, participation rate did vary considerably by state, ranging from a low of 5% (California) to 40% (Kentucky), but it is unclear whether this was a systematic difference with the small sample involved. Also, the average BLS rate for days away from work or restricted duty cases (DAW) for 2001 was determined for all respondent companies to compare exposures to general manufacturing averages. The mean DAW for the 33 participants was 180.8 per 10,000 workers, which was slightly lower than the mean DAW for all manufacturing companies in 2001 at 183.7 (BLS, 2002). Based on this analysis, participants and non-participants did not appear to differ drastically in terms of injury/ illness rates.

The metrics used also had some inherent potential drawbacks. The leading metrics had a number of limitations, including a lack of proven
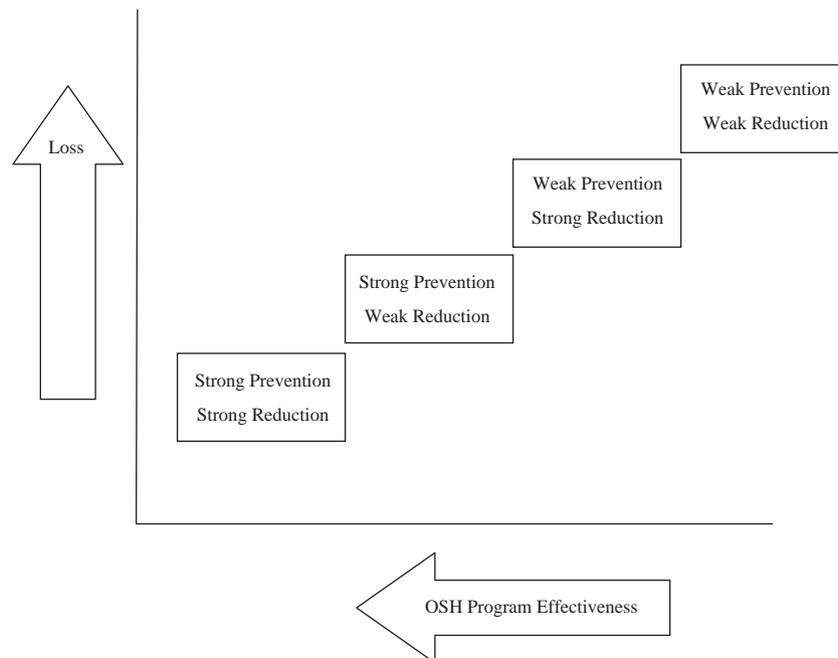
Fig. 2. Depiction of hypothesized association between OSH program effectiveness and injury/ illness losses based on strength of program loss prevention and loss reduction elements.

reliability/ validity and possible response bias since only one respondent at each company was polled and respondents may have differed from non-respondents in terms of individual demographics, such as education level, job tenure, and job title. The trailing metrics were developed using a WC database that may have underrepresented actual injury/illness at the participant companies. Another limitation was that WC loss rates were calculated using only reported 2002 production man-hours for 1999–2003 calculations and temporary employee man-hours were not considered.

4.4. Goals for Future Research

Although leading metrics in this study were shown to be potentially valid explanatory variables for OSH effectiveness, basic research focused on increasing the validity and reliability of leading OSH program metrics is needed. Larger multi-year prospective studies with comparison groups stratified by company size and industry are required to define further the predictive validity of these metrics. A number of researchers are currently developing such studies using some of the more promising program evaluation surveys, including modified versions of the survey originally developed by Hunt et al. (1993), surveys developed by Fernandez-Muniz et al. (2009), and OSHA Form 33. For example, NIOSH is partnering with the Ohio Bureau of Workers Compensation (OBWC), a state insurance compensation carrier, to conduct studies that will include two successive yearly survey administrations and several years of outcome data. This will allow researchers to examine the relationship between trailing WC metrics and leading loss prevention/ loss reduction OSH program assessment metrics over time.

In addition, the metrics in this study were largely completed by individual respondents at the participant companies. Studies involving the representational sampling of a large number of respondents within several organizations are necessary to further refine the inter-rater reliability and utility of these metrics in such multiple-user settings. Further studies are also needed to investigate the use of leading metrics by external consultants and company hourly employees.

Finally, additional research into the relative efficacy of loss prevention and loss reduction metrics is also required. For example, it may be hypothesized that an OSH program is optimized when both loss prevention and loss reduction components are fully engaged (see Fig. 2). In theory, having both a strong safety/ ergonomics program and a strong disability management system may result in the lowest possible frequency and severity of injury/ injury outcomes. In reality, the interplay between loss prevention and loss reduction activities within companies is poorly understood because relatively few other studies have attempted to simultaneously investigate the impact of such integrated approaches on company level outcomes. The current pilot study appears unique in the literature in assessing the impact of self-rated loss prevention and loss reduction activities on company outcomes in a prospective design. This may be due to the lack of an integrated framework for understanding OSH programs. For example, most formalized OSH systems (OSHA VPP, AIHA) and their corresponding evaluation tools (Form 33, UAI) do not include loss reduction (disability management) components. This structure may not fully serve OSH managers who are often held accountable for injury severity and costs, which may be greatly influenced by the level of functioning of their company's disability management systems. Some of the few systems that do include both loss prevention and loss reduction elements are the NIOSH ergonomics program (NIOSH, 1997) and the 10-point Business Plan from the Ohio Bureau of Workers Compensation (OBWC, 2005). The evaluation survey developed by Hunt et al. (1993) remains one of the few methods for assessing such integrated approaches. Additional research using such comprehensive assessment tools is needed to fully understand the relationship between primary prevention and disability management to optimize OSH programs. As well, basic awareness in the OSH community of

formalized disability management guidelines, such as those outlined by the American College of Occupational and Environmental Medicine (ACOEM, 2006), should be increased.

5. Impact on Industry

In summary, this research adds to a growing body of preliminary evidence that valid trailing and leading metrics can be developed to evaluate OSH effectiveness. The use of trailing metrics may be overemphasized in companies due to a lack of awareness and research on the value of leading metrics. The potential strength that several leading variables exhibited in explaining future losses in this pilot investigation and other studies (Amick et al., 2004; Fernandez-Muniz et al., 2009; Iyer et al., 2005) may mean that both the regular trending of past loss outcomes and the rating of leading loss prevention and loss reduction efforts within a company are worthwhile processes. If a company uses either trailing or leading metrics alone to track OSH program effectiveness, only a portion of the probable explanatory variables for system performance are being utilized. An expanded and integrated framework for evaluating OSH programs that considers both primary loss prevention and loss reduction activities using leading and trailing metrics is needed. Such an approach is likely useful for developing data-driven, safety/ ergonomic, and medical management plans that are reactive to past exposures and proactive in identifying system deficiencies that drive future losses.

Appendix A. Supplementary data

Supplementary data to this article can be found online at doi:10.1016/j.jsr.2011.04.001.

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