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# Development and Validation of a Work Safety Compliance Measure

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THESIS APPROVAL

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ABSTRACT

An abstract of the thesis of Tara L. Smecko for the Master of Science in Psychology presented March 16, 1998.

Title: Development and Validation of a Work Safety Compliance Measure

It is important that organizations manage the safety behavior of employees by the implementation of a safety program including periodic assessment of the safety level (i.e., how frequently employees are complying with safety guidelines) in the organization. The occupational safety literature lacks sufficient assessment tools for measuring employee safety behavior.

The purpose of the present study was to develop and validate a comprehensive measure of compliance with safety behavior guidelines in the form of a questionnaire that can be utilized across industries and occupations. The research objectives for the present study were to: 1) Perform factor analysis on the safety questionnaire and obtain a clear factor solution, 2) Identify questionnaire items that are good indicators of their underlying construct (i.e., work safety behavior), 3) Reveal high reliabilities of the factors and overall scale, and 4) Reveal a correlation between accidents on the job and self-reported work safety behavior.

One thousand employees from four different industries in six states were selected as subjects. The 52-item Work Safety Compliance Measure (WSCM) was administered to each subject. Subjects were also asked to report the number of accidents and near accidents experienced in the last 12 months.

The exploratory factor analyses revealed a four-factor solution. Factor loadings were examined and 38 items were retained for subsequent analyses. Each factor represents a type of safety behavior: a) Hazard Communication and General Safety (WSCM-HC), b) Safety Protocol (WSCM-SP), c) Unsafe behaviors (WSCM-Un), and d) Chemical Handling (WSCM-CH). Each of these subscales and the overall scale had internal consistencies above .82. The intercorrelations among the WSCM subscales were considerably lower than subscale reliabilities suggesting that the WSCM measured four empirically distinct constructs. WSCM subscales were negatively correlated with unreported and near accident rates. Multiple linear regression analyses revealed that the Unsafe Behavior subscale was the best predictor of unreported and near accidents. Future research suggestions for the use of the WSCM are discussed.

# DEVELOPMENT AND VALIDATION
# OF A
# WORK SAFETY COMPLIANCE MEASURE

by

TARA L. SMECKO

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# Development and Validation of a Work Safety Compliance Measure

Occupational accidents in the United States are a growing concern for employees, organizations, and the country as a whole. Work accidents were responsible for 5,300 deaths and 3,600,000 disabling injuries in 1995 (National Safety Council [NSC], 1996) and 5,000 deaths and 3,500,000 injuries in 1994 (NSC, 1995). The estimated total cost of occupational accidents in the United States in 1995 was $119.4 billion, including wage and productivity losses, administrative expenses, medical costs, and other employer costs (NSC, 1996). In 1994, the estimate was $120.7 billion, and in 1993, the total cost was $111.9 billion (NSC, 1994). In addition, occupational accidents were responsible for an estimated loss of 120 million work days in 1995 (NSC, 1996). These figures do not reflect *total* costs of occupational accidents in the sense that personal expenses due to physical and emotional suffering are not included. These statistics demonstrate the result of work accidents: death and disability for the worker and rising costs for the employer as well as indirect expenses incurred by others. It is clear that reducing the rate of occupational accidents would save billions of dollars and thousands of lives annually.

Reducing work accidents seems a simple task and fundamental to effective management of an organization. In reviewing accident files of organizations, Heinrich (1950) and others found that most accidents were a function of unsafe behavior by the worker (e.g., failure to use protective devices). Successfully managing the safety behavior of employees clearly involves the implementation and maintenance of a safety program including periodic assessment of the safety level (i.e., how frequently employees are complying with safety guidelines) in an organization. In other words, it is not enough to introduce a safety program or continue the steps of an established safety program without knowing whether employees are complying with an organization's regulations concerning safety behavior. Unfortunately, the occupational safety literature lacks sufficient assessment tools for the goal of measuring employee safety behavior.

The current study attempts to fill a void in the occupational safety literature by developing and validating a self-report measure of work safety compliance behavior. Safety management (i.e., accident control) must begin with sound measurement of the safety level in an organization. Safety management is feasible only as a function of the adequacy of the measures used to identify the hazardous situations and unsafe behaviors existing in an organization. Because the goal of a safety management program is to identify unsafe conditions and behaviors that have accident producing potential, it is important that the safety assessment tools (e.g., safety climate measure, compliance with safety standards) are reliable and valid measures of their intended constructs. Problems, rather than their consequences (i.e., accidents and injuries), need to be measured to help prevent accidents.

Approaches to Safety

Three common methods of reducing work accidents are the Engineering approach, the Personnel approach, and the Industrial-Social approach (Landy, 1989). The Engineering approach assumes that changing the equipment or process (system design) will reduce accidents. The Personnel approach attempts to identify certain personality traits that seem to be correlated with accidents. Individuals who possess these characteristics are either not hired or attempts are made to change those characteristics in workers (through job training), thus reducing accidents. The Industrial-Social approach proposes that accidents can be reduced by properly motivating workers (e.g., through the use of incentives or rewards) to perform their job in a safe manner.

Within the framework of these approaches the occupational safety literature contains a great deal of research suggesting strategies for improving safe employee behavior which would, consequently, reduce accidents in the workplace. Published articles include methods for encouraging self-protective behavior (Peters, 1991), preventing occupational injuries through performance management (Reber, Wallin, & Duhon; 1993), increasing the efficacy of employee involvement in a behavioral-based safety program (Minter, 1990), and increasing the use of personal protective equipment (Dunbar, 1993). Managing safety in the workplace is indeed a necessary endeavor to diminish accident rates, save money, maintain production, and comply with state and Federal safety standards. Before safety behavior can be managed and safety programs evaluated, measurement of employee compliance with company safety guidelines is imperative. Only after identifying behaviors as unsafe and implementing a method to measure how often unsafe behaviors occur can an effective program for improving safety be considered.

Compliance

The definition that best expresses the compliance of employees with an organization's standards is found in Festinger's (1953) description of public compliance. This definition states that public compliance is acquiescence to the apparent wishes of the influence source, without any real acceptance of the source's position. Public compliance is said to occur because a source of influence has power or control over the fate or resources of the other and can monitor actions to ensure that the desired behavior is enacted. According to Festinger, the motivation to comply with the influence source lies in the source's power to reward and punish. The concept of public compliance can be applied to the area of work and work behavior. Employees are motivated to comply with company regulations in order to maintain employment with the company. In the area of work safety, employees are required to follow safety regulations that are dictated by the organization's management (i.e., the influence source). Additionally, it is hoped and expected that in the case of compliance with safety standards, employees are also motivated by a desire for themselves and others to remain uninjured.

Factors Influencing Safety Compliance. Research in the area of occupational safety has found several robust factors that influence safety behavior. Hayes, Johnson, Strom, Langlie, and Trask (1994) found that the best predictors of compliance with safety behavior guidelines were management safety and coworker safety practices. That is, employees who perceived that their management and coworkers endorsed a safe work environment also complied with safety behavior guidelines more frequently than employees who felt their management and coworkers did not endorse a safe work environment. Management safety practices included management's attempt at modeling, encouraging, and rewarding safe behaviors and coworker safety practices included coworkers following safety rules and encouraging others to be safe.

In an analysis of a 1967 and a 1992 safety management inventory study, Planek and Fearn (1993) reported Senior Management, Middle Management, and Supervisor participation as the highest ranked safety program categories. Senior Management participation included modeling safe behavior, publishing a policy expressing management's attitude on safety, and appointing a safety professional. Middle Management participation included periodically reviewing group safety performance, restating management's position on safety, and modeling safe behavior. Supervisor participation consisted of modeling safe behavior, maintaining high standards of employee safety performance, listening to employee safety problems, and providing safety training. In other words, both studies clearly recognized the importance of management and supervisor participation in safety program effectiveness (i.e., reduced accidents and unsafe behavior).

Another study, conducted by Murphy, Sturdivant, and Gershon (1993) examined the influence of worker characteristics (age, job, tenure, gender) and organizational factors (management support, good housekeeping, organizational safety climate) on worker compliance with recommended safety practices and found that management support was the factor that most consistently predicted compliance. Management support was displayed by providing personal protective equipment and supervisory support for recommended safety practices. Management attitudes toward safety (e.g., "My immediate supervisor is concerned about my safety on the job") were also important predictors of employee safe work behaviors.

In a review of the safety literature by Zohar (1980), one of the most consistent findings in factories having successful safety programs (i.e., low accident rates) was a strong management commitment to safety, exhibited in a variety of ways (e.g., top management being personally involved in safety activities on a routine basis and safety matters being given high priority in company meetings and production scheduling). It is clear that management and supervisory interest in safety has been consistently recognized as an influential force in employee behavior and accident rates and has important implications for organizations concerned with safety. Specifically, an organization wishing to increase the safety level (i.e., reduce accidents and injuries) in their company should be aware of the factors influencing safety behavior. Once safety level has been measured (i.e., how frequently employees are complying with company safety behaviors) this knowledge enables management to promote safety effectively.

Other variables that have been reported to improve safety performance in organizations include feedback, supervisory praise, and goal setting (Komaki, Barwick, & Scott, 1978), informational and motivational feedback (Sulzer-Azaroff & Santamaria, 1980), and safety rule training, goal-setting, and feedback (Reber & Wallin, 1984). Thus, consideration of these variables may also be important to organizations in promoting safe behavior.

A discussion of exactly how or why these factors influence compliant behavior is beyond the scope of this paper. However, it is important to note that safety compliance behavior is influenced by a variety of factors, especially the repeated finding of a link between management and supervisory support and safe behavior. Fundamental to most causes of employee noncompliance with safety standards in an organization is the demonstration that management is not effectively managing safety. Employee safety behavior must be measured to determine the rate of compliance with safety regulations so that management can work to improve safety performance.

Current Measures of Safety Behavior

In a review of the occupational safety literature, very little research was found on measures of employee compliance with company work safety guidelines. Research exists in the following work safety areas: measuring employee perceptions of their work safety climate; using different methods (i.e., training, goal-setting, knowledge of results) to increase safe behavior; preventing occupational injuries through behavioral performance management; and implementing a safety program. Only a handful of studies investigate actual measures of safe behavior on the job and no general measure of safety compliance was found in the literature. Awareness of the frequency of employee safety behavior seems fundamental to the work safety issue and accident rates in organizations, yet the literature is lacking in useful measurement tools. Four studies directly relevant to the current research were found.

Observational Measures. Reber and Wallin (1983) developed a behavioral measure of safety in order to determine the relationship between behavior and accident rate in a farm machinery manufacturing company located in the southeastern United States. A list of safe behaviors targeted for observation was developed from reviewing the company's accident rates for the previous 3 years to identify unsafe acts that resulted in injuries. Additional behavioral items were solicited from supervisors and employees, Occupational Safety and Health Administration (OSHA) safety practices, company safety manuals, and recommendations of various tool and equipment manufacturers. The observational items were classified as General Safety, Personal Protective Equipment, Housekeeping, Material Handling, and Tool and Equipment Use. One-hundred-seven employees in 12 departments were observed for 15-20 seconds two to four times per week by a trained observer and the employee's activity (e.g., "Approved safety glasses worn when working beneath equipment where the danger of falling particles exists) was marked as being performed safely or unsafely. Average interrater agreement was 88.4%. Rank-difference correlation (Spearman rho) between mean departmental baseline performance and departmental overall injury incidence rates were computed (-.76). Results revealed a significant inverse relationship between the frequency of safe behaviors on the job and the frequency of occupational accident and injury. Thus, it can be expected that increasing compliance with safety standards would be associated with a decrease in occupational injuries.

In this study, Reber and Wallin (1983) compared safety performance with reported accidents. This neglects all unreported and near accidents due to unsafe behavior and does not necessarily reflect reliable assessment of employee safety behavior. Also, the use of interrater agreement (percent agreement) is problematic. Percent agreement describes the extent to which two observers agree with each other and is inadequate as a reliability assessment (Bakeman & Gottman, 1986). Many factors can affect percent agreement and it is not always clear what the number means.

More importantly, agreement percentages do not take into account the part of the observed agreement that is due to chance.

In a behavioral analysis approach to improving employee safety practices in a food manufacturing plant, Komaki et al. (1978) constructed an observational code to measure safety level. Safety items were identified by reviewing accident reports for the previous three years to examine types and circumstances of injuries. In addition, supervisors were encouraged to contribute items. Each item was clearly defined and specific in nature (e.g., "There are no cardboard spacers on the floor"). Four days a week a trained rater, in full view of the workers, observed 38 employees working in different areas of two departments for a total of 55 minutes (35 minutes in the makeup department and 20 minutes in the wrapping department). Each item on the observation code was checked as performed safely, unsafely, or not observed. Any time an item was performed unsafely, it was recorded as "unsafe" regardless of the number of times it had been performed safely. Interrater reliability (percent agreement) averaged 97.4% agreement for the makeup department and 99.6% agreement for the wrapping department. An intervention program was also introduced and measured in this study and results revealed that employees significantly improved their safety performance after introduction of the intervention. As expected, increased safe behavior was associated with reduced work accidents. These results suggest that defining, measuring, and positively reinforcing safe behavior is an effective approach to reducing occupational accidents.

The items generated by Komaki et al. (1978) were based mainly on reviewing accident reports for the company. As mentioned previously (i.e., Reber & Wallin, 1983), this method neglects all unreported and near accidents experienced by workers. While the company has identified those behaviors and situations that resulted in accidents reported to management, they are missing all unsafe behaviors with accident producing potential. In addition, Komaki et al.'s method of recording any item as unsafe regardless of the number of times it had been performed safely during observation results in a conservative estimate of compliance. That is, an accurate measure of the frequency of safe and unsafe behaviors performed by employees was not obtained. Also, percent agreement was reported as the reliability estimate and, as previously mentioned, this does not necessarily demonstrate adequate reliability.

In both the Reber and Wallin (1983) and the Komaki et al. (1978) studies, all compliance items included in each measure were specific to the sample industry and not generalizable. Moreover, both of these studies obtained safety performance information through observational methods, requiring a large time commitment and monetary expense by the organization.

Self-Report Measures. In another study, using a sample of 250 health care workers, Murphy et al. (1993) utilized a survey assessing employee characteristics (age, job, tenure, gender), organizational factors (management support for following recommended safety practices, good housekeeping, organizational safety climate), occupational injuries, and worker compliance with recommended safety practices. Their aim was to examine the influence of worker characteristics and organizational factors on worker compliance with recommended safety practices. Compliance was measured by six items which assessed the frequency of specific worker behaviors (e.g., "Dispose of sharp objects into a sharps container") on a five-point scale (Never to Always). A reliability estimate (internal consistency) of .61 was obtained for the six compliance items. Since this estimate did not reach minimum acceptable levels each item was analyzed separately in addition to the summed scale. Results of the compliance measure revealed that compliance with recommended safety practices was generally high, but varied according to the specific type of precaution. Occupational differences in compliance items were also found (physicians reported the lowest level of compliance, technicians the highest, nurses intermediate). Gender was the only demographic variable consistently related to compliance, with females reporting better compliance than males. As previously discussed, management commitment to safety was the organizational factor which most consistently predicted compliance. In other words, employees complied most often with recommended safety practices when management expressed support of safe behavior.

The compliance measure used by Murphy et al. (1993) was sample specific and did not consist of enough items to comprehensively measure safety behavior, nor was the reliability estimate (internal consistency) of the six compliance items acceptable. Another issue is the fact that Murphy et al. did not discuss or provide any information about the development of the questionnaire used to assess worker characteristics, organizational factors, and worker compliance.

The current study is based on research by Hayes et al. (1994). Hayes et al. developed and validated the Work Safety Scale (WSS), a 50-item questionnaire designed to measure employees' perceptions of work safety. In the second of two studies validating the WSS, an 11-item measure of compliance with safety behaviors was developed and added to the instrument. Compliance items were written to apply to various occupations. Each item reflected either a safe or unsafe work behavior and subjects indicated how frequently they perform the behavior on the job on a five-point scale from "Never" to "Always". The sample consisted of 181 telephone line workers from a large telecommunications company. The reliability estimate (internal consistency) for the compliance measure was .79. As previously reported, results revealed that worker safety and management safety practices were the best predictors of accidents and compliance with safety behaviors.

Unlike the other compliance dimensions previously discussed, the compliance items generated by Hayes et al. (1994) were general enough to apply to various occupations. However, the compliance measure did not consist of enough items to comprehensively measure safety behavior.

A Comparison Study. In an attempt to identify the most valid and reliable measure of a health-related behavior, Lusk, Ronis, and Baer (1995) compared multiple indicators of hearing protection use by blue collar workers in a midwestern automotive plant. Frequency of the target safety behavior, use of hearing protection, was gathered in three phases. In the first phase, two trained observers measured the use or nonuse of hearing protection in five departments on day and evening shifts. Measurements were taken every half hour for a half day at a time for a minimum of two nonconsecutive half days. Observers surreptitiously recorded hearing protection use while measuring the noise level with dosimeters in each department. Interrater reliability was established at .94. In the second phase, supervisors' reports of their workers hearing protection use were obtained. Their responses to the following items were recorded, for each of the workers they supervised: "What percent of the time would you say each of your workers wore his or her hearing protection while in this workstation area during the (1) last week? (2) last month? (3) last three months?" The final phase involved a self-report measure of hearing protection use. All workers in the plant (N=4,473) were asked to complete a written questionnaire and respond to the following questions: "(1) During the past week in your work area, what percent of the time would you say you actually used hearing protection? (2) During the past month in your work area, what percent of the time would you say you actually used hearing protection? (3) During the past three months in your work area, what percent of the time would you say you actually used hearing protection?" The analyses included only those workers whose use of hearing protection was assessed by all three indicators (N=48).

Results showed that hearing protection was worn the majority of the time (54.4% observed, 73.5% supervisor report, and 62.3% self-report). Pearson, Spearman, and Kendall correlations were computed to assess convergent validity of the three indicators. Observed and self-reported use correlated highly with each other (.69 to .89 depending on the specific correlation coefficient examined). Observations and self-report had low correlations with supervisor report, ranging from .33 to .47. The results also reveal that little social desirability bias was apparent in the self-reported measure. Self-reported use was only 7.9% higher than observed use.

These results strongly suggest that both self-report and observations are valid and reliable methods of assessing a safety-related behavior, the use of hearing protection. However, the data collected emphasized the occurrence of only one safety behavior and would not suffice as a measure of employee compliance with general safety behavior guidelines in an organization.

Job Dimensions of the Safety Function in Industry. DeJoy (1993) developed a safety job activity questionnaire designed to measure the importance and amount of time spent on several job safety tasks. The primary goal was to obtain a description of the task behaviors of working safety professionals within industry. The questionnaire consisted of 24 job activities representing 10 major industrial categories. The 10 categories were: mining, construction, food products, paper, chemicals, rubber and plastics, primary metals, machinery - except electrical, electrical and electronic machinery, and transportation equipment. Questionnaire development involved an examination of the "Scope and Functions" document of the American Society of Safety Engineers (American Society of Safety Engineers, 1982). Four major functional areas were identified: identification and appraisal of hazards, development of hazard control methods, communication of hazard control information, and measurement of hazard control effectiveness. The instrument was completed by 465 working safety professionals representing the 10 industries. Factor analysis identified five primary job dimensions of the safety function in industry: (1) serving as a safety consultant, (2) coordinating compliance and control activities, (3) assessing the effectiveness of controls, (4) analyzing hazards and losses, and (5) conducting specialized studies and reviews. Results also revealed that there were very few differences in the safety function across different industries. DeJoy concluded, "These findings suggest that it is possible to identify a set of generalizable job dimensions for the industrial safety function" (p. 374).

## Measurement Methods

Observation. Reviews of the literature revealed the use of observational methods for recording safe and unsafe employee behavior. In an attempt to measure safety level in an organization prior to implementing a safety program or to evaluate the effectiveness of a safety program, trained raters observed employees for a specified amount of time several times a week and recorded their behavior. While this is a widely used and accepted survey method, there are disadvantages of collecting behavioral information this way. The most obvious is observee bias or what Weick (1968) refers to as *reactivity*. This involves a change in the subject's target behavior due to the presence of the observer and the knowledge of being observed. Clearly, an employee aware that their safety behavior is being monitored would attempt to perform work tasks in accord with safety guidelines advocated by their employer.

Observer bias must also be considered. Recording errors of omission (failing to score a behavior that occurred) and commission (miscoding a behavior), and errors resulting from observer expectancy are all potential sources of observer bias or "experimenter" effects (Rosenthal, 1963). Observers who are informed to look for specific behaviors often make significantly more omission errors (Mash & Makuhoniuk, 1975). In addition, an observer's expectations of the occurrence of a target behavior may often be communicated unintentionally to the subject.

Another potential problem of observation as a survey method is observer drift and involves instability across repeated observational measurement times (Sackett, 1978). Observers, as well as the instrument itself, can drift (i.e., less observer agreement over repeated trials). In addition to observee and observer biases, the initial definition of the behavior to be observed and recorded can be difficult and threatening to reliability. For example, large global units of behavior can be subject to ambiguity and varying interpretations while small, narrowly defined units of behavior can be difficult to categorize and code. Also, it must be accurately determined when a target behavior begins and ends. The method used to code time blocks of observation (e.g., recording the occurrence of a target behavior once within a time block, regardless of the frequency of occurrence or all target behaviors occurring within a time block being recorded each time they occur) can significantly affect the conclusions drawn from results obtained using observational survey methods.

Finally, the process involved in developing a behavioral taxonomy for observation, training observers to monitor and record target behaviors, and analyzing the information obtained would be time-consuming and expensive. As expressed by Sulzer-Azaroff and Santamaria (1980), continuously monitoring all worker operations and recording those behaviors that lead to accidents would be the most direct measure having clearly apparent face validity. However, such an approach would be pragmatically unfeasible requiring almost infinite time, effort, and skill in detecting an accident in progress.

Self-Report. The current study proposes the use of a self-report measure of safety behavior. In general, given the intended use of the instrument, issues of practicality make self-report the method of choice. By employing workers to report risky behavior and unsafe work practices the following advantages are expected (Hoyos & Zimolong, 1988). First, workers are recognized as subject-matter experts. They know their jobs and behavior better than anyone else does and are best qualified to inform management of the hazards that can cause injury. Second, employees are involved in company safety actions. Management acknowledges their importance by requesting their help to improve their work environment. Organizations are realizing the importance of employee involvement in behavioral safety success (Minter, 1990). Third, employees' safety awareness is increased by having to report the frequency of their safety behavior. Employees are often more willing to discuss near accidents (versus actual accidents resulting in injury) in which they were personally involved due to the fact that no blame or negative consequences will result (Tarrants, 1970). Fourth, employees are urged to identify unsafe conditions and behaviors before an accident occurs. Because the method records safety behaviors, rather than incidents (i.e., accidents), potential injuries can be identified before they occur. Accident prevention is thus emphasized. Five, self-report methods of gathering behavioral information allow quantification of results, objectivity, standardization, and ease of comparison across workers, work groups, organizations, and occupations. Six, structured use of questions and scoring items permits the respondent to recognize rather than recall unsafe acts or hazardous conditions. Finally, the approach also permits the collecting of information from a large number of respondents over a short period of time and with small expense.

However, there are problems associated with self-reporting methods (Hoyos & Zimolong, 1988): First, not all unsafe acts are reported. This may be due to memory deficiencies on behalf of respondents. Employees may honestly not remember or be aware of how often they behave unsafely. Intentional faking (social desirability) may also be responsible for distorted information. Employees may not want to report behaving unsafely, especially if they think it will result in negative consequences. Thus, it is important for the employee completing a safety questionnaire to be assured that no negative consequences will be forthcoming. Second, the use of structured items does not encourage respondents to report behaviors or conditions not covered by the questionnaire. This, of course, is also a problem with an observation checklist. In the event that respondents think of safe behaviors not covered on the questionnaire, there will be a section at the end of the compliance scale in which employees can provide additional safe behaviors not included in the main body of the survey. Third, only the behaviors and conditions are reported that are already known to be hazardous. In other words, only the situations that pose obvious danger will be reported.

However, the current questionnaire includes safety items general enough to encompass most potentially hazardous behaviors yet specific enough to be meaningful.

Summary

The shortcomings of previous research on employee safety behavior support the need for a comprehensive and universal measure of employee safety compliance.

The existing compliance measures discussed have several measurement-related problems. They either possess low reliability estimates (e.g., Murphy et al., 1993, internal consistency of .61), contain sample-specific items (e.g., Reber & Wallin, 1983; Komaki et al., 1978), or fail to comprehensively measure the safety behavior of employees (e.g., Hayes et al., 1994). The research by DeJoy (1993) emphasized the job activities of safety professionals rather than the behavior of employees, as is the focus of the current study, but was helpful in the development of the current work safety compliance questionnaire by identifying important dimensions of safety activity common to several major industries. Several of the 24 items on the taxonomy were helpful in deriving safety practices that apply to all employees.

The goal of developing a behavioral measure of work safety compliance applicable across occupations, while being easy and inexpensive to administer, supports the use of a self-report measure. As illustrated above, the researcher has attempted to identify a set of generalizable work safety behaviors of employees and to account for the drawbacks associated with self-report methods of obtaining behavioral information.

## Research Objectives

The current study is exploratory in nature and seeks to identify general safety behaviors that appear to be universally important to successful safety management in an organization. The goal of the current research is to develop and validate a comprehensive measure of compliance with safety behavior guidelines in the form of a questionnaire that can be utilized across industries and occupations. Measurement properties (i.e., factor structure and internal consistency) of the scale are examined and the contribution of emergent compliance measure subscales in predicting accidents on the job are explored.

The research objectives are as follows:

1. Perform factor analyses on the safety questionnaire and obtain a clear factor solution.
2. Identify questionnaire items that are good indicators of their intended factor (i.e., work safety behavior) and retain for subsequent analyses.
3. Reveal high reliabilities (i.e., internal consistency) of the emergent factors (i.e., questionnaire subscales) and the overall scale.
4. Reveal a correlation between the occurrence of accidents and near accidents experienced by employees on the job and their self-reported work

safety behavior. Logically, it is expected that as the number of accidents increase so does unsafe work behavior.

# Method

## Subjects

Data were collected from two populations. In the Spring of 1995, questionnaires were administered to local and graduating apprentices (i.e., steamfitter, pipefitter, plumber, and sprinkle-fitter apprentices) of local steamfitter unions in Oregon, California, Nevada, Wyoming, Michigan, and Alaska (Sample 1). Due to the disproportionately low ratio of female to male apprentices, the majority of the subjects were male. Participation was restricted to active members of the union apprenticeship program. Six hundred questionnaires were administered and a total of 351 were completed and returned (50% response rate). Additionally, in the Fall of 1997, questionnaires were administered to 400 employees of a computer hardware manufacturing company in Oregon (Sample 2). Four hundred questionnaires were distributed and 132 were completed and returned (33% response rate). Industries include Heating, Ventilation, and Air Conditioning (HVAC), plumbing, computer hardware manufacturing, and hospital maintenance. Due to missing data, only 434 questionnaires could be used. The total sample consisted of 342 males and 59 females.

The demographic information is located in Tables 1 and 2. In Sample 1, 94.9

percent of the respondents were male and 5.1 percent were female. The median age of the respondents was 29 years. The median number of years working in current industry was 5 years. In Sample 2, 58.1 percent of the respondents were male and 41.9 percent were female. The median age range of the respondents was 30–39 years. The median number of years working in current industry was 3.5 years. The percentage of workers in each of the four industries is located in Table 3. The majority of the respondents worked in the HVAC industry (36.4%).

Measures

Safety compliance measure. A list of safe behaviors was generated from several sources. First, a review of the occupational safety literature was conducted. This provided the identification of several unsafe acts that have resulted in reported accidents in organizations and safety behaviors specific to different industries. The critical incident technique (Flanagan, 1954), a procedure for gathering a functional description of an activity, was also used in item generation. A critical incident is an example of a behavior that describes positive or negative performance. Critical incidents were obtained through interviews with three safety professionals, including a Certified Industrial Hygienist, Certified Safety Professional, and Certified Environmental Trainer; the owner of a construction company responsible for safety training and adherence with OSHA guidelines; and a security professional responsible for employee training. Each respondent was asked to describe five safe and five unsafe behaviors reflective of the industry in which they work. Industry-specific safety behaviors were converted to generic safety items. Additional behavioral items were solicited from established safety practices advocated by OSHA. Safety behaviors that appeared to be universally important to successful safety management regardless of occupational field were chosen and the final list consisted of 52 behavioral safety items. The 52 items of the safety compliance measure and directions to complete the items are included in Appendix. For each item, respondents are asked to indicate how frequently they perform the behavior on their current job using a 5-point scale from "never" to "always". A safety compliance behavior score was computed by averaging the responses. Higher scores reflect greater compliance with safe behaviors. Negatively phrased items (e.g., "Do not clean up my work area after a job") were reverse coded so higher scores reflect greater compliance with safe work behaviors.

Social desirability. In addition to the 52 safety items, subjects in Sample 1 were asked to complete a short version of the Marlowe-Crowne Social Desirability Scale (SDS; Crowne & Marlowe, 1960). The standard SDS contains 33 true-false items describing culturally acceptable and approved behaviors with a low probability of occurrence. It is used in conjunction with other self-report measures to control for the response tendency to present oneself in a socially desirable manner. The social desirability scale was necessary as a control in the current study since the WSCM asks subjects to report inappropriate behavior which may result in a tendency to respond favorably. The current study used a 10-item version of the SDS (SDS-10) created by Strahan and Gerbasi (1972) and further validated by Fischer and Fick (1993). Strahan and Gerbasi reported a mean Kuder-Richardson Formula 20 reliability estimate of .64 and a correlation between SDS-10 and the standard SDS in the .90s. Fischer and Fick reported a coefficient alpha internal consistency estimate of .88 and a correlation of SDS-10 with the standard SDS of .96.

Other variables. The following information was requested from subjects: age, gender, job title (Sample 1), industry in which they work, and amount of time working in current field (job tenure). Also, subjects were asked to report how many accidents they have experienced in the last 12 months using three different accident indices: (1) reported accidents (accidents reported to supervisor), (2) unreported accidents (not reported to supervisor), and (3) near accidents (a behavior or condition that had the potential to cause an accident or injury but did not).

Procedure

Questionnaires were given to a contact with each organization and that person distributed a questionnaire to each employee. All subjects were asked to complete the 52-item measure of safety compliance on their own time (or on the job if provided by supervisor) and return it to the contact person, who returned completed questionnaires to the researcher by mail. Participants were assured complete anonymity and guaranteed that their participation or declination will not affect their relationship with their employer or Portland State University.

## Results

Item means and standard deviations for the initial item pool of the WSCM were computed and are located in Table 4. Exploratory factor analysis was conducted to determine the factor structure of the WSCM. The total sample of 434 respondents was used for the factor analysis. The determination of sample size was guided by other researchers who recommend some minimum requirements when conducting a factor analysis (Cattell, 1978; Ford, MacCallum & Tait, 1986). A minimum of 200 subjects with a subject to item ratio of five have been suggested as requirements when conducting a factor analysis. The subject to item ratio in this sample was 8. The factor loadings are shown in Table 5. Items with factor loadings greater than .30 and no cross-factor loadings were kept for the final version of the WSCM. Reliability estimates using Cronbach's alpha were calculated for the factors identified in the factor analysis. These factors served as subscales in subsequent analyses. Corrected item-total correlations were calculated for each of the items in the WSCM and are presented in Table 6.

To investigate the first research objective, an exploratory factor analysis (principal axis factor analysis) with iterations was performed to assess the dimensionality of the WSCM. A principal factor analysis was conducted because it was assumed that the questionnaire items were a linear function of some underlying construct (Ford, MacCallum, & Tait, 1986). As anticipated, a clear factor solution emerged. The criteria used to determine the number of factors that describe the correlations among the items consisted of examining the eigenvalues and the scree plot of the eigenvalues. Eleven factors had eigenvalues greater than 1.0 and the first four factors had eigenvalues greater than 2.0. Factors with eigenvalues greater than 2.0 reflected the clearest division. Several factor solutions were explored (i.e., solutions with more than four factors) but resulted in a large number of cross-loadings and less interpretable solutions. The eigenvalues for the first four factors were 14.68, 3.06, 2.28, and 2.03, respectively. The scree plot of the eigenvalues is the plot of eigenvalues against the number of factors. The scree test consists of examining the bend in the line of the scree plot. The number of factors coincides with the place in the scree plot where the descending curve straightens into an even slope. The scree plot of the eigenvalues is presented in Figure 1. The line of the scree plot begins to gradually straighten into an even slope with loadings less than 2.0. Using this criterion also revealed that four factors should be retained. The distribution of each subscale and the overall WSCM are presented in Figures 2 - 6.

Varimax factor rotation (i.e., orthogonal) was conducted for the four-factor solution. Other rotations were attempted, but varimax resulted in the clearest and most interpretable pattern of results. The factor structure (after rotation) is presented in

Table 5. The results of the factor analysis revealed a clear four-factor solution. The factor loadings for each variable are located in Table 5. Factor loadings for the items in Factor I ranged from .43 to .76. Factor loadings for the items in Factor II ranged from .30 to .66. Factor loadings for the items in Factor III ranged from .35 to .60. Factor loadings for the items in Factor IV ranged from .70 to .77.

Total variance reflects the total amount of variance in the items, which includes common variance and unique variance. Total variance can be calculated by summing the number of items that are used in the factor analysis. For the current factor analysis, total variance was 52 (52 items in the WSCM). The first four factors accounted for 42.4% of the total variance. Factor I accounted for 28.2% of the total variance, Factor II accounted for 5.9% of the total variance, Factor III accounted for 4.4% of the total variance, and Factor IV accounted for 3.9% of the total variance. Thus, a moderate proportion of the variance in each of the items can be explained by the four-factor solution.

Next, to explore the second objective, item loadings were examined to determine on which factor each item loaded. As expected, the factor loadings indicated that most items were good indicators of their intended factors (see Table 5). All items that have factor loadings greater than .30 and low cross-factor loadings were retained. An item was considered to cross-load when having a factor loading greater than .30 on more than one factor. A total of 14 items were dropped (10 items crossloaded and 4 did not have factor loadings greater than .30). Three items with loadings greater than .30 on two factors were retained based on the significant range between the two loadings (.15 or greater). The remaining 38 items and the four-factor solution were used for the remaining analyses. The WSCM was designed to include a representative sample of general safety behaviors in the workplace. Dropping the items with the lowest factor loadings resulted in a scale with acceptable internal consistency without jeopardizing the content domain of the WSCM.

All items that have factor loadings greater than .30 (and did not cross-load) on Factor I reflect the communication of unsafe working conditions and general work safety behaviors (12 items). Sample items with high factor loadings are "Report all unsafe working conditions to my supervisor" and "Report any unrecognized safety hazards." Based on the content of the items that load on this factor, this factor will be labeled as WSCM-Hazard Communication and General Safety (WSCM-HC).

All items that have factor loadings greater than .30 (and did not cross-load) on Factor II reflect behavioral compliance with safety standards and procedures (11 items). Sample items with high factor loadings are "Wear safety equipment required by practice" and "Follow all safety warnings and instructions." Based on the content of the items that load on this factor, this factor will be labeled as WSCM-Safety Protocol (WSCM-SP).

All items that have factor loadings greater than .30 (and did not cross-load) on Factor III reflect unsafe work behavior (i.e., negatively phrased items - 12 items). Sample items with high factor loadings are "Alter equipment to save time" and "Improvise when safety equipment is not convenient." Based on the content of the items that load on this factor, this factor will be labeled as WSCM-Unsafe (WSCM-Un).

Finally, all items that have factor loadings greater than .30 (and did not cross-load) on Factor IV reflect the proper handling of hazardous chemicals (3 items). Sample items with high factor loadings are "Properly store hazardous chemicals" and "Properly dispose of hazardous chemicals." Based on the content of the items that load on this factor, this factor will be labeled as WSCM-Chemical Handling (WSCM-CH).

In support of the third objective, computed reliabilities for each factor and the overall WSCM were high. The reliabilities (Cronbach's alpha) for the final subscales were .90 for the WSCM-Hazard Communication and General Safety (WSCM-HC), .84 for the WSCM-Safety Protocol (WSCM-SP), .83 for the WSCM-Unsafe Behaviors (WSCM-Un), and .90 for the WSCM-Chemical Handling (WSCM-CH). The reliability for the overall WSCM was .94. Corrected item-total correlations were calculated for each of the WSCM subscales. A corrected item-total correlation is a correlation of a particular item with the scale score using the remaining items in the scale. These corrected item-total correlations are presented in Table 6. The corrected item-total correlations ranged from .49 to .78 for WSCM-HC; .36 to .72 for WSCM-SP; .31 to .62 for WSCM-Un; and .75 to .83 for WSCM-CH. This indicated that each item seems to be a good indicator of what is being assessed by the other items in its respective scale.

The reliabilities (Cronbach's alpha) of the WSCM subscales in this sample were high. The items for each of the scales were selected based on their factor loadings. Items that load on the same factor are correlated with each other. Because internal consistency estimates reflect the degree to which the items are related to one another, it is not surprising that the scales, which were based on their factor loadings, have high reliability. Scatterplots of the correlations between subscales are presented in Figures 7 – 12.

Scores for each of the WSCM subscales were calculated by summing the responses for the items within each scale and dividing by the number of items in the scale. The means, standard deviations, and intercorrelations among the variables are provided in Table 7. The correlations among the scales indicate that the different safety behavior measures were positively related to each other.

Correlations between social desirability, accidents, the four subscales, and the overall WSCM are also presented in Table 7. Figures 13 – 27 reflect scatterplots of subscales with accident data. Significant correlations were revealed for unreported and near accidents with three subscales and the full scale. Specifically, significant negative correlations emerged between unreported accidents and WSCM ( -.17, $p<.01$), WSCM-HC (-.15, $p<.01$), WSCM-Un (-.18, $p<.05$) and WSCM-CH (-.12, $p<.01$), and between near accidents and WSCM (-.19, $p<.01$), WSCM-HC (-.17, $p<.05$), WSCM-SP (-.16, $p<.05$), and WSCM-Un (-.18, $p<.05$). Reported accidents did not correlate significantly with any other variables.

Because only Sample 1 had continuous accident data, regression analyses were conducted using Sample 1 data only (N=302). Sample 2 accident data were reported in ordinal categories and were not used in the regression analyses.

Multiple linear regression analyses were conducted to examine the predictive ability of the WSCM and WSCM subscales on accidents. In conflict with the fourth objective, all WSCM subscales did not significantly explain accidents and near accidents by workers. The complete WSCM, each WSCM subscale and the SDS-10 were used as predictor variables, and unreported and near accidents served as dependent variables. As previously mentioned, reported accident data did not correlate with any other variables and was, thus, not included in the regression analyses.

A separate regression analyses was conducted for each dependent variable. Results are presented in Tables 8 and 9. First, unreported accidents were regressed on the SDS-10 and all WSCM subscales resulting in a significant $R^2$ value of .06 ($p<.01$).

Only the unsafe behavior subscale (WSCM-Un) significantly accounted for any variance in the number of unreported accidents. When near accidents were regressed on the SDS-10 and all WSCM subscales, results revealed a significant $R^2$ value of .08 ($p<.01$). Both the unsafe behavior subscale (WSCM-Un) and the chemical handling subscale (WSCM-CH) significantly accounted for variance in the number of near accidents. Next, unreported and near accidents were regressed on the WSCM and each subscale individually with the SDS-10 to determine if the WSCM or any subscale predicted accidents independent of other variables. Significant $R^2$ values were revealed for all analyses regressing unreported accidents on other variables (SDS-10 and WSCM, $R^2 = .04$, $p<.01$; SDS-10 and WSCM-HC, $R^2 = .04$, $p<.01$; SDS-10 and WSCM-SP, $R^2 =.03$, $p<.05$; SDS-10 and WSCM-Un, $R^7 =.05$,$p<.01$; SDS-10 and WSCM-CH, $R^2 =.04$,$p<.01$). Specifically, the WSCM was significant in explaining unreported accident, along with the WSCM-Un subscale. In addition, when near accidents were regressed on the predictor variables, results also revealed significant $R^2$ values for all variables (SDS-10 and WSCM, $R^2 = .05$, $p<.01$; SDS-10 and WSCM-HC, $R^2 = .05$, $p<.01$; SDS-10 and WSCM-SP, $R^2 =.05$, $p<.01$; SDS-10 and WSCM-Un, $R^2 =.05$,$p<.01$; SDS-10 and WSCM-CH, $R^2 =.03$,$p<.05$). The WSCM, WSCM-HC subscale, and WSCM-Un subscale were significant in predicting near accidents above social desirability and independent of other variables.

# Discussion

The present study described the development and validation of the Work Safety Compliance Measure (WSCM), a 52-item measure of employee compliance with safety behavior guidelines. Generally, the measure can be described by a four-factor model. Each factor represents one of four types of safety behavior: (a) Hazard Communication and General Safety (WSCM-HC), (b) Safety Protocol (WSCM-SP), (c) Unsafe Behavior (WSCM-Un), and (d) Chemical Handling (WSCM-CH). Each of these subscales and the overall scale had high internal consistency estimates. The preliminary analyses seem to indicate that the WSCM reliably measures four types of safety behavior in the workplace.

The WSCM was designed to assess compliance with safety behavior guidelines in the workplace. Generation of WSCM items was guided by previous research examining unsafe acts which have resulted in reported accidents in organizations (Reber & Wallin, 1983; Komaki et al., 1978), use of the critical incident technique (Flanagan, 1954) by safety professionals, and established safety practices advocated by OSHA. Each item of the WSCM described a safe or unsafe work behavior and asked respondents to indicate how frequently the behavior occurred. The retained items were selected based on psychometric information (high factor loadings) suggesting they were good indicators of their underlying construct. In all, 38 items were selected to be used in the WSCM.

Item evaluation was based on the results of an exploratory factor analysis and corrected-item total correlations. Previous researchers have suggested that factor analyses should be conducted on subject sample sizes of 200 or more with a sample to item ratio of at least five (Cattell, 1978; Ford, MacCallum, & Tait, 1986). For the current study, the sample size exceeded 400 and the subject to item ratio was eight.

The results of the factor analysis revealed a clean, interpretable four-factor solution. Each of the factors can be described as representing a type of safety behavior. All primary item loadings exceeded .30 and did not cross-load on another factor. Corrected-item total correlations also indicated that items within each factor are related to the other items.

The sample used for item selection was heterogeneous with respect to occupational industries represented. Due to the sampling technique used, a variety of occupations were represented. Therefore, the results of the item selection procedures may generalize across a variety of different occupations, and the factor solution may be invariant across different types of jobs.

The reliability (Cronbach's alpha) of each of the WSCM subscales was high (WSCM-H = .90, WSCM-SP = .84, WSCM-Un = .83, WSCM-CH = .90). Thus, the high reliabilities suggest that the items within each WSCM subscale are measuring the same underlying construct. The intercorrelations among the WSCM subscales were considerably lower than each of the WSCM subscale reliabilities (range from .41 to .56), suggesting that the WSCM measured four empirically distinct constructs. Thus, the relatively high internal consistency estimates and the lower interrelationship among the subscales suggest that types of safety compliance behavior, as measured by the WSCM, represent different, but related, constructs.

WSCM subscales were negatively correlated with unreported and near accident rates. Overall, employees who reported fewer accidents and near accidents said they behaved more safety on the job - an anticipated and logical relationship. It is important to note that the Unsafe Behavior subscale was the best predictor of unreported and near accidents. This suggests that perhaps it is behaving unsafely in the workplace (e.g., Item #5 = Improperly set up equipment before use; Item #18 = Work under the influence of drugs or alcohol) that predicts accidents rather than more subtle safety behavior and adhering to proactive safety guidelines (e.g., Item #23 = Properly secure equipment before use; Item #40 = Inspect selected work areas to detect hazards). Thus, reducing unsafe behavior in the workplace should improve an organization's accident rate.

The reliability estimate for the social desirability scale was .65. As previously mentioned, the SDS-10 was used to control for the tendency to respond to questionnaire items in a favorable manner. The SDS-10 was significant in predicting accident data, reflecting a social desirability component to scale responses. However, unsafe behavior significantly predicted unreported and near accidents, and chemical handling predicted near accidents, above the effect of social desirability. This evidence supports the validity of the WSCM-Un subscale, specifically, in explaining accident rates by employees.

Research on occupational accidents has found several factors that contribute directly or indirectly to accident rates, including management and coworker safety practices (Hayes, Johnson, Strom, Langlie, & Trask, 1994), employee characteristics and organizational factors such as management support, good housekeeping, and the organizational safety climate (Murphy, Sturdivant, & Gershon, 1993). The use of the WSCM could provide insight regarding the frequency and type of safety behavior by an organization's employees. The content of the items in the four WSCM subscales reflect four types of safety behavior. Consequently, the specificity of the these items may allow organizations to determine why accident rates are high and provide a means to improve safety compliance and reduce accident rates.

Limitations and Future Research

There are several methodological limitations of the present study. First, the sample of respondents may not be representative of the population of workers to which the researcher would like to generalize. As previously mentioned, the sample consisted of employees working in several different industries. However, it is important to note that the majority of the sample held positions in what are traditionally considered blue collar occupations. Due to sample size limitations, the current study could not determine the extent of factorial invariance across types of occupations. Future studies could determine if the factor structure of the WSCM remains the same across a variety of different occupations and industries. In addition, sample size limitations did not allow the examination of differences between other demographic variables (i.e., age, gender, time working in current industry) in predicting accidents. Future research with a larger sample might explore using demographic variables as covariates.

Second, all variables were measured using a self-report instrument. Thus, correlations between the accident variables and the WSCM subscales may be due to common method variance. Previous studies, however, have found that self-reported safety compliance behavior were related to observed safety behavior obtained from trained observers (Lusk, Ronis, & Baer, 1995). In any event, future studies should use objective safety behavior and accident rate indices to provide additional evidence of construct validity of the WSCM.

Third, all variables were measured at one point in time. Thus, inferences of directional causal effects should be made with caution. For example, results revealed that employees who do not behave unsafely on the job report fewer accidents. Perhaps employees report safer behavior because they haven't experienced many accidents (i.e., they assume they are adhering to safety guidelines because they haven't been injured). It is also possible that individuals have different definitions of accidents and near accidents. For example, some employees may not consider a mishap on the job an accident unless bodily injury occurs. The current study, however, does provide evidence that these variables are related to each other. Future research might employ a longitudinal design to determine the direction of causality with this set of variables.

Fourth, it is possible that the high correlation of subscales may be due to using unweighted sums rather than factor scores. Future studies should explore correlations based on factor scores.

Fifth, correlations between subscales and accident data were not based on an overall pattern. Scatterplots of the correlations reflect that a few responses indicating accidents on the job were responsible for some correlations. Future research with more accident data should explore these correlations further.

Sixth, most subjects reported that they had experienced very few or no accidents. Future research might define the accident data as a dichotomous variable and ask subjects to report accidents on a "yes" or "no" scale. Logistic regression could then be employed and may be more powerful in revealing other relationships between accident data and subscales.

The results of the exploratory factor analysis suggest that employees' safety compliance behavior, as measured by the WSCM, is multidimensional and is related to accidents and near accidents in the workplace. In the future, researchers could apply confirmatory factor analysis on the WSCM to test various measurement models.

Conclusion

The present study described the research supporting the development and validation of a self-report measure of employee compliance with safety behavior guidelines. The preliminary evidence suggests that the WSCM reliably measures four types of safety behavior in the workplace. With further support and validation, the WSCM could enable organizations to assess the frequency of employees' safety compliance behavior and identify which safety behaviors are most often ignored. This information will be useful in the introduction and maintenance of a safety program. In addition, questionnaire results also become a baseline against which to measure safety program progress. Ultimately, the safety behavior knowledge gained from questionnaire administration will help effectively manage safety in organizations, resulting in increased productivity and reduced workers' compensation and related costs.

Table 1

Demographic Characteristics of Sample 1 (N = 302)

| Variable | Categories | Percentage |
|---|---|---|
| Gender | Male | 94.9 |
| | Female | 5.1 |
| Age | Less than 22 years | 8.8 |
| | 22 to 29 years | 45.8 |
| | 30 to 39 years | 32.2 |
| | 40 to 49 years | 7.7 |
| | 50 to 59 years | 4.2 |
| | Over 60 years | 1.4 |
| Job Tenure | Less than 1 year | .3 |
| | 2 to 5 years | 66.3 |
| | 6 to 10 years | 19.1 |
| | 11 to 15 years | 5.2 |
| | 16 to 20 years | 4.2 |
| | Over 20 years | 4.9 |

Table 2

Demographic Characteristics of Sample 2 (N = 132)

| Variable | Categories | Percentage |
|---|---|---|
| Gender | Male | 58.1 |
| | Female | 41.9 |
| Age | Less than 22 years | |
| | 22 to 29 years | 21.9 |
| | 30 to 39 years | 31.4 |
| | 40 to 49 years | 22.9 |
| | 50 to 59 years | 21.0 |
| | Over 60 years | 2.8 |
| Job Tenure | Less than 1 year | 9.0 |
| | 2 to 5 years | 57.8 |
| | 6 to 10 years | 12.2 |
| | 11 to 15 years | 14.4 |
| | 16 to 20 years | 4.4 |
| | Over 20 years | 2.2 |

Table 3

Industry Categories of Sample 1 and Sample 2 (N = 434)

| Industry Category | Percentage |
| --- | --- |
| Heating, Ventilation, and Air Conditioning | 36.4 |
| Computer hardware manufacturing | 31.0 |
| Plumbing | 28.4 |
| Maintenance, hospital | 4.2 |

Table 4

Items Means and Standard Deviations of the Initial Item Pool of the WSCM

| Item[a] | Mean | SD |
|---|---|---|
| 1 | 3.72 | 1.24 |
| 2 | 4.25 | 1.04 |
| 3 | 4.23 | 1.18 |
| 4 | 4.33 | 1.00 |
| 5 | 4.66 | .81 |
| 6 | 3.63 | 1.27 |
| 7 | 4.21 | 1.04 |
| 8 | 4.42 | .91 |
| 9 | 4 39 | .92 |
| 10 | 3.76 | 1.30 |
| 11 | 4.20 | .96 |
| 12 | 3.69 | 1.22 |
| 13 | 4.45 | .88 |
| 14 | 4.06 | 1.32 |
| 15 | 4.06 | .97 |
| 16 | 4.37 | 1.16 |

Note. N = 313 to 414.
[a]Refers to the item numbering in the Work Safety Compliance Measure (Appendix )

Table 4 (cont'd)

| Item[a] | Mean | SD |
|---|---|---|
| 17 | 4.52 | .84 |
| 18 | 4.86 | .67 |
| 19 | 3.94 | 1.23 |
| 20 | 4.17 | 1.09 |
| 21 | 4.37 | 1.09 |
| 22 | 4.03 | 1.17 |
| 23 | 4.29 | .96 |
| 24 | 4.11 | 1.22 |
| 25 | 3.96 | 1.21 |
| 26 | 3.93 | 1.39 |
| 27 | 4.42 | .97 |
| 28 | 4.17 | .99 |
| 29 | 4.52 | .93 |
| 30 | 3.93 | 1.15 |
| 31 | 3.47 | 1.30 |
| 32 | 4.34 | .88 |
| 33 | 4.29 | .97 |
| 34 | 4.15 | .92 |

Note. N = 313 to 414.
[a]Refers to the item numbering in the Work Safety Compliance Measure (Appendix)

Table 4 (cont'd)

| Item[a] | Mean | SD |
|---|---|---|
| 35 | 4.42 | .94 |
| 36 | 4.28 | 1.02 |
| 37 | 4.05 | 1.15 |
| 38 | 4.08 | 1.02 |
| 39 | 4.26 | 1.00 |
| 40 | 3.45 | 1.28 |
| 41 | 3.15 | 1.30 |
| 42 | 4.47 | .99 |
| 43 | 4.36 | .99 |
| 44 | 3.95 | 1.21 |
| 45 | 4.52 | .91 |
| 46 | 4.54 | .82 |
| 47 | 4.49 | .93 |
| 48 | 4.48 | .80 |
| 49 | 4.43 | .85 |
| 50 | 4.32 | .95 |
| 51 | 3.85 | 1.48 |
| 52 | 2.88 | 1.28 |

Note. N = 313 to 414.
[a]Refers to the item numbering in the Work Safety Compliance Measure (Appendix)

Table 5

Factor Structure (Loadings, Communality Estimates) of the Initial Item Pool of the WSCM (N = 434)

| | Factor Loadings | | | | |
|---|---|---|---|---|---|
| Item[a] | I | II | III | IV | $h^{2b}$ |
| 1 | .11 | .23 | -.03 | .17 | .09 |
| 2 | .03 | **.37** | -.02 | .14 | .16 |
| 3 | .04 | **.36** | -.15 | .21 | .20 |
| 4 | .08 | .21 | **.59** | .12 | .41 |
| 5 | .10 | .06 | **.44** | .21 | .25 |
| 6 | .25 | **.42** | .08 | .03 | .25 |
| 7 | .14 | .18 | **.58** | .09 | .40 |
| 8 | .19 | **.56** | .29 | .01 | .43 |
| 9 | .14 | **.66** | .29 | .02 | .54 |
| 10 | .39 | .52 | .20 | .001 | .46 |
| 11 | .32 | **.65** | .29 | .04 | .60 |
| 12 | .33 | **.56** | .20 | .01 | .46 |
| 13 | .17 | **.58** | .24 | .07 | .42 |
| 14 | -.02 | .17 | **.50** | -.03 | .28 |
| 15 | .22 | **.38** | .13 | .11 | .22 |
| 16 | .08 | -.001 | **.35** | .07 | .13 |
| 17 | .10 | .07 | **.60** | .20 | .42 |
| 18 | .10 | -.07 | **.42** | .18 | .23 |

Note. Factor loadings obtained after varimax rotation.
[a] Refers to item numbering in the Work Safety Compliance Measure (Appendix)
[b] $h^2$ = communality

Table 5 (cont'd)

Factor Loadings

| Item[a] | I | II | III | IV | $h^{2b}$ |
|---|---|---|---|---|---|
| 19 | .29 | .29 | .08 | .15 | .19 |
| 20 | .21 | .21 | **.60** | .06 | .46 |
| 21 | .08 | -.01 | .28 | .09 | .09 |
| 22 | **.61** | .23 | .23 | .02 | .48 |
| 23 | **.46** | .30 | .21 | .25 | .41 |
| 24 | **.43** | .24 | .15 | .14 | .29 |
| 25 | **.50** | .25 | .13 | .12 | .35 |
| 26 | .05 | .21 | **.48** | -.06 | .28 |
| 27 | **.54** | .13 | .17 | .25 | .39 |
| 28 | .30 | .19 | **.47** | .09 | .35 |
| 29 | .22 | .12 | **.52** | .17 | .36 |
| 30 | .47 | .38 | .10 | .09 | .38 |
| 31 | .49 | .39 | .05 | .07 | .41 |
| 32 | .33 | .35 | .17 | .31 | .36 |
| 33 | **.55** | .14 | .20 | .23 | .42 |
| 34 | .39 | .44 | .17 | .26 | .44 |
| 35 | .34 | .30 | .19 | .33 | .35 |
| 36 | **.76** | .12 | .25 | .18 | .68 |
| 37 | **.67** | .08 | .16 | .12 | .50 |
| 38 | **.56** | .23 | .22 | .17 | .44 |

Note. Factor loadings obtained after varimax rotation.
[a] Refers to item numbering in the Work Safety Compliance Measure (Appendix)
[b] $h^2$ = communality

Table 5 (cont'd)

Factor Loadings

| Item[a] | I | II | III | IV | $h^{2b}$ |
|---|---|---|---|---|---|
| 39 | **.75** | .11 | .20 | .14 | .64 |
| 40 | **.57** | .18 | .01 | .01 | .35 |
| 41 | **.59** | .19 | -.11 | .02 | .40 |
| 42 | .15 | **.31** | .19 | .11 | .16 |
| 43 | .31 | **.45** | .19 | .23 | .39 |
| 44 | .47 | .42 | .18 | .08 | .44 |
| 45 | .18 | .18 | .23 | **.70** | .60 |
| 46 | .25 | .19 | .22 | **.77** | .73 |
| 47 | .23 | .21 | .20 | **.73** | .67 |
| 48 | .31 | .47 | .29 | .42 | .58 |
| 49 | .37 | .48 | .30 | .32 | .56 |
| 50 | .36 | .31 | .23 | .23 | .33 |
| 51 | -.04 | .21 | **.43** | -.06 | .23 |
| 52 | .14 | .06 | .27 | -.04 | .10 |

Note. Factor loadings obtained after varimax rotation.
[a] Refers to item numbering in the Work Safety Compliance Measure (Appendix)
[b] $h^2$ = communality

Table 6

Corrected Item-Total Correlations for the Work Safety Compliance Measure (WSCM) Items within each subscale

| WSCM-HC (N=299) | | WSCM-SP (N=259) | | WSCM-Un (N=280) | | WSCM-CH (N=303) | |
|---|---|---|---|---|---|---|---|
| Item[a] | r[b] | Item[a] | r[b] | Item[a] | r[b] | Item[a] | r[b] |
| 22 | .69 | 2 | .37 | 4 | .62 | 45 | .75 |
| 23 | .62 | 3 | .37 | 5 | .47 | 46 | .84 |
| 24 | .49 | 6 | .47 | 7 | .62 | 47 | .80 |
| 25 | .59 | 8 | .64 | 14 | .48 | | |
| 27 | .59 | 9 | .67 | 16 | .31 | | |
| 33 | .65 | 11 | .73 | 17 | .55 | | |
| 36 | .78 | 12 | .65 | 18 | .31 | | |
| 37 | .71 | 13 | .60 | 20 | .56 | | |
| 38 | .65 | 15 | .48 | 26 | .52 | | |
| 39 | .79 | 42 | .37 | 28 | .55 | | |
| 40 | .54 | 43 | .51 | 29 | .50 | | |
| 41 | .57 | | | 51 | .45 | | |

Note. WSCM-HC refers to Hazard Communication and General Safety; WSCM-SP refers to Safety Protocol; WSCM-Un refers to Unsafe behaviors; WSCM-CH refers to Chemical Handling.

[a]Refers to the item numbering in the Work Safety Compliance Measure (Appendix).

[b]Corrected item-total correlations.

Table 7

Means, Standard Deviations and Intercorrelations among the Variables (WSCM, WSCM subscales, SDS-10 and accidents)

| Variables | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. WSCM | 4.21 | .55 | (.94) | | | | | | | | |
| 2. WSCM-HC | 4.04 | .77 | .85** | (.90) | | | | | | | |
| 3. WSCM-SP | 4.22 | .64 | .80** | .56* | (.84) | | | | | | |
| 4. WSCM-Un | 4.32 | .63 | .74** | .41* | .47* | (.83) | | | | | |
| 5. WSCM-CH | 4.53 | .81 | .65** | .52* | .45* | .41* | (.90) | | | | |
| 6. SDS-10 | 5.78 | 2.18 | .34** | .33* | .30* | .19* | .24* | (.65) | | | |
| 7. REPACC | .22 | .45 | -.002 | .02 | -.01 | -.03 | .02 | -.10 | (--) | | |
| 8. UNREPACC | .20 | .57 | -.17** | -.15* | -.10 | -.18** | -.12* | -.17** | .15* | (--) | |
| 9. NEARACC | .77 | 1.20 | -.19** | -.17* | -.16** | -.18** | -.01 | -.18** | .08 | .35** | (--) |

Note. N = 283 to 418. Reliability estimates (Cronbach's alpha) located on the diagonal. WSCM = Work Safety Compliance Measure, WSCM-HC = Hazard Communication and General Safety Subscale, WSCM-SP = Safety Protocal Subscale, WSCM-Un = Unsafe Behaviors Subscale, WSCM-CH = Chemical Handling Subscale, SDS-10 = Short version Social Desirability Scale, REPACC = Reported accidents, UNREPACC = Unreported accidents, NEARACC = Near accidents.

* $p < .05$, ** $p < .01$.

Table 8

Regression Analyses Using WSCM Subscales and SDS-10 as Predictor Variables (N = 302)

| Variable | β | t |
|---|---|---|
| Unreported Accidents | | |
| SDS-10 | -.13 | -2.08* |
| WSCM-HC | -.066 | -.85 |
| WSCM-SP | .06 | .72 |
| WSCM-Un | -.15 | -2.08* |
| WSCM-CH | -.02 | -.27 |
| Near Accidents | | |
| SDS-10 | -.13 | -2.10* |
| WSCM-HC | -.12 | -1.6 |
| WSCM-SP | -.06 | -.78 |
| WSCM-Un | -.14 | -2.02* |
| WSCM-CH | .17 | 2.31* |

Note. WSCM = Work Safety Compliance Measure, WSCM-HC = Hazard Communication and General Safety Subscale, WSCM-SP = Safety Protocal Subscale, WSCM-Un = Unsafe Behavior Subscale, WSCM-CH = Chemical Handling Subscale, SDS-10 = Short version Social Desirability Scale.
* $p < .05$.

Table 9

Regression Analyses Using WSCM, WSCM Subscales and SDS-10 as Predictor Variables (N = 302)

| Variable | β | t |
|---|---|---|
| Unreported Accidents | | |
| SDS-10 | -.13 | -2.03* |
| WSCM | -.13 | -2.11* |
| | | |
| SDS-10 | -.14 | -2.21* |
| WSCM-HC | -.10 | -1.70 |
| | | |
| SDS-10 | -.15 | -2.53* |
| WSCM-SP | -.05 | -.85 |
| | | |
| SDS-10 | -.14 | -2.38* |
| WSCM-Un | -.15 | -2.61** |
| | | |
| SDS-10 | -.15 | -2.43* |
| WSCM-CH | -.08 | -1.39 |

Note. SDS-10 = Short version Social Desirability Scale, WSCM = Work Safety Compliance Measure, WSCM-HC = Work Safety Compliance Measure, Hazard Communication Subscale, WSCM-SP = Work Safety Compliance Measure, Safety Protocal Subscale, WSCM-Un = Work Safety Compliance Measure, Unsafe Behavior Subscale, WSCM-CH = Work Safety Compliance Measure, Chemical Handling Subscale.

* $p < .05$, ** $p < .01$.

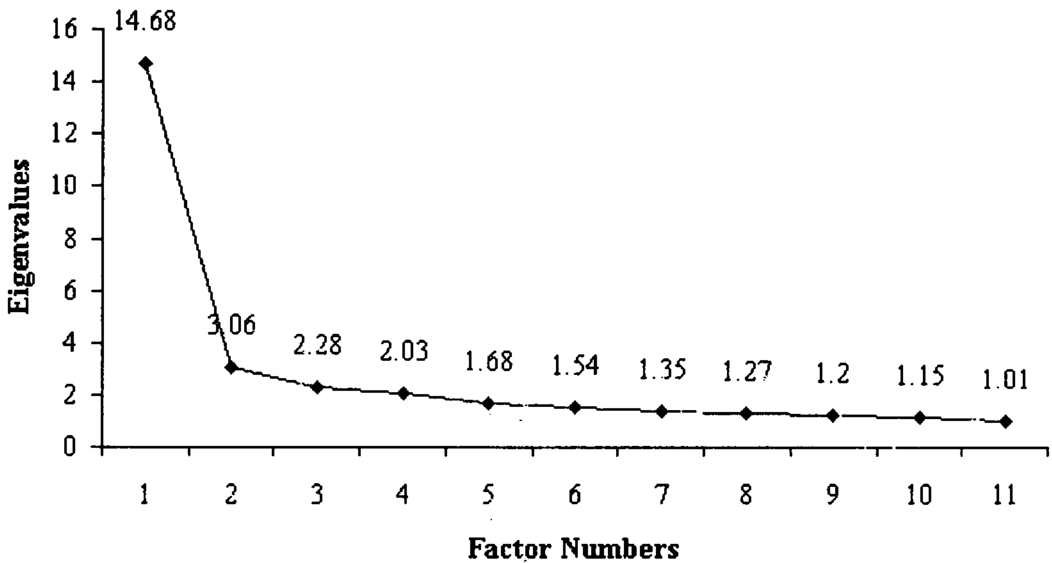
Table 9 (cont'd)

| Variable | β | t |
|---|---|---|
| Near Accidents | | |
| SDS-10 | -.13 | -2.05 |
| WSCM | -.15 | -2.34* |
| | | |
| SDS-10 | -.14 | -2.20* |
| WSCM-HC | -.13 | -2.05 |
| | | |
| SDS-10 | -.14 | -2.33 |
| WSCM-SP | -.12 | -1.88 |
| | | |
| SDS-10 | -.15 | -2.51* |
| WSCM-Un | -.15 | -2.47* |
| | | |
| SDS-10 | -.19 | -2.98 |
| WSCM-CH | .03 | .51 |

Note. SDS-10 = Short version Social Desirability Scale, WSCM = Work Safety Compliance Measure, WSCM-HC = Work Safety Compliance Measure, Hazard Communication Subscale, WSCM-SP = Work Safety Compliance Measure, Safety Protocal Subscale, WSCM-Un = Work Safety Compliance Measure, Unsafe Behavior Subscale, WSCM-CH = Work Safety Compliance Measure, Chemical Handling Subscale.
* $p < .05$, ** $p < .01$.

Figure 1

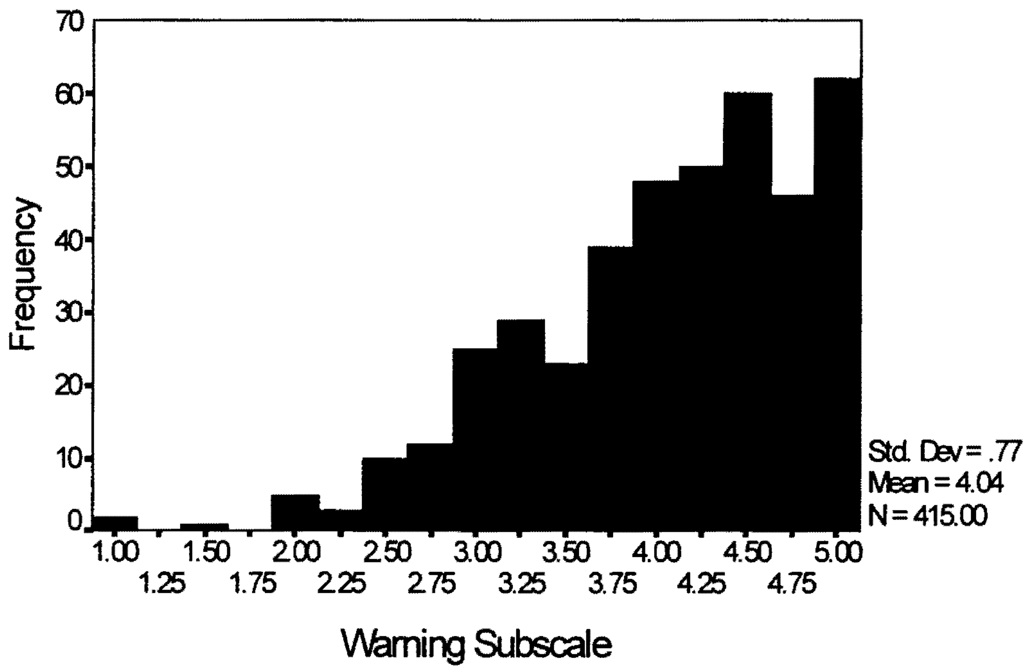
Scree plot of the eigenvalues from the factor analysis of the 52 WSCM items (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 2

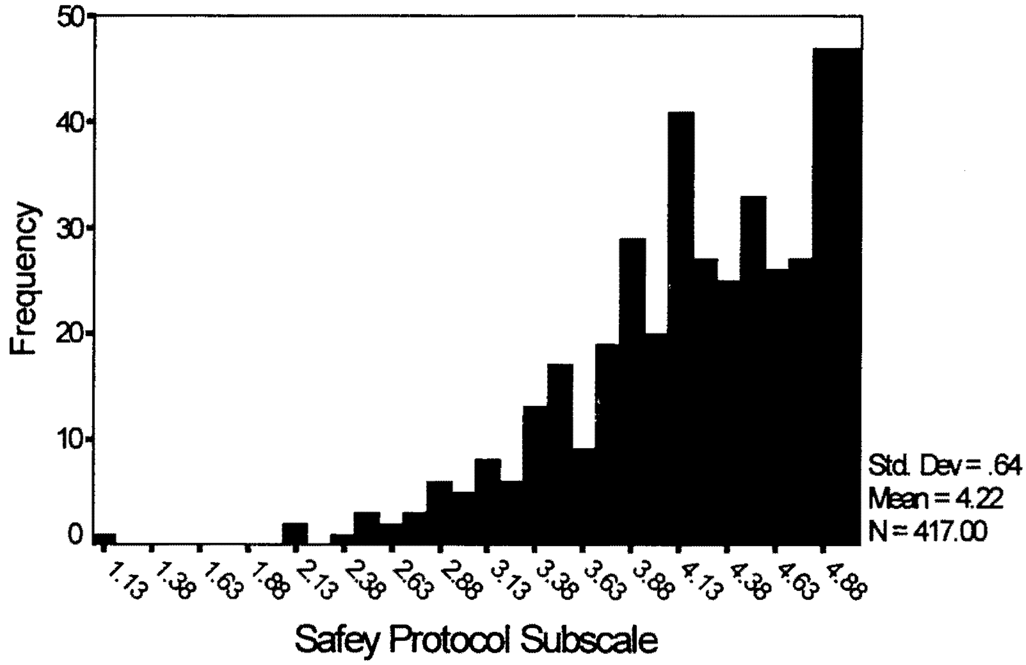
Response distribution for the WSCM Warning Subscale (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 3

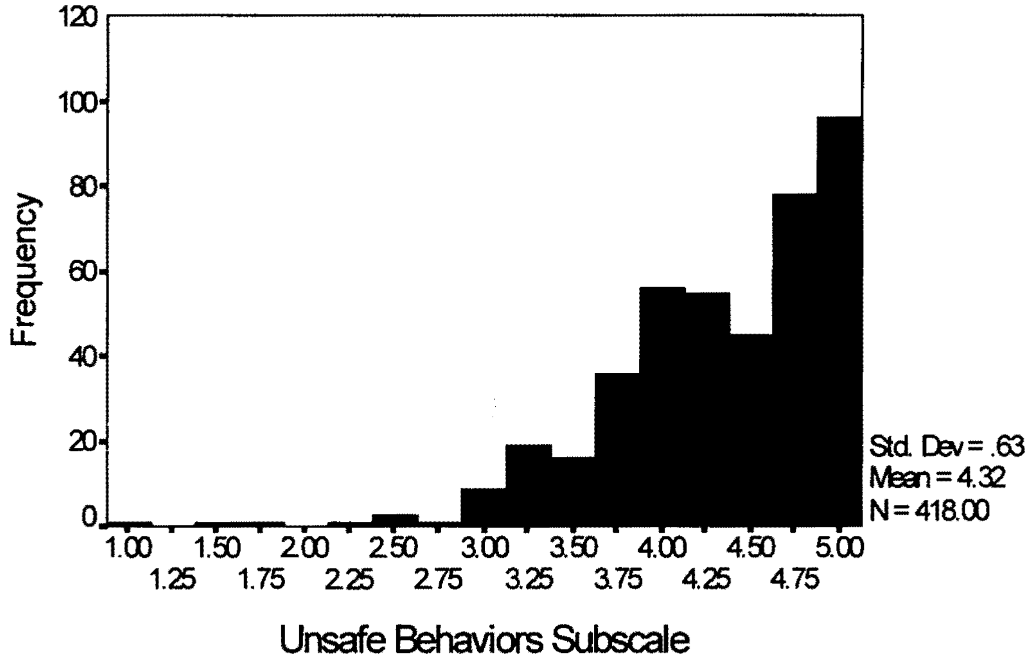
Response distribution for the WSCM Safety Protocol Subscale (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 4

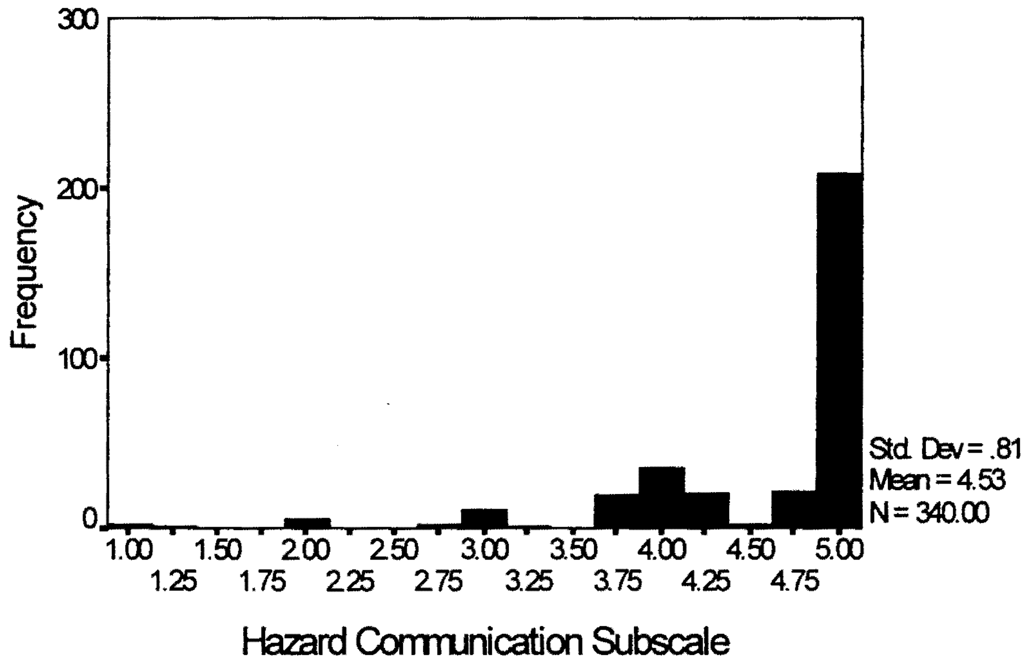
Response distribution for the WSCM Unsafe Behaviors Subscale (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 5

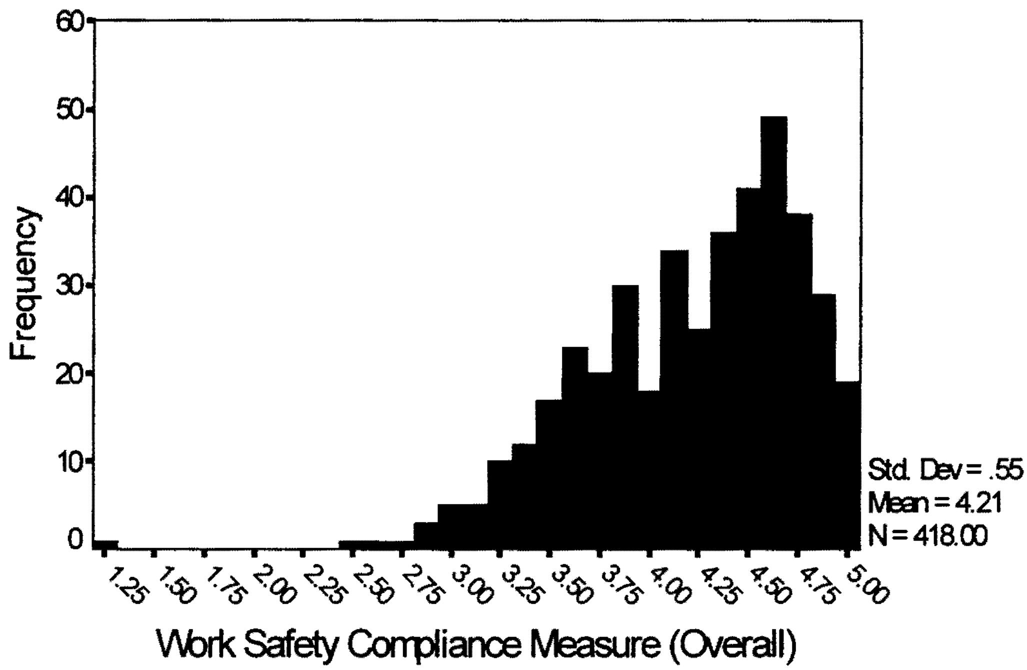
Response distribution for the WSCM Hazard Communication Subscale (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 6

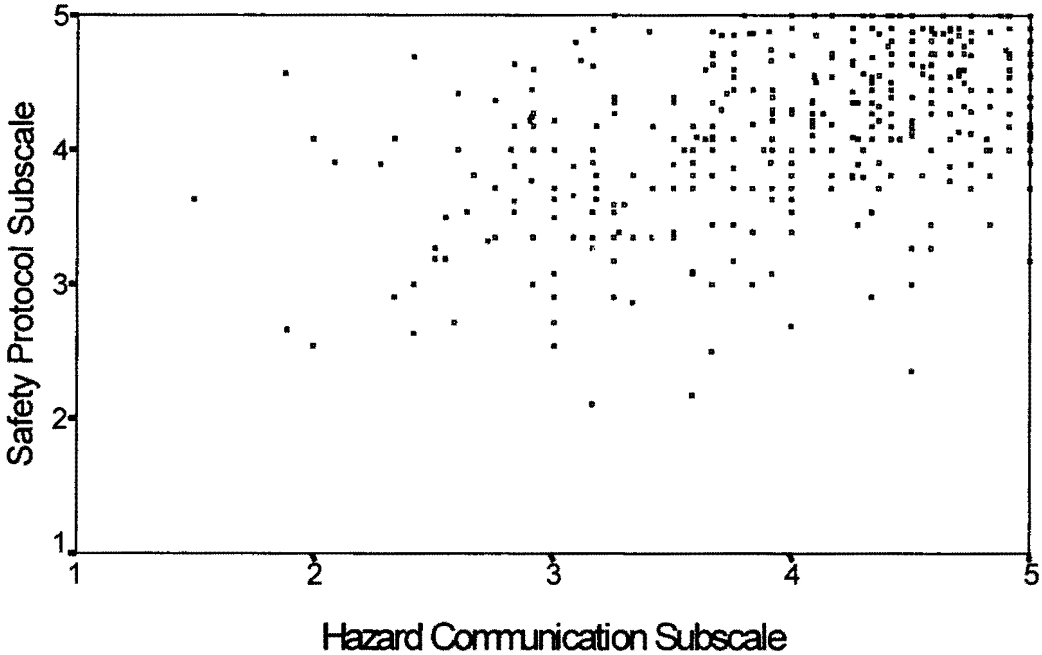
Response distribution for the WSCM (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 7

Correlation between WSCM-Hazard Communication and WSCM-Safety Protocol Subscales (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

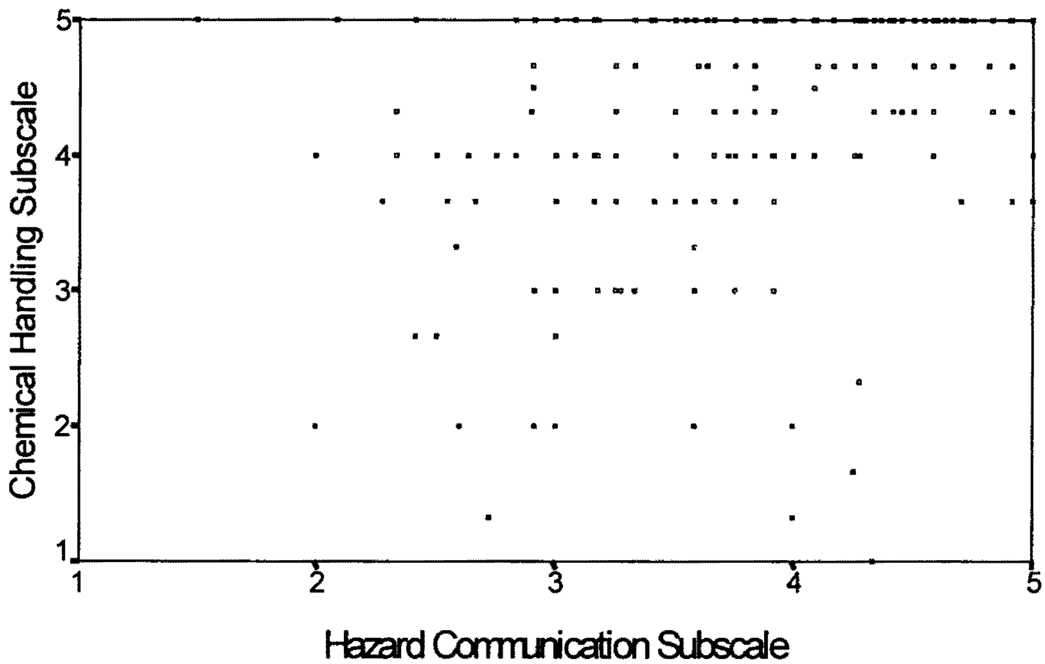
Figure 8

Correlation between WSCM-Hazard Communication and WSCM-Unsafe Behaviors Subscales (N=434)


Note. WSCM refers to the Work Safety Compliance Measure.

Figure 9

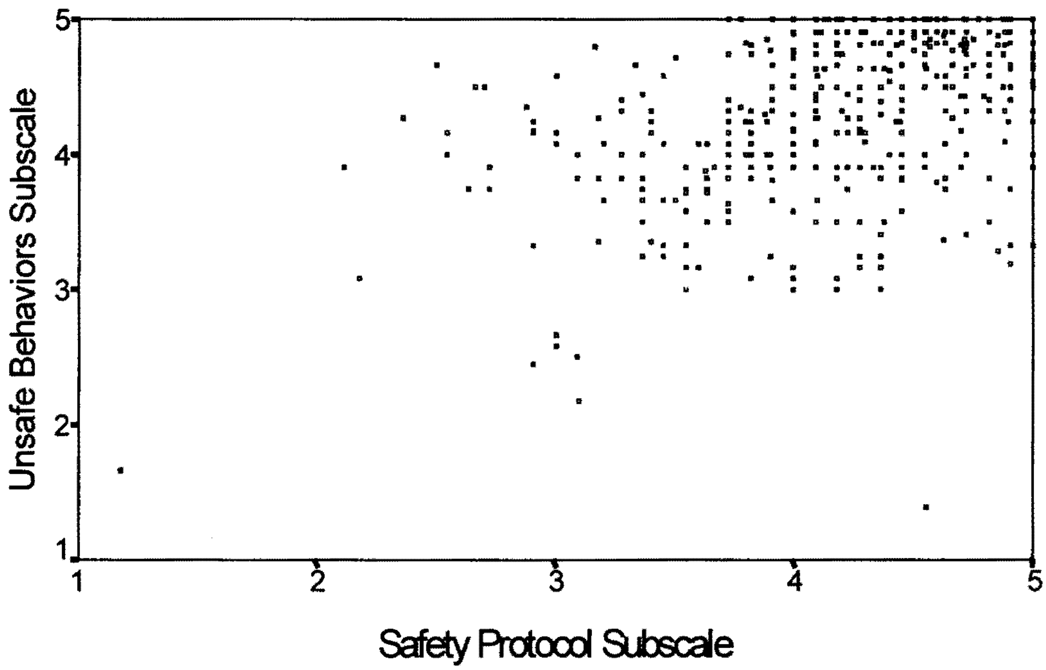
Correlation between WSCM-Hazard Communication and WSCM-Chemical Handling Subscales (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 10

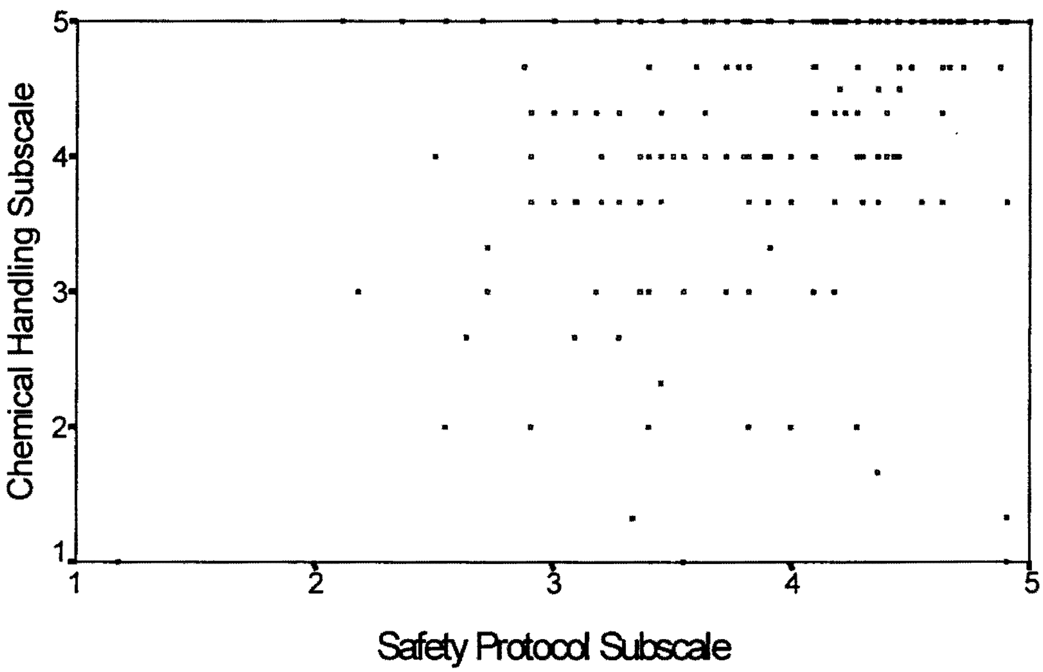
Correlation between WSCM-Safety Protocol and WSCM-Unsafe Behaviors Subscales (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 11

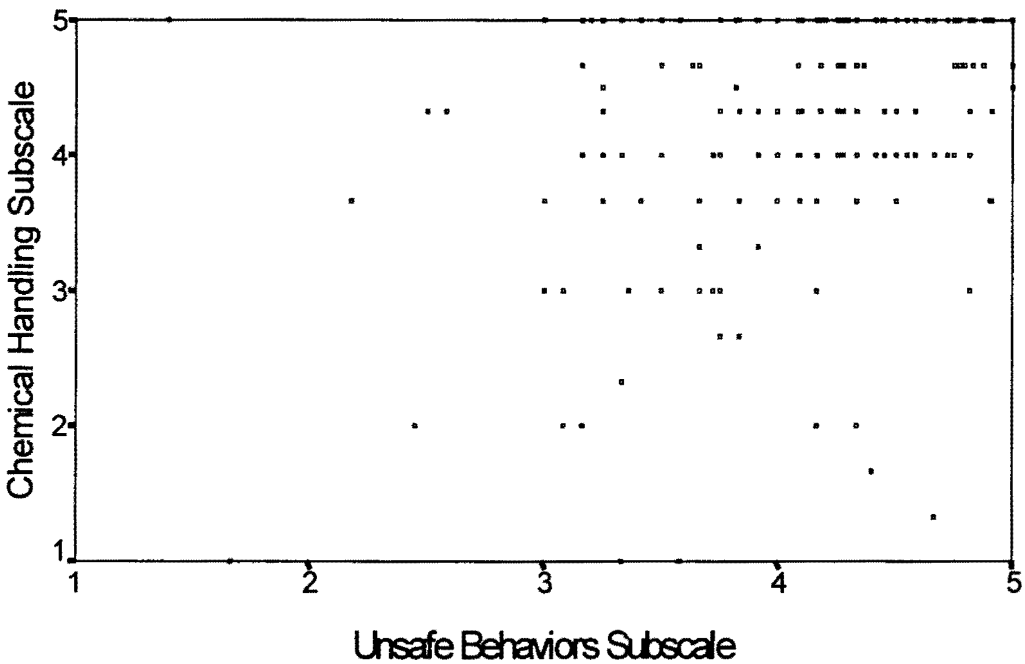
Correlation between WSCM-Safety Protocol and WSCM-Chemical Handling Subscales (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 12

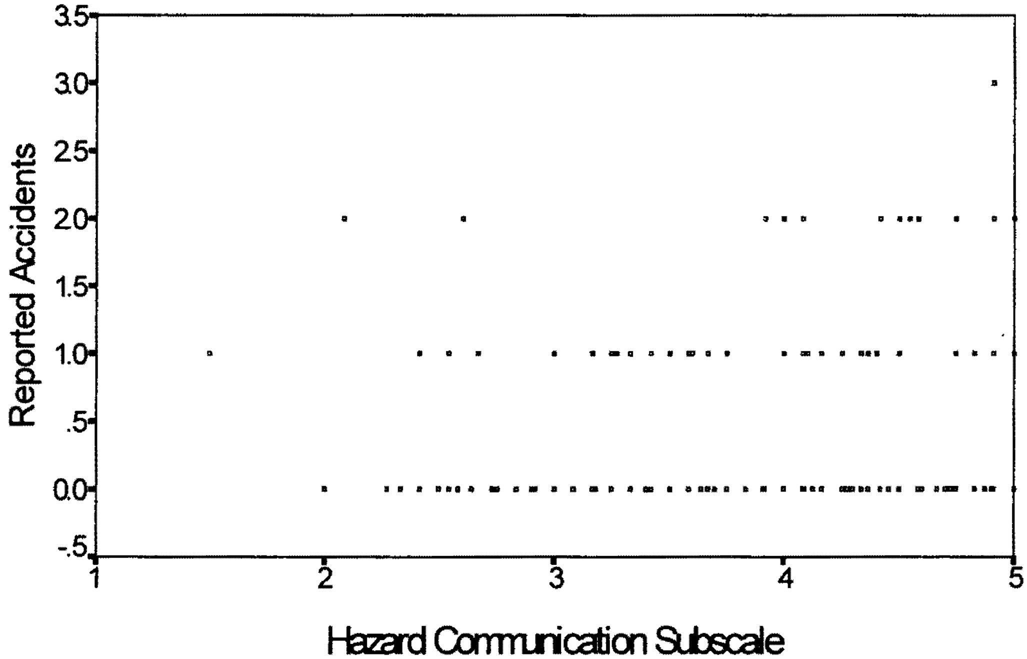
Correlation between WSCM-Unsafe Behaviors and WSCM-Chemical Handling Subscales (N=434)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 13

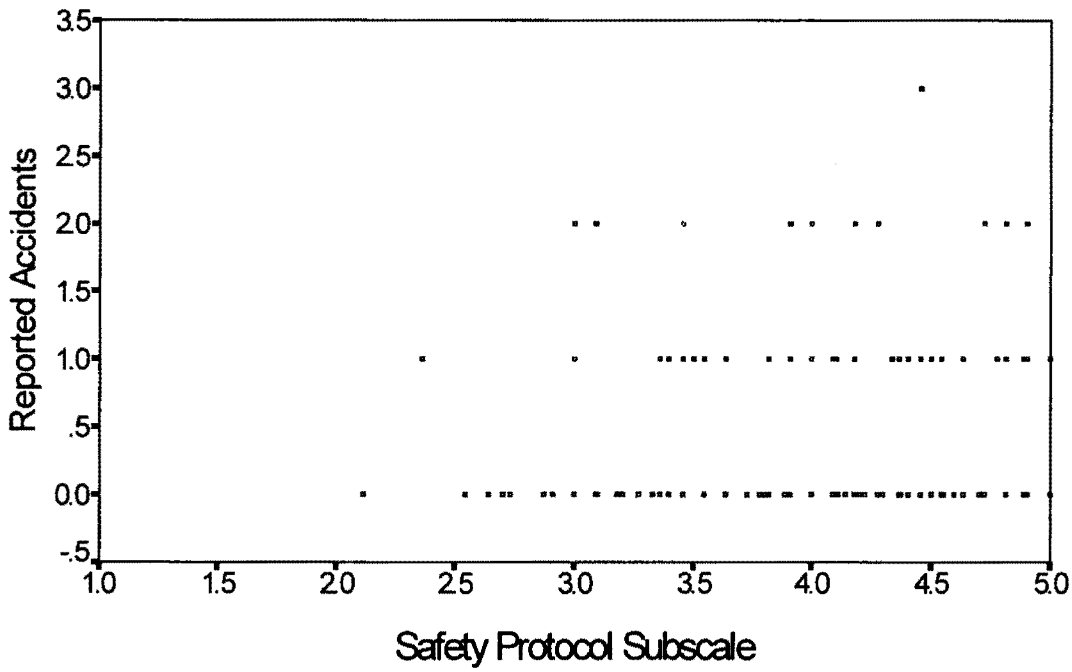
Correlation between WSCM-Hazard Communication Subscale and Reported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 14

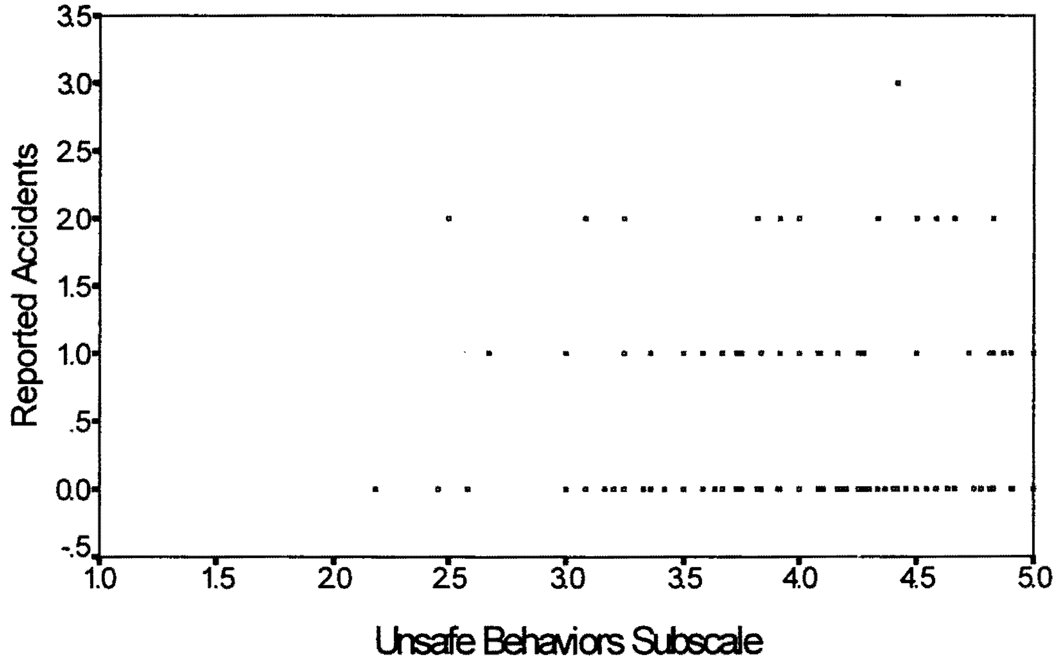
Correlation between WSCM-Safety Protocol Subscale and Reported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 15

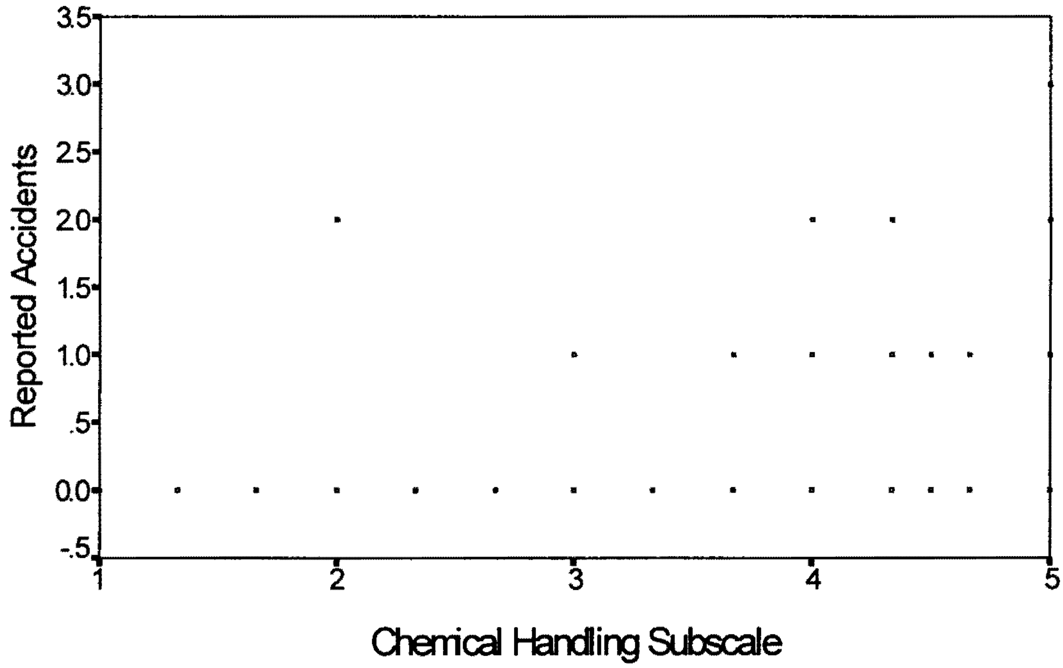
Correlation between WSCM-Unsafe Behaviors Subscale and Reported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 16

Correlation between WSCM-Chemical Handling Subscale and Reported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

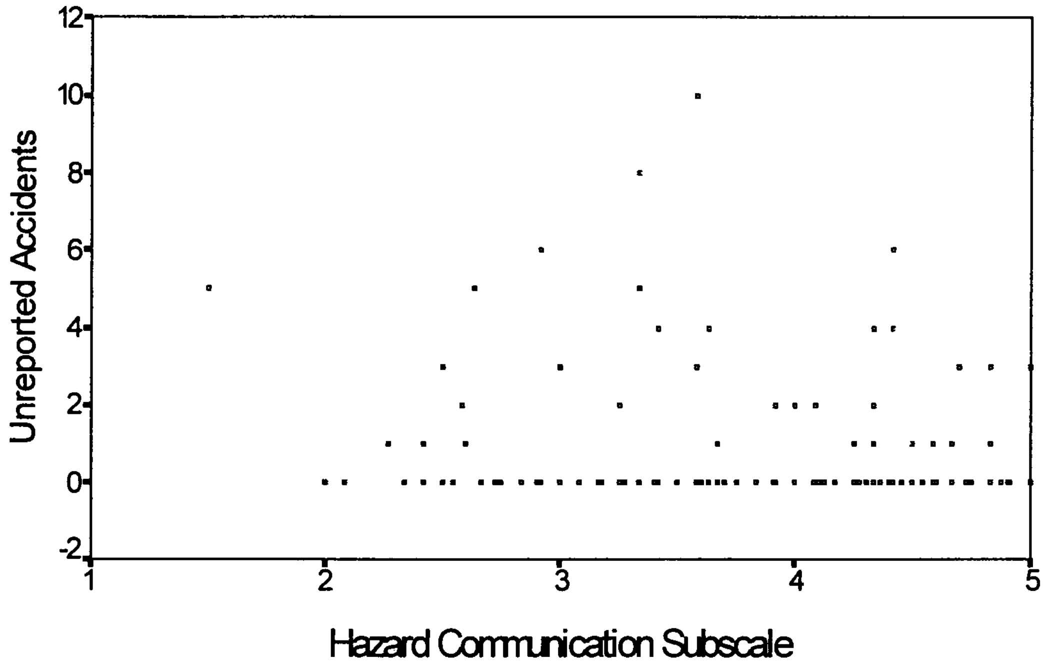
Figure 17

Correlation between WSCM and Reported Accidents (N=302)


Note. WSCM refers to the Work Safety Compliance Measure.

Figure 18

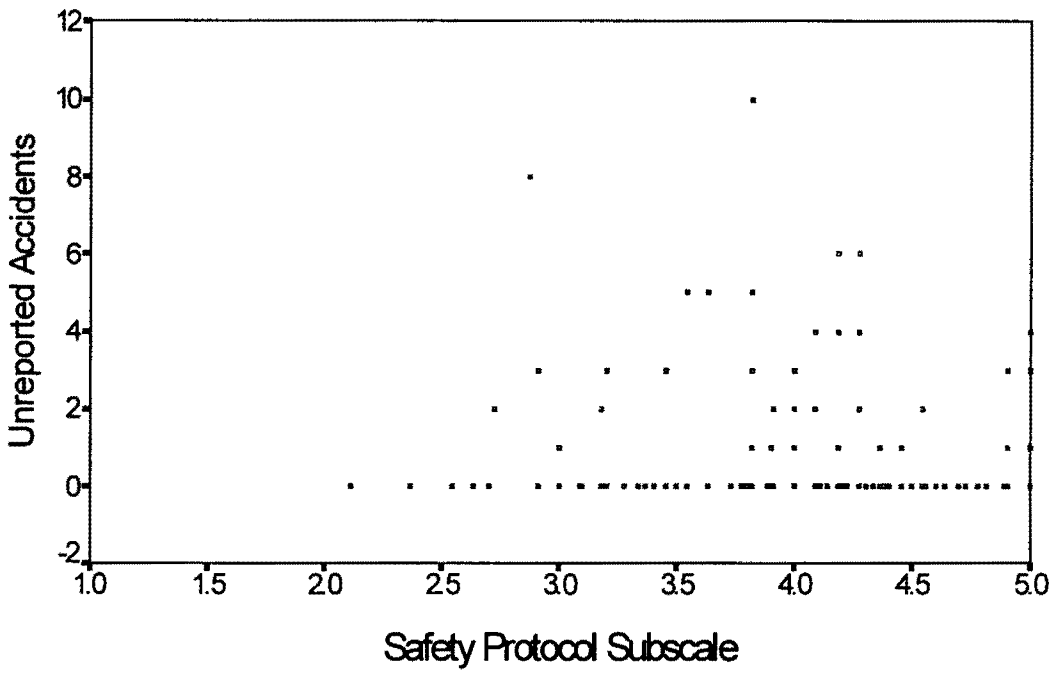
Correlation between WSCM-Hazard Communication Subscale and Unreported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 19

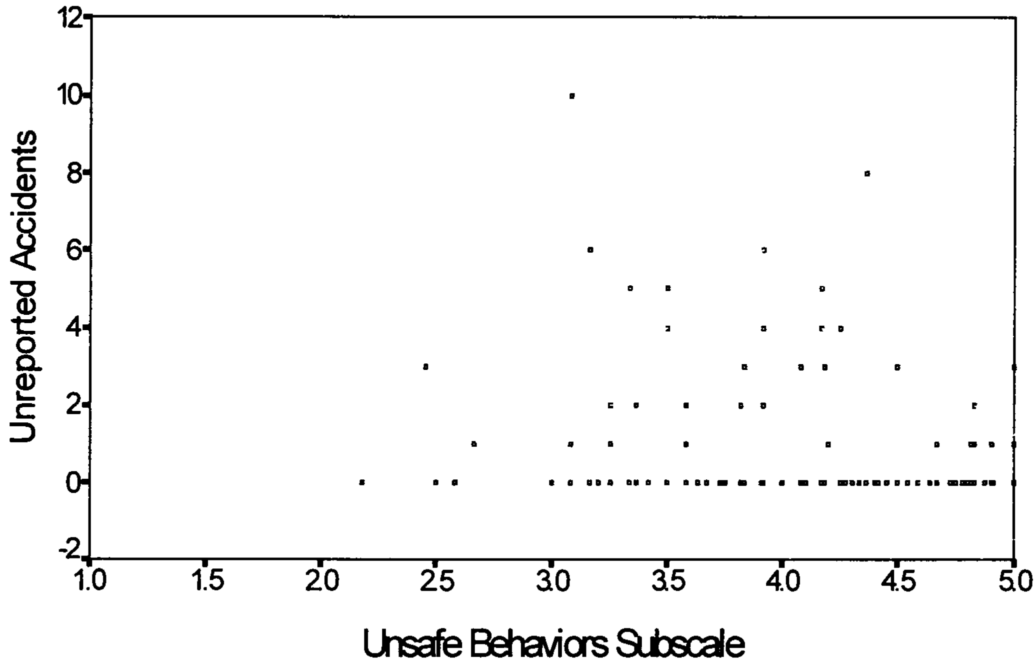
Correlation between WSCM-Safety Protocol Subscale and Unreported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 20

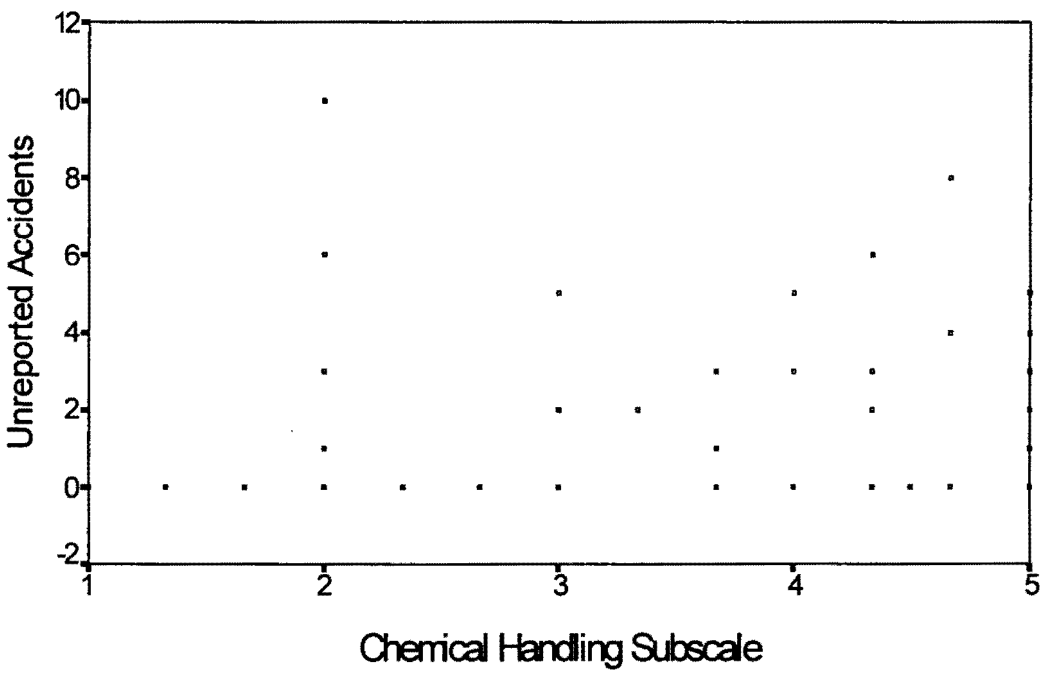
Correlation between WSCM-Unsafe Behaviors Subscale and Unreported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 21

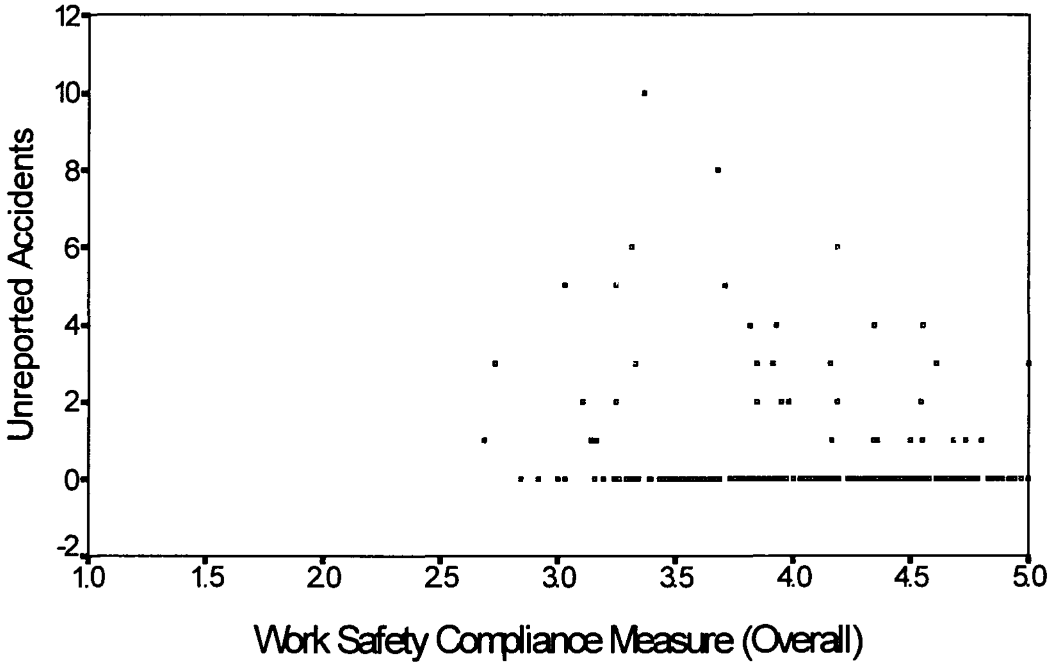
Correlation between WSCM-Chemical Handling Subscale and Unreported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 22

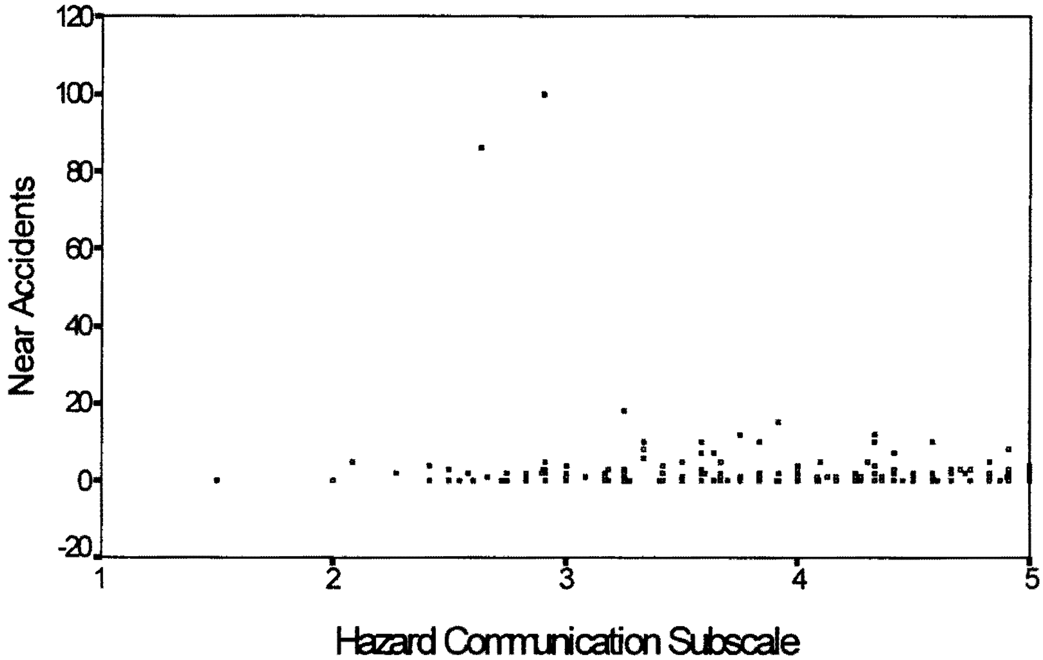
Correlation between WSCM and Unreported Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 23

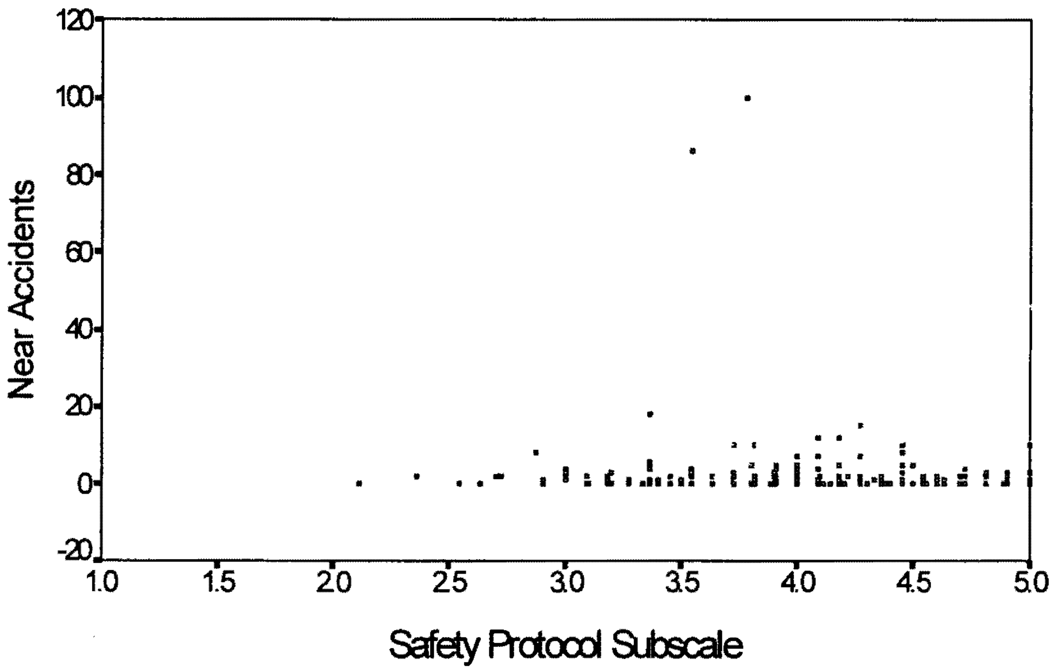
Correlation between WSCM-Hazard Communication Subscale and Near Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 24

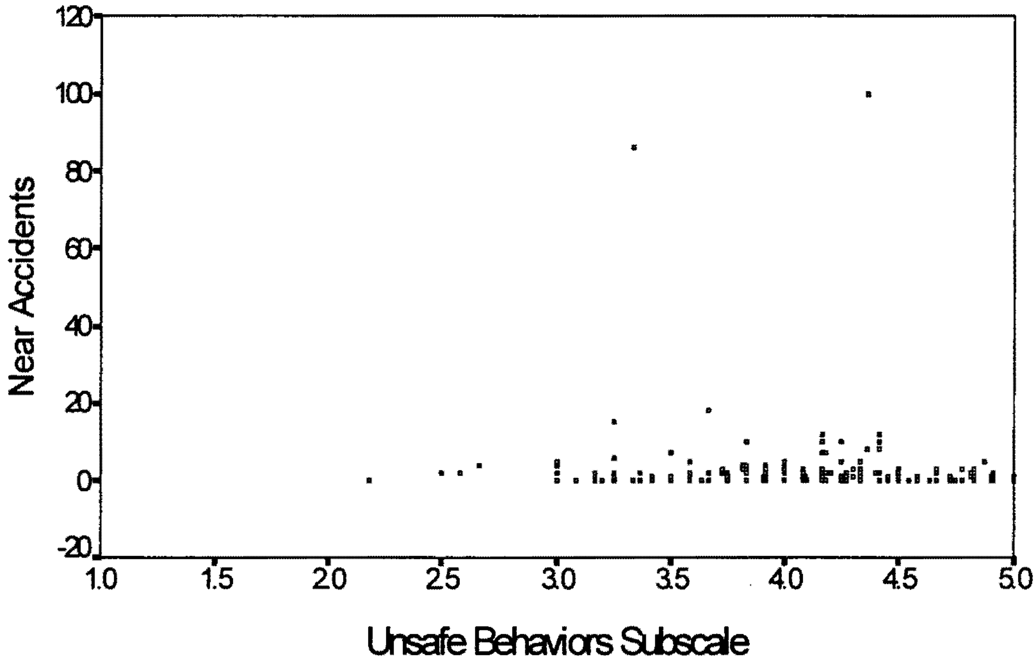
Correlation between WSCM-Safety Protocol Subscale and Near Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 25

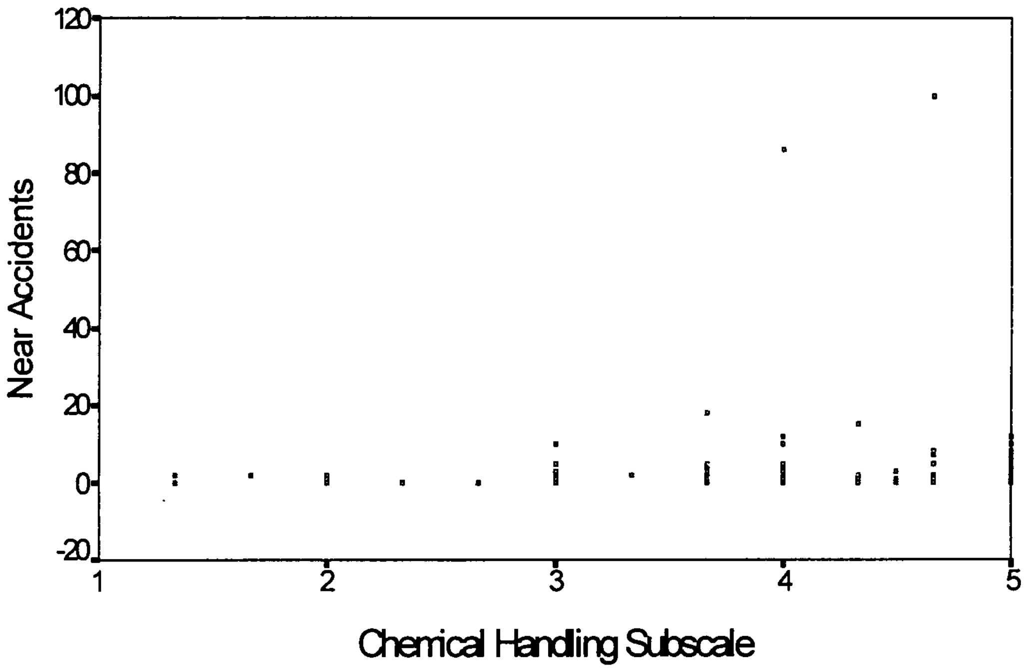
Correlation between WSCM-Unsafe Behaviors Subscale and Near Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 26

Correlation between WSCM-Chemical Handling Subscale and Near Accidents (N=302)




Note. WSCM refers to the Work Safety Compliance Measure.

Figure 27

Correlation between WSCM and Near Accidents (N=302)


Note. WSCM refers to the Work Safety Compliance Measure.

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## Appendix. WSCM

| Item | Factor Name |
|---|---|
| 1. Prepare materials for safe usage. | |
| 2. Use necessary safety equipment in dangerous work situations. | SP |
| 3. Use necessary safety device when working around harmful chemical fumes. | SP |
| 4. Alter equipment to save time. | Un |
| 5. Improperly set up equipment before use. | Un |
| 6. Replace old/damaged equipment prior to use. | SP |
| 7. Take shortcuts in safety guidelines in order to get the job done faster. | Un |
| 8. Follow emergency safety procedures. | SP |
| 9. Wear safety equipment required by practice . | SP |
| 10. Make sure emergency safety equipment is on site. | |
| 11. Follow all safety warnings and instructions. | SP |
| 12. Follow proper maintenance schedules for equipment. | SP |
| 13. Wear protective clothing required by practice. | SP |
| 14. Follow safety procedures only when I have time. | Un |
| 15. Keep my work area clean. | SP |
| 16. Display improper behavior in work environment. | Un |
| 17. Exceed equipment's recommended maximum limitations. | Un |
| 18. Work under the influence of drugs or alcohol. | Un |
| 19. Properly label hazardous work areas. | |
| 20. Improvise when safety equipment is not convenient. | Un |

| | | |
|---|---|---|
| 21. | Do not clean up my work area after a job. | |
| 22. | Report unsafe work conditions to my supervisor. | HC |
| 23. | Properly secure equipment before use. | HC |
| 24. | Step away from an unsafe condition in my work area. | HC |
| 25. | Encourage coworkers to behave safely. | HC |
| 26. | Follow safety procedures only for tasks I think are important. | Un |
| 27. | Warn coworkers of unsafe working conditions. | HC |
| 28. | Tend to become careless when performing routine tasks. | Un |
| 29. | Modify or alter equipment without management's approval. | Un |
| 30. | Inspect equipment prior to use. | |
| 31. | Periodically perform a thorough inspection of equipment. | |
| 32. | Return all equipment to its proper storage place after use. | |
| 33. | Communicate with coworkers regarding hazards relevant to them. | HC |
| 34. | Equipment is kept in an orderly fashion. | |
| 35. | Any spills are cleaned up immediately. | |
| 36. | Report all unsafe working conditions to my supervisor. | HC |
| 37. | Report any unrecognized safety hazards. | HC |
| 38. | Correct safety problems when I see them. | HC |
| 39. | Report safety problems to my supervisor. | HC |
| 40. | Inspect selected work areas to detect hazards. | HC |
| 41. | Make recommendations to management on preventing accidents. | HC |
| 42. | Attend all scheduled safety meetings. | SP |
| 43. | Keep emergency exits in my work area clear. | SP |
| 44. | Make sure emergency equipment is at hand. | |

45. Properly use hazardous chemicals. CH
46. Properly store hazardous chemicals. CH
47. Properly dispose of hazardous chemicals. CH
48. Properly use equipment required by practice.
49. Properly store equipment required by practice.
50. Behave on the job as if there is the possibility of accident or injury.
51. Follow only safety guidelines I think are important. Un
52. Work when sick or tired.