The Use of Supervisory Practices as Leverage to Improve Safety Behavior: A Cross-level Intervention Model

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Abstract

The paper presents three intervention studies designed to modify supervisory monitoring and rewarding of subordinates' safety performance. Line supervisors received weekly feedback concerning the frequency of their safety-oriented interactions with subordinates, and used this to self-monitor progress towards designated improvement goals. Managers higher up in the organizational hierarchy received the same information, coupled with synchronous data concerning the frequency of workers' safety behaviors, and highlighting co-variation of supervisory action and workers' behavior. In all the companies involved, supervisory safety-oriented interaction increased significantly, resulting in significant changes in safety behavior and safety climate scores. Continued improvement during the post-intervention period suggests that managerial policy concerning the role of line supervisors in behavioral safety has been modified. Applied and theoretical implications are discussed.

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Safety behavior presents a paradox to practitioners and researchers alike because, contrary to the assumption that self-preservation overrides other motives (Maslow, 1970), careless behavior prevails during many routine jobs, making safe behavior an ongoing managerial challenge. This is evident in the fact that failure to use the protective gear *provided at the workplace* accounts for about 40% of work accidents. This statistic has not changed for more than 20 years despite continuing efforts (National Safety Council, 1999). Zohar (2002a) suggested that this paradox could be explained away by the incorporation of known learning principles and cognitive biases with the assumption that behavior is guided by the principle of maximizing expected utility. Thus, a cost/benefits analysis incorporating melioration bias (Herrnstein, Loewnstein, Prelec, & Vaughan, 1993) and self-relevant negative-events bias (Plous, 1993) suggests that the appraised benefits of unsafe behavior will often outweigh those of safe behavior, and this inequality will become stronger due to successive reinforcement learning effects (Erev, 1998; Erev & Baron, 2001). Melioration bias concerns the tendency to assign greater weight to short-term results when choosing among action alternatives, while self-relevant negative-events bias concerns the tendency to under-estimate the likelihood of being adversely affected by rare negative events (i.e. 'it will never happen to me' syndrome). Thus, the immediate costs of safe behavior, such as slower pace, extra effort, or personal discomfort, are given greater weight than low-probability long-term benefits, resulting in a situation where the expected utility of unsafe behavior exceeds that of safe behavior. This inequality is strengthened by the fact that safe behavior results in non-events (i.e. avoidance of low-probability injury), whereas unsafe behavior leads to immediate reinforcement and tangible benefits (e.g. increased pace, greater comfort), resulting in reinforcement-based learning favoring unsafe behavior patterns. Safe behavior poses thus managerial challenges.

This analysis suggests that successful attempts must modify the value function for safe behavior by introducing short-term rewards that outweigh immediate costs. Literature reviews reveal that the most effective interventions employed known behavior modification principles, resulting in an intervention framework known as the 'behavioral safety' approach (Geller, 1996; Krispin &

Hantula, 1996; McAfee & Winn, 1989; O'Hara, Johnson, & Beehr, 1985). Behavioral safety uses the ABC framework (i.e. Antecedents-Behavior-Consequences. See: Luthans & Kreitner, 1985; Stajkovic & Luthans, 1997), focusing on two antecedents, i.e. training and goal setting associated with target safety behaviors (e.g. housekeeping, earplugs), and two types of consequence, i.e. feedback and incentive. The notion of consequences is functionally equivalent to reinforcement (Skinner, 1974), referring to any behavior-contingent outcome that influences the frequency of preceding behaviors (Geller, 1996). In most cases, intervention is based on publicly displayed feedback charts, based on observations by external observers or co-workers, in which the gap between baseline level and designated goal provides the necessary incentive for change (for a recent example, see: Lingard & Rowlinson, 1997). A meta-analysis by Krispin and Hantula (1996) revealed strong effect sizes for most behavioral safety interventions, confirming the efficacy of this approach.

A qualifying attribute of the behavioral safety framework is the use of the workgroup as the unit of analysis. Namely, the measurement unit in feedback charts is the percentage of workers displaying the target behaviors as compared to designated goals. The onus for change thus lies with the individual worker, and the reinforcement provided by feedback and (material and social) incentive is also directed at the worker. However, this approach does not take full account of unique attributes of the organizational context at this level of analysis (Heath & Sitkin, 2001; Rousseau & Fried, 2001). It focuses on individual workers, but does not include the immediate superiors despite the latter's primary role in influencing subordinate behavior. This omission is noteworthy because effective line supervisors continually provide the antecedents and consequences employed in behavioral safety interventions, i.e. they monitor work in progress and act accordingly, providing positive or negative consequences depending on observation outcomes (see review in Komaki, 1998). Such practices clarify both supervisory directives and expectations (i.e. antecedents) and behavior-outcome contingencies (i.e. consequences). Thus, whereas behavioral safety interventions depend on external observers (including co-workers) for feedback and incentives, effective supervisors obtain the same information and offer incentives as part of their daily routine. Furthermore, the incentives delivered by superiors (e.g. personal attention and recognition) have consistently been shown to provide the strongest reinforcement value in the organizational context, surpassing material and social incentives (Stajkovic & Luthans, 1997). An intervention that improves supervisory safety practices could present, therefore, a new intervention model whose distinctive feature is that intervention takes place at the level above target behavior, i.e. supervisory practice is modified in order to introduce change on the shop floor. This is a cross-level change whereby processes taking place at one hierarchical level influence a lower, subordinate level (Klein, Dansereau, & Hall, 1994; Morgeson & Hofmann, 1999).

Consideration of the organizational context indicates that cross-level effects must also cover a third hierarchical level, because change of supervisory practice must be supported by higher management, i.e. the intervention must involve two layers of management in order to ensure maintenance of change. As noted above, doing things safely often entails slower pace and extra effort, a situation in which safety is at odds with other aspects of performance, particularly speed and productivity for which supervisors are directly accountable (Falbruch & Wilpert, 1999; Pate-Cornell, 1990; Wright, 1986). The costs associated with safe behavior will increase whenever work pressure increases, which is reportedly the most common demand category for both white-collar and blue-collar occupations (French, Caplan, & Harrison, 1982; Quick, Quick, Nelson, & Hurrell, 1997). Thus, in order to maintain modified supervisory practices, higher-level managers must communicate high safety priorities even under increased work pressure.

A recent study by Zohar (2002a) presented many of the above ideas, and provided an empirical test of supervisory-level intervention that consisted of providing weekly personal feedback to line supervisors in one company, accompanied by communication of (high) safety-priority from direct superiors (i.e. section managers). Feedback concerned frequency of safety-related interaction with subordinates based on repeated, randomly timed episodic interviews with subordinates. During interviews, workers described their most recent interaction with their supervisor. Results indicated a change in supervisory safety practices (i.e. frequency of safety-oriented interaction with subordinates) over a short period, from a baseline rate of 9% to a new plateau averaging 58%. This, in turn, resulted in a significant decrease in minor-injury rate for the 18 experimental groups, accompanied by significant improvement in their safety climate perceptions. Results for the 18 control groups remained unchanged. Since minor-injury rate is influenced by all kinds of unsafe behavior, including transient or uncommon action, it was concluded that the intervention had an overall effect on performance safety.

The present work was designed to extend the empirical base of supervisory-level intervention by testing effect sizes in three different companies, and to incorporate additional ideas and methodological refinements. As noted above, higher-level management must be involved in communicating high safety priority, in order to sustain change of supervisory practice. Whereas Zohar (2002a) included only immediate superiors (i.e. section managers) in the intervention, the present series of studies also included top management by regularly providing senior managers with summary information, designed to induce changes in managerial policy concerning the role of line supervisors in regard to behavioral safety. Such policy changes were stimulated by demonstrating that line supervisors could enhance subordinates' safety performance without productivity criteria falling below designated targets. The significance of such a policy change can be appreciated considering the many organizations where supervisory roles are defined in terms of productivity and quality criteria, leaving safety behavior a contingent, often ill-defined aspect (Pate-Cornell, 1990). Thus, although we used external observation of workers' safety performance during intervention (which may resemble conventional behavioral safety intervention), the information was used (jointly with safety-oriented supervisory interaction) to change managerial policies and practices rather than workers' safety behavior.

A second major change concerned substituting the time-consuming episodic interviews with subordinates (see Zohar, 2002a) with more efficient data collection of supervisory interactions. In the present work we employed experience sampling methodology (ESM), using a brief self-report form adapted from ESM research (see review in Alliger & Williams, 1993). Briefly, ESM involves in situ, signal-contingent recording of events and related cognitions and behaviors using short, fact-oriented questionnaires (Alliger & Williams, 1993; Eckenrode & Bolger, 1995). Subjects report factual data concerning current circumstances at work each time they receive a signal (e.g. beeper, phone, alarm wristwatch) during the workday for several consecutive days or weeks. Signals are usually programmed to go off at random intervals during the workday, excluding such times as scheduled rest or food breaks. As noted by Alliger and Williams (1993), ESM provides reliable data concerning daily activity and environmental circumstances, and is little affected by memory shortcomings.

For all three interventions, workers' safety behavior in organizational sub-units was the main dependent variable. A panel of safety officers and line managers in each company identified relevant behaviors prior to intervention. Trained observers on the research team conducted the observations before, during, and after the intervention, using random time schedules. Because the observers arrived daily to conduct these observations, we used this as the platform for collecting ESM data, so that observers would hand in ESM forms to a sample of workers in given units before moving on to the other units to conduct observations, using alternating and variable daily schedules.

In addition to collecting behavior-observation data in workgroups, safety climate perceptions were also obtained before and after the intervention in company A, in order to examine the cognitive changes induced by intervention. This was done in order to ascertain that modified supervisory practices influenced employees' collective appraisal of the kinds of role behavior likely to be rewarded and supported in organizational sub-units. Such change should mediate the relationship between supervisory practice and workers' behavior. We used a recently developed, group-level climate scale (Zohar, 2000) whose items refer to supervisory expectations of, and reactions to safe/unsafe behavior under ordinary and high-pressure conditions. The interpretation of climate as collective assessment of priorities (e.g. safety vs. production) and expected benefits associated with different role behaviors follows the theoretical model presented by Schneider and colleagues (Schneider & Reichers, 1983; Schneider, Bowen, Ehrhart, & Holcombe, 2000).

Method

General Procedure

During the 2-month period prior to intervention, baseline rates of safety-oriented supervisory interaction and workers' safety behavior were established in each company. The 4-month follow-up period covered a sufficiently long period for modified supervisory practices to have become normative, reflecting modified supervisory role definitions. In Company A, safety climate questionnaires were administered during work-hours one month before and two months after intervention.

The intervention phase lasted three months, during which bi-weekly personal feedback was given to supervisors and their immediate superiors (i.e. section managers). This feedback consisted of cumulative frequencies of reported interactions concerning safety between supervisor and subordinates (identified as safety-oriented interactions), out of all reported role-related interactions during consecutive 1-week intervals. Each supervisor received individual feedback, whereas section managers were given comparative information about all the supervisors in their section. The section managers were instructed to inform each supervisor of his/her relative position (i.e. by comparison to the other supervisors) on a bi-weekly basis, and to communicate approval or disapproval depending on this information. They were also instructed to apply a performance-appraisal format to these meetings, i.e. inquire about the reasons for success/failure, identify facilitators/inhibitors, and set specific improvement goals for the following two weeks before concluding each meeting. Senior managers also received summarized information during scheduled management meetings throughout the intervention, highlighting co-variation of supervisory practices and workers' safety behavior. Furthermore, available productivity data were incorporated in the reports, highlighting the fact that modified supervisory practices do not result in productivity loss. Since the intervention was limited to three months, it was made clear from the outset that modified supervisory practice would afterwards be normative and require changes in managerial policy concerning supervisory roles.

Feedback information was collected by means of brief ESM questionnaires. Members of the research team visited each workgroup twice weekly to observe workers' safety behaviors, using a quasi-random schedule of day and time of arrival, avoiding visits immediately before or after lunch, or on the first day of the week. On each visit, they gave ESM forms to workers in half the workgroups, before proceeding to observe behavior in the other half. The forms were collected about half an hour later. Initially, the questionnaires were filled with the help of a member of the research team, providing guidance and explanations, but after several occasions most workers took only 3-4 minutes to complete the forms unaided. Workers were assured of anonymity, since only summarized statistics were used. An announcement by the plant manager at the outset of each intervention encouraged workers to participate. Supervisors delivered similar messages during departmental meetings. Participation was voluntary, and few workers refused to participate (4% or less in each company).

Measures

Safety-oriented supervisory interactions were measured with a brief ESM questionnaire, which included the following items: (a) An open-ended, single-sentence description of work-related activities over the previous two hours; (b) A yes/no question, as to whether there had been verbal/non-verbal interaction with the supervisor during the previous two hours; (c) If yes, the main subjects of interaction had to be marked on a short, empirically derived checklist (i.e. productivity, quality, safety, other); and (d) If the interaction was verbal, the respondent was asked to provide a single-sentence quotation from it. The last item was used to test internal reliability of ESM forms. The majority of forms (92%) were internally consistent, since the citation agreed with both the nature of the reported activity (item 1) and marked checklist items (item 3). Forms of questionable reliability were discarded.

Using the checklist and quotations, episodes reported by workers were then classified as safety-oriented, productivity/quality-oriented, or both. Thus, if a supervisor referred to the pace or quality of completed work, expressing satisfaction, dissatisfaction, or merely commenting on it, this episode was classified as productivity-oriented, while references to proper actions with safety implications or expressions of satisfaction with safety as criterion, were classified as safety-oriented. (Note: workers were asked to report only work-related interactions.) Feedback to supervisors consisted of the number of safety-oriented episodes out of all reported episodes (%) over consecutive 1-week periods. Episodes relating both to safety and to production were counted as both (i.e. included in the numerator and denominator).

Safety behaviors were measured by trained observers on the research team, using a quasi-random schedule of day and time of arrival. Observers used a short checklist for each workgroup, comprising behaviors selected by a panel of safety officers and line managers in each company. Checklists included up to 7 items, comprising company-wide safety behaviors that allowed between-unit comparisons (e.g. personal protective equipment) and department-specific behaviors that allowed within-unit monitoring over time (e.g. specific operating procedures). In all cases, the first two weeks of observations were used to acquaint both workers and observers with each other, discarding the collected data. Observers were unobtrusive, collecting data while walking slowly through production halls, and stopping only after receiving the required information. In all cases, workers seemed to have ignored their presence after the initial two weeks. Inter-judge reliability revealed considerable agreement (r_s=0.89, p<0.01).

Group Safety Climate was measured with a 10-item questionnaire comprising the two sub-scales, i.e. Supervisory Action, and Expectation (Zohar, 2000). Examples of Action items are: 'My supervisor says a good word whenever he sees a job done according to the safety rules', and 'My supervisor seriously considers any worker's suggestion for improving safety'. Examples of Expectation items include: 'As long as there is no accident, my supervisor doesn't care how the work is done' (reverse scoring), and 'Whenever pressure builds up, my supervisor wants us to work faster, rather than by the rules' (reverse scoring). Alpha reliability for pre-intervention administration was 0.74 for Action, and 0.79 for the Expectation sub-scale. Post-intervention alpha reliability was 0.77 for Action and 0.79 for Expectation.

Results and Discussion

Company A: An oil refinery

The participants in the first project were 121 line workers and 13 supervisors in an oil refinery where imported crude oil is upgraded and canned for national distribution. The workforce was all-male, average age 33.9 (SD=6.2), and average plant tenure 6.1 (SD=5.8). The all-male supervisory personnel was older (average age=44.2, SD=5.1) and with longer tenure (average tenure=10.4, SD=5.2). The plant has two main sub-sections, i.e. oil refining and upgrading, and canning and distribution. The refinery section presents major safety hazards due to the flammability of raw materials flowing through numerous pipes, and risks associated with movement of operators in vertical and horizontal access zones. The canning and distribution section presents fewer hazards, mostly associated with pressurized filling of cans and barrels, and movement on floors that are slippery with oil residues.

Figure 1 about here

Figure 1(a-b) presents the results of intervention for each sub-section, using the two most relevant safety behaviors per section according to the expert panel. The behaviors in the refinery section include: (a) compliance with electrical grounding procedures and use of spark-free hand-tools; and (b) movement in horizontal and vertical access zones without crossing designated paths. Behaviors in the canning and distribution section include: (a) use of protective gear (gloves, shoes, safety glasses); and (b) housekeeping, relating mainly to cleaning oil spills with appropriate materials and equipment. As can be seen in Figure 1(a-b), there was a steady increase in frequency of safety-oriented supervisory interactions in both sections, rising in the refinery section from an average base-rate of about 35% to 50% by the end of intervention, and continuing to climb during the follow-up months, reaching a plateau averaging 70%. Results in the distribution section reveal a similar pattern, rising from a base-rate of 25% to 40% by the end of intervention, and reaching a plateau averaging about 65% by the end of follow-up.

The continued increase in safety-oriented interactions after the end of intervention suggests changes in managerial policy, including re-definition of supervisory roles. The change in supervisory practice is reflected by a concomitant change in frequency of unsafe behavior in both sections, suggesting causality. Unsafe behaviors declined from a base-rate of about 20% in the refinery section and 30% in the canning and distribution section, to a plateau of near-zero frequency by the end of the intervention (excluding housekeeping, which took longer to decline). Correlation analyses reveal strong negative correlations between rates of supervisory practice and unsafe behavior as follows: r_s=-0.81 for unsafe electric work, r_s=-0.57 for unsafe movement, r_s=-0.86 for failing to use protective gear, and r_s=-0.89 for poor housekeeping ($p<0.01$ in all cases). Safety-climate data collected before and after intervention revealed significant differences between administrations. Using paired t-tests, differences for the Supervisory Action sub-scale resulted in t=3.59 ($p<0.01$) and those for the Expectation sub-scale resulted in t=4.11 ($p<0.01$). Because climate scores reflect workers' consensual perceptions of the behaviors that are rewarded and supported in organizational units (i.e. prioritization of possible behaviors), the significant improvement in climate indicates that changes in workers' safety behavior were caused by modified supervisory safety practices.

Two aspects of these results are noteworthy. Firstly, baseline rates of supervisory safety interactions and workers' safety behaviors in the refinery section were exceedingly poor, considering the major hazards involved. In fact, the situation was more hazardous than hitherto indicated, because this refinery was located near a large oil storage farm and a number of chemical plants, increasing potential fire hazards to catastrophic proportions. Although top management was keenly aware of the hazards, previous attempts (aimed at the workers' level) failed to bring about any lasting change. Such discrepancies between high risk and low safety behavior rates are not uncommon, and constitute a recurring theme in accident investigations in different countries, including the Chernobyl disaster (see review in Kletz, 2001). The high levels of risk might have influenced the outcomes of intervention, inducing management to embrace policy changes with regard to the role of line supervisors. To examine this possibility, the second project was conducted in a manufacturing plant presenting more ordinary levels of risk.

Methodologically, these results support the use of ESM questionnaires for collecting data of supervisory interaction patterns. In addition to direct evidence based on co-variation in supervisory and workers' data, the supervisory interaction results bear striking resemblance to those reported by Zohar (2002a), that were based on repeated interviews with workers. In each case there was a low base-rate, accelerating after the beginning of intervention, and leveling at about 65-70%. The switch from time-consuming interviews to the more efficient ESM forms seems, therefore, to have had no detrimental impact on intervention effectiveness. Thus, the second project used the same methodology.

Company B: Processing baked goods

The participants in the second project were 248 line workers and 23 supervisors in a modern food plant producing pasta and other long-life baked products. Most of the workforce was male (68%), average age 33.5 (SD=7.4), and average plant tenure 4.8 (SD=5.1). The supervisory personnel was older (average age=40.2, SD=6.3) and all male. The plant employed a large number of minorities and immigrants (mostly from Russia), some of whom had only limited command of the new language. Russian-speaking research assistants were hired to help workers fill in the ESM forms. A second relevant contextual factor concerns the fact that a multi-national corporation, known for its emphasis on safety and health, had recently become a majority shareholder in this plant. The intervention took place, thus, after a sustained effort had been made to improve safety records and bringing them up to par with the corporation's standards.

The plant is divided into three main sub-sections, i.e. handling, preparing, and mixing the raw materials; converting raw materials into baked products in large ovens connected by conveyor belts; and packaging the finished products. Workers attending the various baking processes had to monitor baked products on conveyor belts in and out of ovens, adjust the conveyors, and clear jams. The hazards posed by this work related, therefore, to sources such as moving machine parts, hot surfaces, manual and mechanical materials handling, and slippery surfaces due to residues of flour or water. The expert panel in the plant agreed, accordingly, that the three plant-wide safety behaviors included machine handling (especially in regard to moving or hot parts), materials handling at the raw-material and packaging ends of the line, and housekeeping (mostly cleaning slippery floors). Figure 2 presents the data with these behaviors as the dependent variables.

Figure 2 about here

The most conspicuous aspect of this figure is the high base-rate of supervisory interaction, averaging 54% for safety-oriented interactions, with a correspondingly low base-rate of unsafe behaviors, averaging 16%. This was probably the result of sustained efforts over the previous months due to corporate takeover, as noted above. In many ways, therefore, this study tests the incremental effect of supervisory-level intervention over established approaches under conditions of high motivation on behalf of top management. The results in Figure 2 reveal a steady increase in supervisory interaction rates, reaching a plateau averaging 68% by the end of intervention. It is important to note that this rate had not changed by the end of a 4-month follow-up period. Unsafe behavior graphs reveal concomitant change, dropping from an initially low base-rate to a near-zero frequency that hardly changed during follow-up observations. Correlation analyses resulted in the following data: $r_s=-0.81$ for unsafe machine handling, $r_s=-0.75$ for unsafe materials handling, and $r_s=-0.79$ for poor housekeeping ($p<0.01$ in all cases).

Despite marked differences in baseline rates, the outcomes of this intervention resemble those of the previous intervention. In particular, it is noteworthy that supervisory interactions reached a plateau in both cases at about 70%, by which time the incidence of unsafe behavior had dropped to a near-zero level. This suggests a ceiling effect in which there was little to gain by including safety issues at any higher frequency, because subordinates had reached maximal safety behavior standards. However, we only observed the most important safety behaviors, which are those that supervisors are also likely to pay attention to. It is thus possible that more transient or secondary unsafe behaviors continue to occur at some above-zero rate.

From a methodological perspective, the heterogeneous composition of the workforce and the language barriers of immigrant workers seem to have had little effect on intervention efficacy. This can be attributed mainly to the fact-oriented nature of the ESM questionnaires. On a different note, although we were dealing with more commonplace hazards, the company was highly committed to improving safety due to external, corporate-level pressures. Thus, although intervention cannot succeed in the long run without managerial commitment, it might be argued that this commitment was so strong in the present case as to create unusually favorable conditions for success. (It should be remembered, though, that we have demonstrated incremental effects on previous attempts in this direction.) The third and last intervention took place at a site where there were no external pressures, representing an effort by management to improve its safety records.

Company C: Processing milk products

The participants in the third project were 187 line workers and 13 supervisors in a modern food plant specializing in a range of fresh milk products, mostly white cheeses and yogurts. Most of the workforce was male (89%), average age 29.5 (SD=8.1), and average plant tenure 5.6 (SD=6.6). The all-male supervisory personnel was older (average age=37.5, SD=7.2) and better educated. As before, this plant can be divided into three main sub-sections associated with handling and preparation of raw materials, conversion of raw materials into milk products in a series of tanks and processing devices connected by pipes, and packaging and cold-storage of finished products. However, production processes in this plant could be monitored and adjusted from a separate control room filled with computers and graphic display units resembling those in chemical plants. Thus, hazards posed by this work relate mostly to the input and output sub-sections, i.e. raw materials and finished products. The expert panel in this plant concluded that plant-wide safety behaviors should include: earplugs (due to noise generated by cooling equipment throughout the plant), housekeeping associated with slippery or cluttered floors, and keeping doors shut to separate traffic and noise zones. The latter also affected quality by helping to maintain desired temperatures and cleaner atmospheric conditions. Figure 3 presents the pertinent data with these behaviors as dependent variables.

Figure 3 about here

The base-rate of supervisory safety interactions is markedly lower than in the other plants, averaging 15%. This resembles the base-rate reported in Zohar's (2002a) original study in a metal processing plant. Improvement continued steadily after the end of intervention, reaching a plateau averaging nearly 50% by the end of the 4-month follow-up period. This reinforces the interpretation that changes in managerial policy resulted in modified supervisory roles, with supervisors becoming accountable for safety behavior of subordinates. Rates of unsafe behaviors demonstrated a parallel change, decreasing from respective base-rates to a plateau averaging nearly 30% (with 'door jamming' averaging 40% by the same time). Correlation analyses resulted in the following data: r_s=-0.91 for unused earplugs, r_s=-0.78 for poor housekeeping, and r_s=-0.89 for door jamming ($p<0.01$ in all cases).

The results in Figure 3 suggest that by the end of follow-up, supervisory interaction and workers' behavior had not yet reached maximally expected rates. Whereas in the other two companies (and in Zohar's original study), supervisory interactions attained a near-70% mark, in the present case, the maximal rate was only around 50%. Similarly, while workers' unsafe behavior reached a near-zero value by the end of intervention in previous companies, in the present case they only averaged 30%. This implies a symmetry between supervisory and workers' data, reinforcing the idea that supervisory practices serve as leverage for modifying workers behavior. If supervisors do not give maximal attention to safety issues during interaction with subordinates, workers will also not behave safely on all occasions. This symmetry supports the basic rationale that supervisory attention and recognition counterbalance the costs associated with safe behavior.

The data presented in Figure 3 provide additional support for this rationale, indicating that 'door jamming' was least affected by modified supervisory practices. Closing doors, as workers often commented, is quite bothersome, requiring workers pushing carts or driving forklifts to perform extra maneuvers each time they pass through a door (i.e. stop, open door, go through, stop, close door, resume movement). Since this occurs frequently during a workday, many workers prefer to jam the doors open. The fact that 'door jamming' entailed the highest costs in terms of slowing down and extra effort, suggests this as the reason for its reduced responsiveness to changed supervisory practices. From a cost/benefits perspective, greater supervisory monitoring and rewarding were necessary to achieve improvement in this particular behavior.

Why is this company different in terms of maximally demonstrated improvement? One possibility is that, despite its technological sophistication, this plant had a limited safety infrastructure, and has only recently hired a safety officer. Supervisory personnel in this plant had thus had little safety training or none, appraising this aspect as having little relevance to their work role. Management, although keen to improve the situation, favored gradual assimilation, and exerted less punitive pressures on supervisors during the intervention than in the other companies. Another possibility concerns the fact that in this plant we accepted its general manager's request of integrating quality with safety goals during the intervention, expecting supervisors to improve both performance facets (see description below). This may have moderated the learning curve due to greater load.

General Discussion

The studies described above were designed to test supervisory-level intervention using ongoing interaction between supervisors and subordinates as leverage for modifying workers' behavior. This intervention is based on the idea that supervisory monitoring and contingent rewarding (or punishing) will modify the cost/benefits ratio associated with safety behavior, which is initially biased against safe behavior in routine work situations. The interventions consisted of providing bi-weekly personal feedback about frequency of safety-related interactions with subordinates, together with communication of (high) safety-priority from direct superiors and senior management. Results repeatedly indicated that supervisory safety practices (i.e. frequency of safety-oriented interaction with subordinates) changed markedly from baseline rates during intervention, and continued to improve, reaching a new plateau by the end of follow-up observations four months later. This, in turn, resulted in a significant decrease in the incidence of unsafe behavior, accompanied by a significant improvement in safety climate perceptions. (N.B. the latter was measured only in company A.)

Supervisory-level intervention utilizes on-going interaction between supervisors and subordinates instead of relying on extraneous parties to communicate antecedents and consequences, as is usually the case in established, worker-level interventions. Supervisors in the present sample related to many productivity, quality, and safety issues during interaction, providing both antecedents and consequences. To provide an empirical basis for this contention, we analyzed the content of supervisory quotations in ESM forms, using an open-ended Q-sort technique. The analysis resulted in the following five categories: (a) informative exchange, i.e. general warnings, reminders, information, and explanations; (b) directive exchange, i.e. instructions, directives, and priorities; (c) corrective exchange, i.e. referring to irregularities, mistakes, and deviations from standards; (d) supportive exchange, i.e. expression of satisfaction, recognition, and appreciation; and (e) inquisitive exchange, i.e. asking for data, updated information, and subjective assessments from subordinates. Categories (a) and (b) relate to antecedents, whereas (c) and (d) relate to positive and negative consequences. Antecedents accounted for 39% of exchange topics, consequences accounted for 52%, and inquiries accounted for the remaining 9%. Most supervisory interactions with subordinates were a composite, e.g. informative and corrective, or directive and inquisitive. Furthermore, 44% of all exchanges referred to two task facets (e.g. productivity and quality or safety) rather than having a single focus. This suggests that supervisory messages transmitted during verbal exchanges are multidimensional, offering an interesting, if little studied research agenda (for an exception see Komaki, 1998).

During intervention, patterns of supervisory interaction (i.e. safety practices) are modified in order to change the cost/benefits ratio of workers' safety behavior. The demonstrated change in workers' behavior is used to induce a complementary change in managerial policies. From the outset we emphasize that the intervention is designed to create supervisory-level changes, but it is ultimately management's responsibility to maintain these changes by redefining supervisory roles. It is more feasible to redefine the supervisors' roles, i.e. to change a relatively small group of individuals, than to change the attitudes and behavior of production workers, who are often less committed to the organization. Furthermore, a relatively small group of key individuals can often induce plant-wide changes because, modifying the behavior of one key individual in an average workgroup of 10 employees, is conducive to improving a wide range of behaviors in those he/she supervises. Supervisory-level intervention also offers an important advantage in terms of sustaining change because modified supervisory roles will be less susceptible to interruption after the intervention. Whereas worker-level interventions, subsumed under the standard behavioral safety approach, have no formal mechanism to maintain change (except through ongoing observations and feedback by external observers or co-workers), supervisory-level intervention provides role-change as underlying mechanism. This is evident in the continual improvement in supervisory safety interaction after intervention, witnessed in the three companies. However, more direct testing of this mechanism is required, suggesting an interesting research agenda.

Supervisory-level intervention also differs from worker-level intervention programs in that the latter are designed to modify discrete, often simple target behaviors that can be easily observed for feedback purposes (Krispin & Hantula, 1996; O'Hara, et al., 1985). This results in a narrow focus on overt safety behavior to the exclusion of large-scale hazards and potential disasters associated with more subtle unsafe practices. A supervisory-level intervention allows modification of all subordinate safety behaviors (including transient and uncommon ones), because antecedents and consequences are based on continual supervisory monitoring in constantly changing situations. Thus, although we used a number of discrete safety behaviors as dependent variables, this was done in order to induce policy changes by top management rather than focusing on these behaviors as intervention targets.

This intervention model is advantageous from a theoretical perspective because it creates a link with cross-level effects, an important construct of management theory (House, Rousseau, & Thomas-Hunt, 1995). In discussing results of their meta-analysis, Krispin and Hantula (1996) suggested that behavioral safety studies have become repetitive after more than 20 years, and that the time has come for better integration with other domains of management research. Our incorporation of cross-level supervisory effects on subordinates' safety behavior offers one possibility in this direction. Inclusion of more than one performance facet in the intervention model (e.g. safety *and* quality) can extend this line of research, though this would require more complex (though clear and consistent) policies concerning supervisory roles.

This possibility was tested in company C (i.e. milk-products plant) by including quality criteria in the weekly feedback to supervisors, using the same ESM forms. Supervisors in this company thus received bi-weekly feedback concerning both safety and quality-oriented interactions, accompanied by expectations and goal-setting from immediate superiors encompassing both facets. In order to monitor intervention effectiveness, we asked a management panel to identify plant-level quality behaviors (in addition to the safety behaviors identified above). These behaviors included: (a) proper clothing, including head and beard covers; (b) cleanliness of working areas, including removal of small objects and clearing of air-suction vents; and (c) adherence to maximal allowable times before refrigeration. Pertinent results, including comparisons between safety- and quality-oriented interaction rates and corresponding workers' behaviors, are presented in Figure 4, using weekly averages of all observed safety- and quality behaviors. As can be seen in this figure, there are strong parallels between the two facets, despite a constant gap in terms of relative frequency, with safety and quality improving at about the same rate, indicating that supervisory roles can be modified to include multiple performance facets. Figure 4 suggests that quality has higher priority than safety in terms of the frequency of supervisory interactions, and that these relative priorities have not changed. This is also reflected in frequency data for unsafe and poor-quality workers' behavior, with unsafe behavior surpassing the frequency of poor quality behavior throughout observations. Once again, the relative emphasis of supervisors on particular job facets is reflected in the relative frequencies of workers' behavior relating to those facets, reinforcing the basic premise that supervisory practice provides the leverage for modifying workers' behavior.

Figure 4 about here

The results presented in Figure 4 suggest, therefore, that the supervisory-level model can be expanded to include other performance facets as long as management provides explicit priorities and guidelines for each facet. This intervention model thus offers a general method for supervision-, or transactional leadership development. As noted by Cacioppe (1998), leadership development programs should include multiple training methodologies. Available methods are typically classroom-based (i.e. away from work), employing information derived from various sources, e.g. leadership and personality scales, 360-degree feedback, and simulations with group observations (Gist & McDonald-Mann, 2000). Weekly, ESM-based supervisory feedback offers complementary, work-related information, offering an additional training method.

The distinction between transactional and transformational leadership (Bass, 1985; 1990; Yukl, 1998) suggests additional directions for intervention. Whereas the present series of studies deal with transactional supervision, several other recent studies suggest that transformational leadership is associated with better safety records (Barling, 2002; Zohar, 2002b) attributable, among other things, to greater concern for members' welfare (Bass, 1990; Yukl, 1998), including physical welfare in situations of heightened risk (Hofmann & Morgeson, 1999). Overall, therefore, it can be argued that, whereas improved transactional supervision enhances safety behavior of shop-floor employees, transformational qualities result in incremental effects. This suggests that supervisory-level intervention should be expanded to include both leadership dimensions, using available strategies for transformational-leadership development (Bass & Avolio, 1997). Another possible direction for expansion is indicated in a recent study showing that leadership quality (measured in terms of leader-member exchanges, or LMX scores) influences sub-unit safety records through its effect on openness of safety communications (Hofmann & Morgeson, 1999). Considering that the LMX model refers to leadership at the dyadic level of analysis (Dansereau, Yammarino, & Markham, 1995), this suggests that supervisory-level intervention should also be tested at the dyadic level. All of which suggests that cross-level intervention offers theoretical and applied opportunities that are unavailable when intervention is restricted to worker level.

Another theoretical implication of this work concerns the social-cognitive role of climate perceptions. Since its inception, safety climate research has been based on the assumption that climate perceptions serve the adaptive function of informing behavior-outcome expectancies (Zohar, 1980, 2000). In other words, they inform subordinates of the kinds of behaviors likely to be rewarded and supported, which allows them to anticipate supervisory approval/disapproval in a variety of situations, especially when prior information is not available. The results for company A, the oil refinery plant, offer additional evidence in this regard, because our intervention manipulated the supervisory attributes to which safety-climate perceptions are said to relate. The fact that climate perceptions improved significantly following the intervention provides empirical support for this, replicating previous findings (Zohar, 2002a).

To summarize, the present research suggests that the hierarchical nature of organizations allows for behavioral safety interventions at the supervisory level, i.e. above the shop-floor level where injuries occur. This implies that complementary interventions can be conducted concurrently at several hierarchical levels. Furthermore, the organizational context must be better integrated in intervention programs, taking into consideration that changes taking place at any hierarchical level must be supported by concomitant change at other levels in order to maintain change over time. Intervention models must assume a multi-level perspective because processes taking place at any organizational level influence, and are influenced by, adjacent levels, i.e. processes at different levels are inter-connected (House, Rousseau, & Thomas-Hunt, 1995; Klein, Dansereau, & Hall, 1994; Morgeson & Hofmann, 1999). Given that occupational safety, as measured by workers' compensation rates, has hardly improved over the last twenty years despite sustained efforts (Shannon, Mayr, & Haines, 1997), it is obvious that new intervention models are needed. We hope that the model presented in this paper, and the concept of complementary, cross-level interventions will stimulate further research along these lines.

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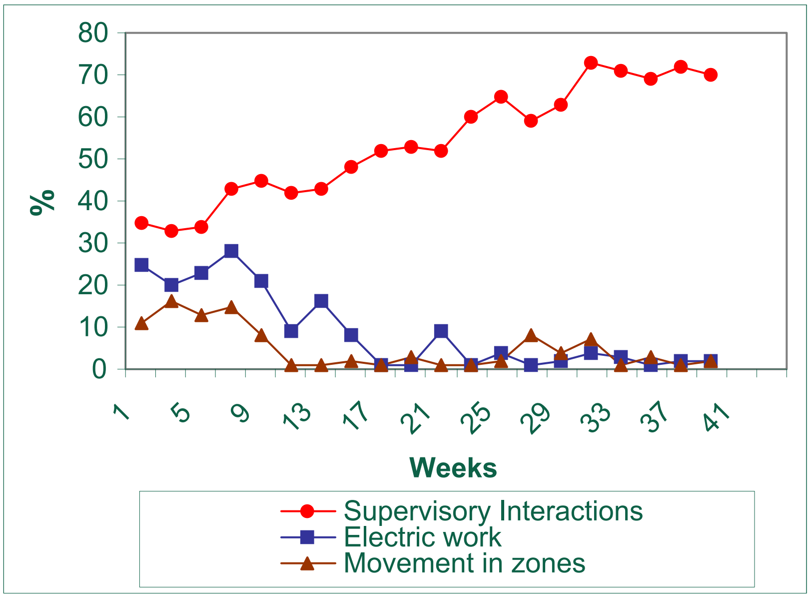
Figure 1a

Company A: Oil refinery sub-section

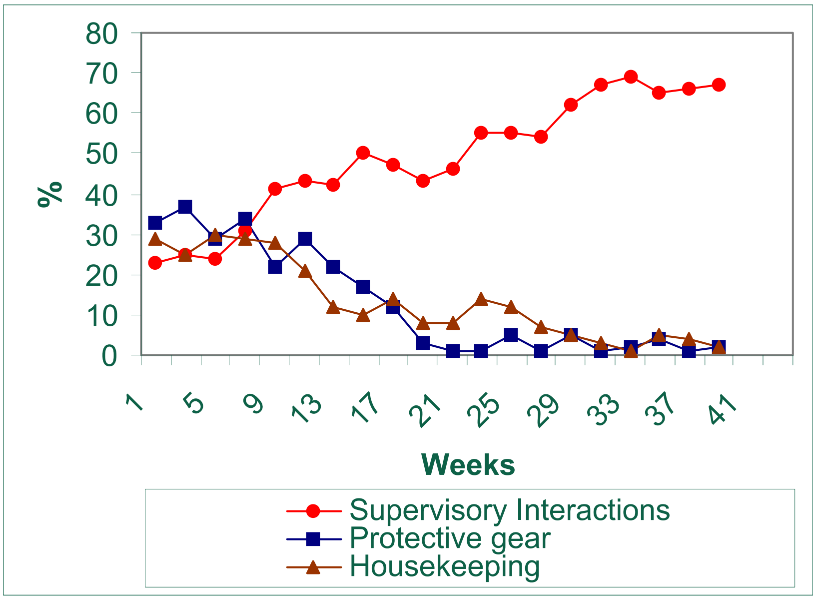


Notes: (a) Workers' data refer to % unsafe behavior.

(b) Intervention started on week 9 and ended on week 21.

Figure 1b

Company A: Canning and distribution sub-section

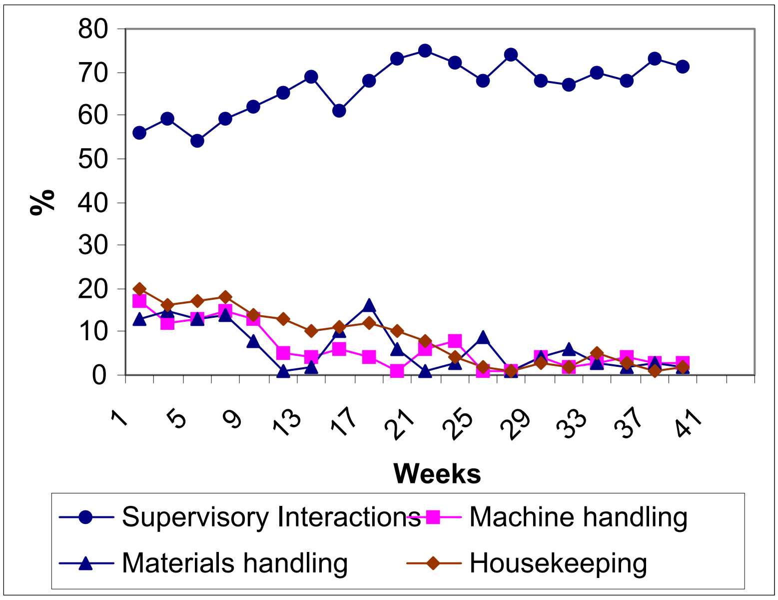


Notes: (a) Workers' data refer to % unsafe behavior.

(b) Intervention started on week 9 and ended on week 21.

Figure 2

Company B: Processing baked goods

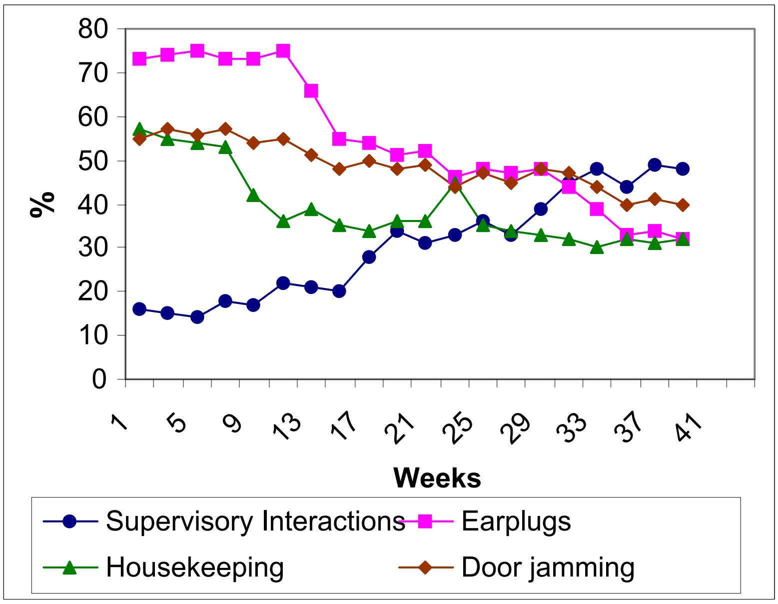


Notes: (a) Workers' data refer to % unsafe behavior.

(b) Intervention started on week 9 and ended on week 21.

Figure 3

Company C: Processing milk products

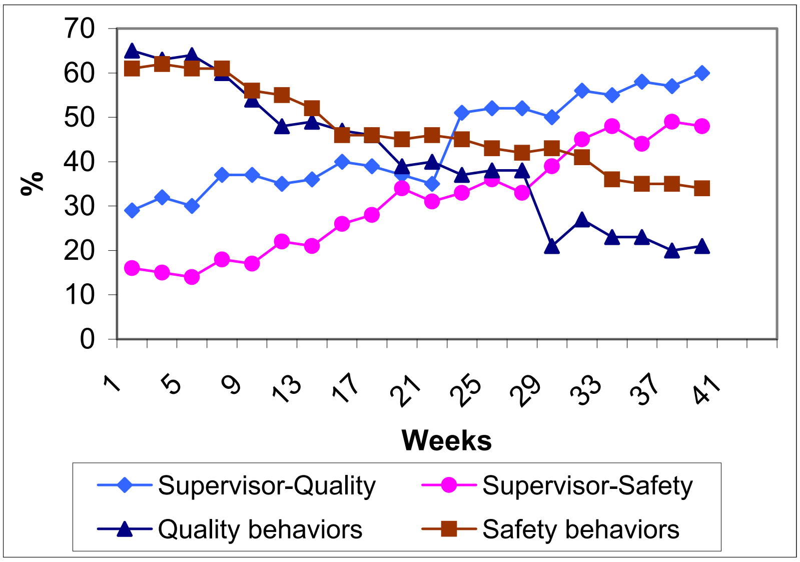


Notes: (a) Workers' data refer to % unsafe behavior.

(b) Intervention started on week 9 and ended on week 21.

Figure 4

Company C: A comparison of safety and quality improvements



Notes: (a) Workers' data refer to % unsafe behavior.

(b) Intervention started on week 9 and ended on week 21.