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Reducing accidents using goal setting and feedback: A field study

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Goal-setting and feedback techniques, previously used in a study to improve safety in the UK construction industry, were applied to a three-shift production plant, employing approximately 540 people. Critical safety behaviours were identified using accident records and 'in-depth' interviews. Checklists of critical behaviours were developed for each of 14 departments in the factory. Forty-eight observers were trained to observe their colleagues' safety performance and complete the checklists. 'Baseline' measures were taken over a four- to six-week period. Participative goal setting was used to set safety improvement 'goals' for the critical behaviours, within each department. Performance feedback was presented graphically in each department on a weekly basis. The results indicate significant improvements in safety performance, with a corresponding reduction in the plant's accident rate. Paradoxically, a statistical inverse relationship was not obtained between safety performance and accident rates, although the importance of non-safety variables in accident causation was demonstrated.

There is little doubt that safety in the workplace is an area of growing importance. Its importance to managers and occupational psychologists is further enhanced by recent, and projected, changes in the locus of legal responsibility for safety issues. Following the Piper Alpha disaster and the associated Cullen Report (Cullen, 1990), the Health and Safety Executive has shifted its emphasis towards an 'auditing of systems' approach, rather than 'inspection of sites' in the North Sea oil industry. It is likely that this approach will be extended to other sectors of industry. The implications are that management will have to develop safety management systems that encourage safe working practices, rather than respond to the consequences of accidents. An accident is defined as 'any undesired circumstances which give rise to ill health or injury; damage to property, plant, products or the environment; production losses or increased liabilities' (HSE, 1992). The Cullen report (1990) specifically mentions the use of goal setting as a technique that might be more widely used to address failures of management control, within safety management systems.

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Goal setting affects performance by directing the attention and actions of individuals/groups; mobilizing effort; increasing persistence; and by motivating the search for appropriate performance strategies (Locke, Shaw, Saari & Latham, 1981). Setting difficult, yet achievable goals, and providing performance feedback in relation to them, can influence behaviour, if employees are committed to the goals. Performance feedback is usually defined as 'information about the effectiveness of particular work behaviours' (Taylor, Fisher & Ilgen, 1984) and is thought to fulfil several functions. For example, it is directive, by clarifying specific behaviours that ought to be performed; it is motivational, as it stimulates greater effort; and, it is error correcting, as it provides information about the extent of errors being made. The relationship between goals and performance feedback is complex, but goals have been demonstrated to mediate the effectiveness of feedback, while feedback has been shown to moderate the effectiveness of goals (Locke & Latham, 1990). The relationship between goals and feedback can be construed as the joint effects of motivation and cognition that control action. Goals, for example, inform individuals to achieve particular levels of performance, in order for them to direct and evaluate their actions and effort, while performance feedback allows the individual to track how well they are doing in relation to the goal, so that if necessary, adjustments in effort, direction or possibly task strategies can be made. Thus performance feedback involves information and tells individuals what the current status is, while goals involve evaluation and tell individuals what is desirable. Goal setting and performance feedback, therefore, complement each other, and, in combination, are far more effective than either one alone, thereby providing a powerful management tool for effecting change. A review of previous research (McAfee & Winn, 1989) indicated that safety behaviour could be improved by systematically monitoring safety-related behaviour, setting goals and providing performance feedback. In the first UK study of its kind, Duff, Robertson, Cooper & Phillips (1993) applied goal-setting and feedback techniques to the improvement of safety on construction sites. The construction industry, it can be argued, is unique in many of its working practices, which are determined to a large extent by the transient nature of the workforce and the continually changing working environment. The construction industry also has one of the worst safety records of any sector of the British economy. Traditionally, manufacturing and other sectors have had a far better accident record. Therefore, on the basis that it might be easier to improve safety in an industry where a disproportionate number of accidents occur, in relation to other sectors of the economy, it becomes important to investigate whether or not these behavioural techniques are as effective in more 'main-stream' sectors such as manufacturing in the UK, where it should be more difficult to improve safety.

The measurement of safety performance is an issue that has often been raised (Grimaldi, 1970; Jacobs, 1970; Tarrants, 1970). Many safety measures rely primarily on incidence of injuries. Two main problems with such measures is that 'lost-time' injuries are rare events (Jacobs, 1970) which makes them unsuitable as the primary indices of the effectiveness of a safety programme (Komaki, Barwick & Scott, 1978); lesser injuries, although more frequent, are also unreliable due to under-reporting (Tarrants, 1970). Such measures only record the consequences of the problem, not the events which lead to these consequences. Measures based on direct observation and recording of particular unsafe behaviours are recommended as more sensitive and reliable indicators of safety performance (Fitch, Hermann & Hopkins, 1976). However, it has been shown that different methods of measurement will determine the treatment effect size, which has implications for the introduction of motivational strategies (Cooper, Phillips, Robertson & Duff, 1993). Previous research (Komaki *et al.*, 1978; Reber & Wallin, 1983, 1984; Reber, Wallin & Chokkar, 1984) utilizing safety behaviour as an indicator of safety performance has typically incorporated an 'all or nothing' (AON) approach to measurement. That is, for any particular item on a safety performance measure, all personnel's behaviour is either safe or, if one person's behaviour is unsafe, all personnel are deemed to be unsafe. Because only two scores are possible, a large amount of overall variance is common, which contributes to floor and ceiling effects. Conversely, incorporating some form of proportional scaling, whereby the proportion of safe to unsafe behaviour is recorded, reduces the amount of overall variance, leading to a more stable and sensitive measure. One group of researchers (Reber & Wallin, 1983, 1984; Reber *et al.*, 1984) obtained statistically significant inverse relationships between an 'all or nothing' behavioural measure of safety performance and both a plant's overall injury incident rate (rho = −.76), and lost-time injury incidence rate (rho = −.65). Some problems exist, however, with these findings. First, their definition of a lost-time injury (LTI) is of one or more workdays missed. The UK industry standard definition of an LTI is three or more workdays missed. Thus, their LTI incident rate is somewhat inflated, which may have led to a type 1 error, by virtue of reducing the amount of error variance, thereby increasing the likelihood of obtaining a significant result. Second, discrepancies exist between the reported rank order correlations, between publications, despite the fact that they are all based upon the same data. Third, the correlations were based upon baseline measures of safety performance over a 13-week period, compared with the plant's preceding three years injury incidence rate on the basis that current baseline data exhibit similar levels of safety performance, prior to, or in the absence of, intervention/treatment procedures (Herson & Barlow, 1976; Komaki, 1977). However, this line of reasoning does not take account of possible changes in personnel, safety policies, the organizational context, or economic conditions over the preceding years, which may in all impact individually or collectively upon a plant's incident injury rate. Some degree of association is to be expected given that the individual items that make up the behavioural safety performance measure are derived to a large extent from a plant's existing accident records, although not every type of incident would be reflected in the measure. This suggests that the focus of any investigation attempting to validate a behavioural measure of safety performance should be upon the relationship between the current observed levels of *actual* safety performance and accident occurrence during an intervention period. Sheehy & Chapman (1987), in their review of industrial accidents, emphasized that as safety programmes take place in an organizational context, there is a likelihood of a relationship between non-safety organizational variables and accident rates. Due to the fact that construction sites themselves are transient in nature, with no archival accident data, Duff *et al.* (1993) found it impossible to establish whether or not there was an inverse relationship between a site's safety performance and accidents, because of this lack of accident data pertaining to any one site. Similarly, because the construction study was undertaken purely by researchers in isolation from the organizational context, no measures of concurrent non-safety variables were available. Thus, this study was undertaken not only to assess the utility of this approach in the manufacturing sector when implemented by the workforce itself, as opposed to researchers, but also to examine two subsidiary hypotheses: (1) That an inverse relationship exists between actual safety performance and accident rates; and, (2) that a relationship exists between concurrent non-safety organizational variables and accident rates. It is important to examine both of these subsidiary hypotheses together, as it allows the relative theoretical importance of each to be determined. Depending on the relative strengths of each type of relationship, both researchers and practitioners alike will have a better idea of where best to focus their future efforts. Because there are two different strands of inquiry to this research, the method and results sections of each are segregated and reported separately. The effects of the goal-setting and feedback intervention are reported first. The issue of the different relationships that might exist are reported second.

Method

Setting

The study was conducted in a subsidiary of a large multinational company, on a large single site, multi-departmental factory, manufacturing cellophane film with approximately 540 employees. Two-thirds of production workers are employed on a continuous, three-shift (6–2, 2–10, 10–6), seven-day week, 10-day cycle, rota. The remaining production operatives are employed on a two-shift (6–2, 2–10), six-day week, 10-day cycle, rota. Support staff (i.e. human resources, customer services, secretarial, and administration) are employed on a 'normal' five-day, 39-hour week. Compared with the construction industry, therefore, the workforce is more stable, although the majority work on a rotating shift pattern.

Study background

Historically, the company has had a high commitment to improving safety. Both the main and executive boards start their meetings with safety issues as the first item on the agenda. Active safety committees, which include both management and shopfloor representatives, have been in place since the early 1960s, prior to the recommendations made in The Robens Report (1972). Moreover, full-time safety and fire advisors are *in situ*, as well as a medical surgery, staffed by trained nurses. Attempts to improve safety in previous years were primarily reactive, rather than proactive, involving correcting dangerous situations after accidents had occurred. More recently, emphasis was placed on 'hazard spotting'. It has been estimated that on average, approximately 30 per cent per annum of this plant's capital expenditure has been on safety-related issues. Other approaches have included attempts by a trained counsellor to identify and counsel individuals who have been involved in more accidents than is the norm, to heighten their safety awareness. Over a number of years, these approaches led to an approximate 10 per cent year-on-year reduction in the number of accidents. Despite all these efforts, a base level of accidents remained, below which it was proving difficult to reduce accidents further, to the extent that the plant was third from bottom in the company's national league table, for safety performance. Senior site management spoke to several employees with regard to safety, and was informed by the workforce that the majority of accidents were caused by people's behaviour. This resulted in a shift in focus to unsafe behaviours in conjunction with hazard spotting, which led to the current study.

Measures

Safety performance. Developing a reliable performance measure was the first objective of the study. This consisted of identifying possible contributory factors to accident causation and subdividing these into observable behaviours or situations that are indicative of safe or unsafe events. Due to the many and varied production processes, many types of accidents can occur for many different reasons. It was therefore decided to analyse the company's accident records for the previous two years. Following a fixed sequence, the accident records were sorted into three main categories. The first step was to sort the accident data by department. The second step consisted of identifying the different types of accident *within* each department, and then sorting these by the place of injury on the body. This step allows identification of both the main types of accident, and the types of task contributing to the causes of accidents. Third, the records were classified on the basis of whether or not the individual's behaviour, or the situation had contributed to the accident. A last final step was to peruse the records to ascertain whether or not particular individuals were involved in more accidents than the norm, in relation to their peers, within the two-year period. In addition, the time frame of accident involvement for these individuals was examined. Once the classification procedure was complete, the main focus of attention was placed on the specific behavioural causes. For example, it was found that forklift drivers often damaged their thumbs, due to the way they placed their hands on a knob on the steering wheel; operatives often cut the back of their hands on circular knives when threading the cellophane film through slitting machines, simply because spare knives were left in the way; operatives in the casting department often cut themselves with razor blades when clearing up wet cellophane waste, simply because they would not dispose of razor blades in the appropriate receptacles provided for them; similarly, maintenance engineers often found themselves squirted in the eye with fluids, when undoing valves, because they were not wearing eye protection. The safe and unsafe behaviours gleaned from analyses of the accident records, were subjected to verification, in terms of their utility and practicality, through in-depth, semi-structured interviews with a random sample of approximately 15 per cent of the workforce ($N = 72$). This resulted in additional items being included that had not shown up in the accident records. On the basis of both the accident records and interviews, departmental checklists of critical behaviours were constructed. This was achieved by stating the items in behaviourally specific terms, and where ambiguity may be a problem, giving a set of clear and explicit instructions. An example item was 'No spare knives may be left on the right hand side of bar, on slitting machines. A maximum of three spare male knives only, may remain on left hand side of the bar when not in use'. Thus, the items of the checklists were written as specifically as possible to allow consistency in scoring between observers, thereby increasing the reliability of the measure. Given that there were 14 departments, each undertaking different types of tasks, there were obviously some differences in the types of accidents reported, which meant that different critical behaviours needed to be measured for different departments. In terms of similarity in accident causes, the same critical behaviour checklists were utilized for all the different offices. Each departmental checklist was further refined by the departmental managers, departmental safety committees and the plant's safety policy support team (SPST) who provided feedback as to the appropriateness of each of the items.

Scoring the safety performance measure. The scale used to rate the individual items that determine safety performance on the departmental checklists consists of three columns, the headings of which are Safe, Unsafe and Not Seen. Each item on the checklist is scored in the Safe column as either 1, which represents all people behaving completely safely, or 0 which reflects the fact that some or all people are behaving unsafely. In effect, the Safe column represents an all or nothing measure (Komaki *et al.*, 1978). Conversely, the Unsafe column reflects the frequency of incidents of unsafe behaviours. This avoids the possibility of floor and ceiling effects common to all or nothing measures (Cooper *et al.*, 1993) and allows the proportion of safe to unsafe behaviours to be recorded. For each particular item, the unsafe column is scored by adding together all the instances of unsafe behaviour. The Not Seen column simply reflects the fact that during a particular observation session, people were not undertaking that particular activity. This allows these items to be discarded from the final percentage calculation. In summary, there are only two possible scores that can be recorded in the Safe column. These are either 1 or 0. The Unsafe column can range from 1 to infinity. Thus, if a score of 1 is recorded in the Safe column, a 0 must be scored in the corresponding Unsafe column. Conversely, if a score of 0 is recorded in the Safe column, then a score ranging from 1 to infinity, will be recorded in the corresponding Unsafe column. The result of scoring safety performance in this way is that the scoring system is weighted heavily towards unsafe behaviour, which detects the slightest improvement in the frequency of safe behaviours. Therefore, any improvements in safety behaviour that are detected, will be real improvements that correspond with reality on the shopfloor. The formula for calculating the percentage of safe behaviour is based upon individual totals of both the Safe and Unsafe columns, and dividing the sum of these totals into the amount of safe behaviours recorded and multiplying by 100, i.e.

$$\%\ \text{safe behaviour} = \frac{\text{total safe}}{\text{total safe} + \text{total unsafe}} \times 100$$

Goal commitment. A goal an individual is not committed to will not have much of an effect upon subsequent performance. Commitment refers to the degree to which a person is attached to a goal, considers it significant or important, and is determined to reach it, even in the face of set backs and obstacles. Thus, individuals can only be described as committed to a goal, if they are actively trying to reach it. Erez & Zidon (1984) obtained a strong relationship between goal commitment and performance, when they found that performance declined as commitment declined. Previous research (Hollenbeck & Klein, 1987) highlighted the lack of a standardized measure of goal commitment. Subsequently, Hollenbeck, Williams & Klein (1989) constructed a self-report uni-dimensional measure (Cronbach's alpha = .88). This measure was adapted to reflect British English as well as redefining the goals in terms of safety (Cooper, 1992). The resulting measure was constructed with four positively and four negatively loaded items, alternately positioned, and scored on a five-point Likert-type scale, anchored on a dimension from highly disagree to highly agree. The maximum possible score is 40, and a high score is indicative of high commitment. The negatively worded items are reverse coded, so that a high score on these scales indicates high goal commitment. The responses are summed to provide an overall index of commitment for each individual. The scores for each individual are then summed to provide an overall index of goal commitment within each department.

Procedure

Management briefings. During the planning stages, two-hour briefings were held with line management to outline and explain the philosophy of utilizing goal setting and feedback to improve safety performance. At the end of these briefings management were asked to demonstrate their commitment to the successful implementation of the approach by fulfilling certain requests. These were (*a*) that they allow all their subordinates to attend the goal-setting meetings; (*b*) allow the shift observer to conduct one observation session on every shift; (*c*) that the managers themselves attend the goal-setting sessions to provide support to the observers; (*d*) managers should praise subordinates who work safely; (*e*) managers should keep a formal self-report record, on a weekly basis, as to how frequently they gave praise to their subordinates, in general terms; (*f*) managers should regularly remind workers to try and reach the safety goals; (*g*) allow the distribution of the goal-commitment questionnaires; (*h*) senior management, including the chief executive, to make a point of visiting each department on a weekly basis to discuss and make comments on the progress to date; and (*i*) to reinstitute the interdepartmental safety shield, to reward the department with the best progress.

Recruiting observers. Senior production management were tasked with the recruitment of observers on the basis of three criteria. First, the observers had to be people who were known to be committed to safety. Second, each observer had to be willing to undergo training, and continue to observe their colleagues' safety performance for at least six months. Third, one observer had to be obtained from each individual shift crew, in order to ensure that on every work shift, the same observer would be *in situ*. In the event, senior managers recruited 48 observers from the various departments, but it soon became evident that the specified criteria had not been followed, and that the observers had to a large extent been press ganged, which led to some initial problems (see discussion).

Training. Each safety observer ($N = 48$) undertook two days' training in the basic theory and practice of the behavioural approach. The training was done in two separate sessions, with two groups of 24 observers, one week apart. The training content included elements of goal setting, behaviour modification, team decision making, how to manage resistance from others, the provision of individual feedback, observational techniques and scoring of the departmental checklists. Similarly, part of the training was devoted to practice observations within all the departments. These practice sessions led to further refinements of the checklists. The observers continued supervised practice observations for a further two weeks, within their respective departments, to ensure they were comfortable and conversant with their task.

Establishing departmental baselines. Following the two-week practice period, a copy of the checklist for each department was enlarged to A3 size and publicly displayed on health and safety notice boards in the appropriate department. This was done to try and mitigate some of the observers' difficulties by making it explicit which behaviours were being monitored.

The observations in each department took on average approximately 10 minutes to complete, and were undertaken on every shift by the observer touring the department. In order to ensure that the pattern of observations were not predictable, they were undertaken at different times during each shift, on different days. However, in some instances, in some departments, no data were collected due to the absence of the observer.

Completed departmental checklists were posted in a collection box in the main production office for the computation of results. Four weeks of data were subsequently collected from each department to provide a 'baseline' figure from which any improvements could be compared. Each week's figures were calculated and averaged to provide an overall index of each department's safety performance level. These averages were then posted on the feedback charts.

Establishing departmental goals. All factory personnel, including senior management, attended their respective department's 'goal-setting' meetings. The meetings were conducted with small groups ($N = 77$), over a period of eight days, led mostly by the researchers rather than the observers (it was intended that the observers conducted the goal-setting meetings). Approximately 10 per cent of these meetings consisted of the observers going around their departments and talking to people individually, accompanied by a researcher, in order to minimize interruptions to the production process.

The meetings began with an explanation of the purpose and the philosophy of the behavioural approach. Particular emphasis was placed on the fact that no individual employee could be identified as a result of the observations; and no disciplinary action would be taken against individuals who did not follow the procedures advocated on the checklists. A copy of the checklist was given to all those present, to clarify the particular behaviours being monitored. The results of the baseline observations were then presented to the groups, in graphical form on 4 × 3 ft charts, with the vertical axis indicating the percentage of safe behaviour, and the horizontal axis indicating number of weeks ($N = 52$).

Each individual group were asked to agree upon a goal that was 'difficult, but achievable' for improvements in safety, in relation to the appropriate baseline average. When consensus could not be reached within a group, as was often the case, each individual's suggested goal level was recorded. Subsequently, all the suggested figures were summed and averaged to provide a goal that the group could agree on. Once all the groups within each department had agreed a goal, the group goals were summed and averaged to provide the departmental goal. Although this may seem a long-winded way of going about establishing goal levels, participation induces commitment to, and 'ownership' of, an improvement process. Previous research in the UK has demonstrated that assigned (delegated) goals demotivate the workforce, with subsequent detrimental effects upon performance (Cooper, Robertson, Duff & Phillips, 1992). The respective departmental goal levels were then entered as a solid line on each of the feedback charts. The employees were also informed that the results of subsequent observations would be continued to be posted on the charts on a weekly basis. The baseline averages and the goals set by each department are recorded in Table 1.

Table 1. Baseline averages and goal levels, by department

Department	Baseline average (%)	Goal level (%)
Casting	27	70
Coating	69	80
Viscose & Day gang	65	80
Engineers	46	85
Finishing: Slitting/recovery	28	65
Reelwrap	52	75
Sheeting	100	95
Works laboratory	58	85
Power house	64	95
Offices:		
IT, Sales & Accounts	67	100
Engineers office	67	85
Production office	89	95
Customer services	100	95
Despatch	90	—

Following the goal-setting meetings the feedback charts were posted in the appropriate departments. Observations continued at the same rate as that during the baseline period. The results of weekly observations (Friday 6 a.m.–Friday 6 a.m.) were posted on the departmental feedback charts every Friday morning. Additionally, information referring to the worst three scoring items in each department were posted next to that department's feedback chart, in order to make explicit to the workforce where to focus their attention the following week. During the remainder of the intervention phase progress was monitored and assistance given to observers when necessary.

Results

Goal commitment

The goal-commitment questionnaire was distributed to all personnel ($N = 540$), one week after the goals had been set. The response rate was 32.6 per cent with 171 completed forms being returned. Since only a few personnel in some departments returned this questionnaire, the departmental results should be interpreted with caution as perhaps only those highly committed to the goals completed the measure. Cronbach's alpha for the measure in this study was .80, which is comparable to that achieved in the construction research (Duff *et al.*, 1993). The results for the factory as a whole indicate that commitment to the safety goals was high (mean score = 32.56, SD = 4.75), which translates into an 81.4 per cent (SD = 11.88 per cent) score. Table 2 provides the results of the goal-commitment questionnaire by department and globally. When transformed into percentage terms, it can be seen that commitment to the safety goals ranged from 75 to 90 per cent.

Table 2. Goal commitment, by department. Mean scores and percentage of commitment levels

Department	Mean score	SD	Number	Per cent	SD	Range (%)
Casting	31.8	5.37	25	79.5	13.42	47.5–100
Coating	32.91	5.35	35	82.29	13.37	50–100
Engineering	32.9	3.48	10	82.35	8.7	67.5–97.5
Reelwrap	36.0	2.94	4	90.0	7.36	80–97.5
Sheeting	29.86	4.34	7	74.64	10.84	52.5–85
Slitting/Recovery	30.76	4.97	17	76.91	12.42	47.5–92.5
IT/Sales/ACC	32.84	3.04	19	82.11	7.6	67.5–95
CDS/HR	31.1	3.07	10	77.75	7.68	65–87.5
Office/Prod & Engineers	33.39	3.89	16	84.22	9.73	60–100
Viscose/Day gang	33.67	2.65	9	84.17	6.61	75–95
Laboratory	34.17	2.14	6	85.42	5.34	80–95
Other	33.38	7.75	13	83.46	19.38	25–100
Global	32.56	4.75	171	81.4	11.88	25–100

Notes. Polarity: high score = high commitment.
Maximum score = 40.

Safety performance

The safety performance results were examined from two perspectives. The first focused on whether or not the goal-setting and feedback intervention impacted upon actual safety behaviour. The second examined the effects of the intervention on the plant's accident rate, during the intervention. For the purposes of this study, due to the wide conceptual definition of an accident conceived by the HSE (1992), it was decided to focus solely on injury occurrences that were recorded in the plant's accident book.

A steady global improvement in safe behaviour performance was observed across the factory as a whole. The plant's global safe behaviour performance levels, by week, with baseline data are illustrated in Fig. 1, which indicates an improvement from a 52.5 per cent average recorded over the four-week baseline period, increasing to 75.6 per cent safe at the 9–12 week point, However, a drop in safety levels occurred during the last four weeks (12–16) of the intervention period to an average of 70 per cent safe, which coincided with a significant increase in the overall accident rate during this time period (see Fig. 2), due to maintenance being undertaken in a haphazard manner, in the casting department.

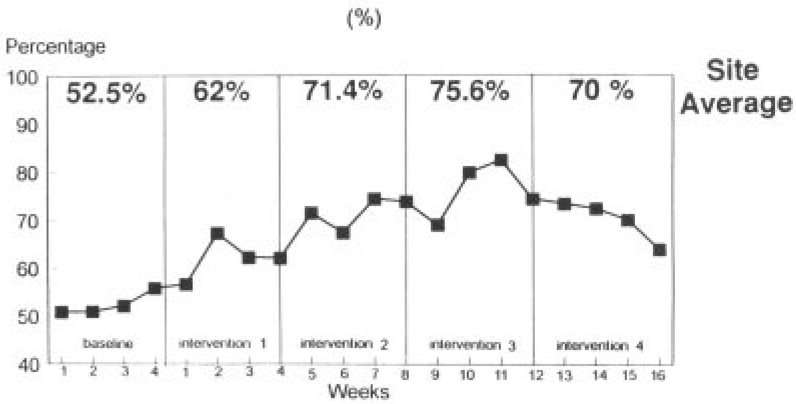

Figure 1. Weekly safe behaviour performance.

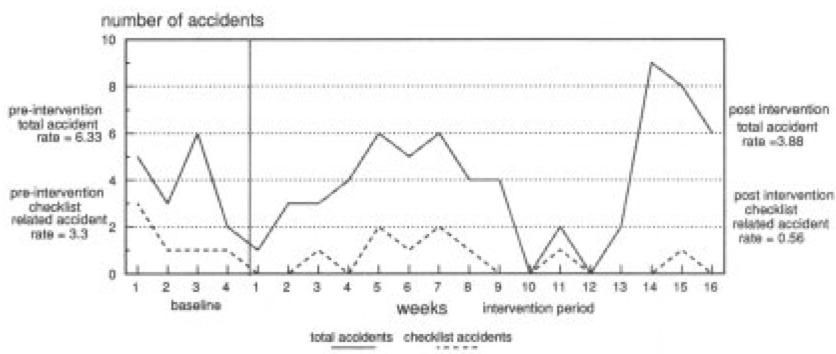

Figure 2. Accident rates per week. Total accident vs. checklist accident rate.

Table 3. Percentage safety performance by week and department

		Baseline period				Intervention period															
Department	Goal %	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Reelwrap	75	50	62	—	49	57	56	58	45	78	93	95	78	—	—	97	—	80	—	—	—
Sheeting	95	C	C	C	C	C	C	C	C	C	C	C	94	C	C	C	C	C	C	C	C
Slitting	65	39	24	29	24	41	57	33	40	48	43	50	32	34	45	44	52	39	36	38	40
Casting	70	22	28	28	28	27	36	29	38	42	40	32	45	52	61	68	58	43	45	48	42
Coating	80	67	58	74	71	54	71	67	71	76	65	69	63	62	85	82	74	62	78	78	70
Engineers	85	40	45	41	61	73	71	70	80	C	89	90	86	C	C	C	—	88	C	—	—
Laboratory	85	47	—	67	63	67	57	—	63	66	84	81	88	88	88	90	65	84	92	90	90
Despatch	—	82	83	C	95	90	96	C	83	C	C	C	C	96	C	C	C	92	C	C	C
Power house	95	57	48	64	81	96	96	C	74	70	71	73	96	96	C	96	C	C	—	C	96
Viscose & Day gang	80	63	61	62	76	73	79	74	69	83	77	85	78	78	83	84	82	82	82	86	65
IT/Sales & Accounts	100	55	56	64	94	85	83	95	C	96	C	98	98	97	C	C	C	C	C	C	C
CSD & HR	95	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Engineering office	85	66	62	35	45	52	90	C	—	83	93	93	88	97	92	96	97	74	58	54	66
Production office	95	84	89	92	90	C	85	94	90	96	98	C	C	C	C	90	97	C	60	70	73

Key. No data collected = —; 100% = C.

Table 3 provides a record of the percentage of weekly safety performance data together with the goal levels set by each department. These show that levels of safe behaviour improved in most departments, with the majority attaining their goal some of the time. For example, the progress made in the casting department is an excellent example. Although just failing to achieve their goal (70 per cent), they managed to achieve a high of 68 per cent safe behaviour level from the 'week one' level of 22 per cent, although performance subsequently decreased. Similarly, the engineering department, starting from 40 per cent, not only reached their goal (85 per cent), but also managed to achieve 100 per cent towards the end of the intervention.

Testing the statistical significance of any improvements is not a simple matter, however, because this type of experimental design violates major assumptions of typical factorial designs, and the number of data points is insufficient for a time-series design (Pritchard, Jones, Roth, Stuebing & Ekeberg, 1989). In order to ensure that the observed differences between the baseline and the intervention period were not due to chance variation, the data for each department were subjected to an independent groups one-way ANOVA. The baseline and 16-week intervention period (divided into four-week blocks) were treated as levels of the factor. The results, however, are considered to be conservative, because an independent group design results in an inflated error term, and because the small number of data points ($N = 4$ in the treatment periods) requires large mean differences for significance.

Results of the analysis reveal that in nine of the 14 departments (see Table 4) the resulting F was significant, indicating that the improvements in safe behaviour were not due to chance variation in performance, but due to the goal-setting and feedback safety programme. Two of the departments (sheeting and Customer Services Division (CSD)), *a priori*, were not expected to reveal any significant differences, due to the fact that both departments exhibited 100 per cent safe behaviour during the baselines, the level of which was subsequently maintained throughout the intervention period.

Of the remaining three departments (Slitting, Coating and Despatch) the failure to reach significance, may in the case of despatch, be due to high baseline levels, which resulted in small mean differences, thus failing to fulfil the criteria for this type of analysis. In the case of both the slitting and coating departments, failure to reach significance may not only be due to small mean differences between the various time periods, but may also be related to the inconsistent improvements in safety performance levels, week on week. This indicates that perhaps these departments were not in reality as committed to attaining their goal, as their departmental commitment scores would suggest.

Accidents

In order to examine the effects of the goal-setting and feedback intervention on the plant's accident rate, it is necessary to establish the extent of recorded injury occurrences, prior to the study. It is also important to make a distinction between the number of accidents related to the various departmental safety performance checklists and the total number of accidents *per se*, because it allows for the effects of the specificity of the safety goals to be examined. During the year 1991, 307 minor injuries, and 22 lost-time (three or more days away from work) accidents were reported. Of these, 172 (52.3 per cent) were related

Table 4. One-way ANOVA results by department

Department	Source of variation	Sum of squares	d.f.	Var.	*F*	*p* <
Reelwrap	between	6158.203	4	1539.55	48.643	.01
	within	474.75	15	31.65		
Sheeting	between	7.203	4	1.8	1.000	n.s.
	within	27.0	15	1.8		
Slitting	between	617.8	4	154.45	2.801	n.s
	within	827.0	15	55.13		
Casting	between	2588.301	4	647.08	27.07	.01
	within	358.5	15	23.9		
Coating	between	257.3	4	64.32	1.036	n.s.
	within	931.25	15	62.08		
Engineers	between	7457.3	4	1864.32	52.914	.01
	within	528.5	15	35.23		
Laboratory	between	2784.7	4	696.18	10.34	.01
	within	1010.25	15	67.35		
Power house	between	3978.8	4	994.7	10.075	.01
	within	1481.0	15	98.73		
Despatch	between	315.8	4	78.45	2.56	n.s.
	within	462.75	15	30.85		
Viscose & Day gang	between	713.8	4	178.45	5.07	.01
	within	528.0	15	35.2		
IT/Sales & Accounts	between	3048.7	4	762.18	9.42	.01
	within	1214.25	15	80.95		
CSD	between	5.0	4	1.25	1.00	n.s.
	within	18.75	15	1.25		
Engineering office	between	5293.3	4	1323.32	8.87	.01
	within	2238.5	15	149.23		
Production office	between	1306.8	4	326.7	4.42	.05
	within	110.0	15	74.0		

to the subsequent departmental checklists. During 1992, the year in which the study was undertaken, in the 20 weeks prior to the intervention being introduced, but including the baseline period, 77 minor, and two lost-time accidents occurred, of which 35 (44 per cent) were related to the subsequent departmental checklists. During the 16-week intervention period, 61 minor accidents and two lost-time accidents were recorded, nine (14.3 per cent) of which were related to unsafe behaviours on the various departmental checklists.

A comparison between the 1992, 20-week preintervention period and the 16-week intervention period indicates a 21 per cent decrease in the plant's overall accident rate, and a 74 per cent reduction in accident occurrences related to the departmental safety performance measures. Similarly, a global comparison between the years 1991 and 1992 indicates an overall average decrease of 55 per cent in minor accidents and 82 per cent in lost-time accidents. Figure 2 illustrates the accident rate, by week, for both the baseline and intervention periods. A comparison is made between the total average number of accident occurrences and the average number of accidents related to the departmental checklists. The total accident rate prior to the intervention was 6.33, reducing to 3.88 by the end of the intervention. The checklist accident rate prior to the intervention was 3.3, reducing to 0.56 by the end of the intervention period. Thus, on the basis of these figures, it can be concluded that safety related goal-setting and feedback interventions will have some effect on a plant's accident rate, further supporting previous evidence that specific goals focus attention and action (Locke & Latham, 1990).

Subsidiary hypotheses

In order to examine and test the prediction that there is an inverse relationship between actual safety performance and a plant's accident rates (Reber & Wallin, 1983, 1984; Reber *et al.*, 1984) the weekly percentages of the plant's global safety performance ($N = 20$) were correlated with the actual number of accidents, per corresponding week, that occurred during the intervention period. The initial correlation focused upon the total accident rate, which yielded a very small negative correlation ($r = -.095$, d.f. = 18, n.s.). A small negative correlation ($r = -.20$, d.f. = 18, n.s.) was obtained for checklist-related accidents. Thus, although the correlations were in the predicted direction, neither analysis supports the hypotheses of an inverse relationship between actual safety performance and accident rates. Computing the coefficient of determination (r^2) for both analyses, shows that overall only 4.9 per cent of the factors accounting for variability are common to both variables, which suggests one or more intervening factors.

Sheehy & Chapman (1987) in their review of industrial accidents postulated a relationship between concurrent non-safety organizational variables and accident rates and that these should be measured, in order to understand the overall effects of a safety programme. In addition they advocate recognizing that the nature of some tasks could limit the extent to which accidents can be reduced. Three specific organizational factors for which data were available were examined. The first factor focused on any effects that shiftwork may have had on the plant's occurrence of accidents; due to the fact that the majority of accidents in the plant occurred in the casting department, the second factor focused on the relationship between the casting department's 'wet break average', and accident rate. The term 'wet break average' refers to the event of the cellophane film shearing and wrapping itself around the rollers on the machine during the production run; the third factor focused on the effects of sickness and holiday absenteeism, on the casting department's accident rate.

The plant's previous two-year accident records were analysed to determine whether or not there were time-of-day effects related to shiftwork, in accident occurrences. The data were analysed in two-hour blocks, starting from midnight (i.e. 00.00–01.59 a.m.). The resulting histogram indicated that the pattern of accident occurrences fits a normal curve (see Fig. 3), with the exception of the midnight to 01.59 a.m. block which indicates a slight peak. The data were further subdivided and analysed by department. This revealed that 30 per cent of all accident occurrences were concentrated in the casting department, 23 per cent in the finishing departments, 18 per cent in the engineering department, 14 per cent in the coating department, with the remaining 15 per cent spread across the remaining departments. The casting department figures reveal that, over the preceding

Figure 3. Accident occurrence by time of day.

two years, slightly more injuries occurred during the midnight to 01.59 a.m. time span, than any other. However, on the whole the accident data do not show any real trends, in any department, that may be the result of shiftworking. Therefore, no further analyses related to shiftwork were undertaken.

The next variable to be examined was the relationship between the casting department's 'wet break average' and accident rate. This revealed a significant statistical relationship between the weekly wet break average, and accident occurrence during the 16-week intervention period ($r = .68, p < .01$). The coefficient of determination (r^2) indicates that 46 per cent of the variance is common to each factor. In comparison, a small correlation of .37 was found between the total accident occurrence across all the departments and wet break average. This result not only suggests that accidents increase as activity increases, but that the nature of the task mediates the relationship between safety performance and accident rates. In the casting department, when a wet break occurs, the running speed of the machines is slowed down to approximately 30 metres per minute, or 70 metres per minute with a break on the dry end. However, despite the slow-down, the situation remains hazardous. It is further compounded by the speed with which the personnel react to the situation, the close proximity in which a group of people will work, and the heated conditions of the environment. Thus the nature of the task in the casting department further increases the likelihood of an accident occurring.

Similarly, in many organizations, pressures resulting from the present economic climate have tended to reduce manpower levels to the minimum required for effective production. This appears to be the case in this instance. Manning levels in the casting department are minimal, which means that if an employee is absent for any reason when a problem occurs, the activity rate for those remaining automatically increases. This is likely to result in the abandonment of the safe behaviours being advocated and monitored while employees respond to the situation, at a time when they are the most crucial. Indeed, an analysis of casting absenteeism (sickness and holiday) and accident rates for the previous 12 months revealed a significant positive correlation ($r = .75, p < .01$) for sickness absenteeism and accident rate, but a negative correlation ($r = -.53$) for holiday absence. The coefficient of determination indicates that 56 per cent of the variance is common to both sickness absenteeism and accidents. This suggests that sickness absence, which increases the activity levels of those remaining, has a larger effect on the likelihood of accidents occurring, than the nature of the task. The negative impact of the holiday absence is probably related to the fact that alternative cover is planned and provided, which is not the case for sickness absence.

The strength of association between the nature of the task and accidents, and sickness absenteeism and accidents indicates that these are prime candidates as intervening variables, as in total the two factors appear to explain 70 per cent of the overall variance. These findings further reinforce the importance of ascertaining the effects that concurrent non-safety variables have in impacting upon workplace safety (Sheehy & Chapman, 1987).

Discussion

In support of Duff *et al.* (1993) this study indicates that the utilization of goal setting and feedback to improve industrial safety performance in the UK can be very effective.

Despite the extent of this plant's prior commitment to improving safety, which may be somewhat unique in relation to industry as a whole, one of the major benefits of this type of safety improvement programme appears to be a better understanding by the workforce of the relationship between safe behaviour and accidents. Not only did the workforce increase their usage of safe working methods, but the number of accidents related to the items on the safety performance measure also decreased over the intervention period. This provides further support to the notion that specific, difficult goals direct attention and action, and mobilize effort (Locke & Latham, 1990). Moreover, even when formal goals have not been set, performance can improve if feedback is provided. For example, the despatch department refused to become involved with the safety programme. However, management persisted in involving them. First, by posting their safety performance checklist in their department during the baseline period, and second, by continually monitoring their safety performance on a daily basis, and posting the results weekly on a feedback chart. Despite their refusal to become involved, safety performance improved during the baseline period from 83 per cent to 100 per cent in the third week. This was subsequently maintained, in the main at 90 per cent and above during the intervention period. This suggests that they were working towards an implicit goal of 100 percent, that was achieved 50 per cent of the time. It is pertinent to contrast this study's results with the minimal effects that previous research has recorded for traditional approaches such as informational safety campaigns (Saarela, Saari & Aaltonen, 1989) and safety training (Hale, 1984) which attempt to change employees' attitudes, that may be affected by the social norms within a particular workplace (Guttinger, 1984).

Glendon (1991) suggested that within the context of safety change interventions, both behaviour and attitudes should be addressed concurrently by incorporating active employee involvement, and utilizing feedback in long-term programmes. Focusing upon people's safety behaviour within a goal-setting and feedback paradigm appears to fulfil these needs. For example, one of the central tenets of this approach is that safety is devolved to those most affected, to further enhance an individual's acceptance of responsibility (Schlegel, 1979; Trist, Susman & Brown, 1977). This requires that employees become involved and actively participate in the generation of the observational checklists; in the setting of goals; and in monitoring the safety behaviour of their colleagues. Therefore, the core of this process utilizes a participative bottom-up, rather than a top-down approach (Pritchard, 1990), although management commitment and support are essential prerequisites (Griffiths, 1985) to facilitate the introduction of this type of safety intervention. Encouraging participation and acceptance of goals, however, does not mean that employees should be given complete freedom to set their own goals, but that goals should be arrived at by a process of sensible and realistic discussion. Taking part in discussions to decide the safety goals, not only makes it clear to employees how specific and difficult the goal should be, but also clarifies to all concerned, the best strategies to adopt, and the resources that may be needed to maximize goal attainment. The efficacy of the bottom-up approach is supported by related evidence (Jermier, Gaines & McIntosh, 1989) which suggests that management have insufficient knowledge of the risks involved in a task, and are too far removed from operations to make meaningful assessments, compared to those directly involved. It has been shown, that if employees perceive the risks of a given task to be underestimated by management, it is likely that commitment and loyalty to that organization will be undermined as the employer will be perceived to be unwilling to provide a safe working environment (Drapkin, 1980). This evidence may have implications for other types of organizational interventions that rely on managerial assessments of subordinates' tasks. If a mismatch exists between management's and employee's frames of reference about the nature of the tasks involved, management's efforts to improve performance are unlikely to succeed, because they will not focus upon the specific elements of the task that would produce the intended improvements.

Although this study utilized a participative bottom-up approach, it was not without problems, which in the main were related to the organization's communication system. For example, despite holding management briefings during the planning and preparation stages, information with regard to the study was not communicated down through the management hierarchy to the shopfloor. This caused some initial problems such as (*a*) some line managers and the majority of the workforce were unclear as to what the project was about, and how it would affect them; (*b*) the workforce were unclear as to what the observers' duties would entail; (*c*) the importance of the safety performance checklists was unclear. Other difficulties arose from the recruitment of volunteer observers. It became apparent at the start of the training that the observers had in fact been chosen by management and instructed to attend a training course in safety. Not one observer had been given information as to what being an observer entailed. This resulted in some observers feeling that they would be perceived as management spies by their colleagues. In the event, some observers were accused of being paid management spies and had to perform their task under hostile conditions. To their credit, the majority of the observers became highly committed to their task, and persevered despite their peers' hostility. Interestingly, there was no shortage of volunteers when observers were sought for the next, or subsequent phases, suggesting that a positive culture change had taken place. Indeed, a related aspect to this research has shown that the plant's overall safety culture improved as a result of the goal-setting and feedback intervention (Cooper & Phillips, 1994).

The introduction of this type of safety improvement scheme, particularly with its heavy emphasis on shopfloor participation, will also have an effect on the way an organization is managed. *De facto*, therefore, this type of intervention becomes organizational development and change, which is likely to encounter resistance. Resistance was encountered from both shopfloor workers and management. Managerial resistance was mostly passive, and was most notably expressed as a lack of involvement by middle management. For example, some observers were initially discouraged from carrying out their duties, because their departmental line managers thought the project was a waste of time. Managerial resistance gradually faded, however, particularly after further briefings were held to address their problems. However, despite repeated requests that managers should give praise for safe performance, it was never really provided consistently, by any of the managers, and very few self-report records were ever kept. The resistance from the workforce was most forcibly expressed during the goal-setting meetings. It was originally intended that the observers would conduct these meetings, with management in attendance to provide support as well as demonstrating their commitment to the intervention. In the event, many of the observers felt uncomfortable conducting these meetings, and the responsibility fell back to the researchers. Resistance from the workforce ranged from passive non-involvement to outright hostility, almost all of which was directed at the manager attending the meeting. To a large extent, because the researchers were seen as independent 'outsiders', involvement in these issues could be avoided. However, a policy of noting the issues raised, and passing these on to senior managers was adopted, particularly when the line managers stopped attending the goal-setting meetings, due to the hostility. Although some problems may be encountered, organizations may also derive additional benefits. After a period of time, it became apparent that shopfloor workers were more willing to comment on both safety and non-safety issues, and that management appeared more willing to listen and act upon these issues. For example, the near-miss reporting system was perceived by the workforce as inadequate, in that once reported, the originator of the report did not receive any feedback as to what actions were being taken and by whom. This was addressed by including a 'tear-off' feedback slip on the near-miss reporting form, that was completed by management and given back to the originator of the report. The effect of this simple solution was twofold: first, perceptions of management receptivity to workers' concerns about safety appeared to be considerably enhanced; second, the issues raised by the near-miss report were dealt with more rapidly than had previously been the case. It could be argued, therefore, that after some initial teething problems, this type of safety programme leads to improvements in communications and industrial relations with subsequent increases in morale. It would also appear, however, that participation in the area of safety will inevitably raise expectations regarding participation in other areas of working life, which we believe can only be beneficial to the functioning of organizations (Wilkinson, Marchington, Goodman & Ackers, 1992).

Goal commitment

Previous research has established a direct causal relationship between performance and goal commitment (Locke & Latham, 1990), in that high commitment leads to high performance, and low commitment leads to low performance. However, in this study this causal relationship was not supported, as the relationship between the departmental commitment and safety performance scores appears to be quite poor. For example, the sheeting department recorded the lowest mean levels of commitment, but exhibited good safety performance. Conversely, the reelwrap department recorded the highest mean scores for commitment, but safety performance did not really improve until the fifth week of the intervention. A number of alternative possibilities may explain this result: first, despite an internal reliability of .8 the discriminatory value of the commitment measure is poor; second, the response rate of 32.6 per cent was insufficient to reflect the true levels of commitment within the respective departments, although, in one sense, the low return rate of the commitment measure may be a more valid indicator of actual commitment to the safety intervention, than the mean values recorded; third, because commitment is thought to be continually modified as a function of information about the direction and magnitude of performance levels (Vance & Collella, 1990), it is possible that the discrepancies between actual performance levels and the departmental goals resulted in the goals being rejected. An alternative explanation may reside in a combination of all three of the above possibilities. In any event, further research is needed to devise a better psychometric measure of goal commitment in relation to safety.

Study limitations

It could be argued that an intervention was already in operation during the baseline period, by virtue of the two-week practice observations prior to the baseline, and the public posting of the departmental checklists on the health and safety notice boards. Indeed, during the latter half of the baseline period, global safety performance improved despite the lack of feedback. This suggests that some of the workforce had internalized some of the specific behaviours on the departmental checklists, and set themselves implicit goals related to the behaviours, supporting previous evidence that specific goals direct attention and action (Locke & Latham, 1990). However, in statistical terms the effects on the study results are minimal, given that any baseline improvements will result in a reduction in the magnitude of difference, between the baseline and intervention periods. This would have the effect of reducing the probability of any statistically significant results.

Further, it is possible that the behaviour of those being monitored during the 10-minute observation periods differed from their behaviour during non-observation periods. To a large extent, this possibility was controlled by the randomization of the observation periods, from day to day. Moreover, due to the nature of the majority of tasks, it would have been difficult for most operatives to mask their normal behaviour specifically for the observation periods. However, in some instances the possibility still remains.

Similarly, it could be argued that the results were confounded by informal competition between the various departments. This possibility cannot be totally discounted, but it is unlikely to have been a major factor given that there was very little movement of employees between departments. Thus, other departments' safety performance levels were not general knowledge to the majority of the workforce, with perhaps the exception of line management. Thus the possibility of competition between departmental managers remains, which may have had subsequent effects on their subordinates' safety behaviour. Within the production departments, however, requests were made by the workforce to provide weekly feedback of each individual shift crew's safety performance levels, rather than the global safety performance of the department, suggesting that a competitive element existed within the departments rather than between the departments.

Accidents

Given that in reality there were improvements in safety performance and a significant reduction in checklist-related accidents, it is a paradox to find a lack of support for an inverse relationship between actual safety performance and accident rates. Other unmeasured factors, such as heightened safety awareness, better acceptance of self-responsibility for safety or the novelty factor of introducing this type of safety intervention, may account for the actual changes. The lack of a statistical relationship may, in part, be explained by insufficient data points related to the relatively short duration of the intervention; the use of a proportional scale to record safety performance, as opposed to an 'all or nothing measure'; that operatives' safety behaviour was demonstrably different during the observation periods than at other times during their shift; or, that no direct relationship between a measure of safety performance and accident rates actually exists, due to the many confounding factors that are likely to intervene. An example of the latter point is provided by the global decrease in safety performance, and increase in the total accident rate (not the checklist-related accident rate), during the last four weeks of the intervention period. On the surface, there appears to be no real explanation for the decrease in global safety performance. However, during this four-week period the majority of the company's employees were significantly involved in the organization and preparation of the local annual town carnival, outside of their working hours. This suggests that fatigue may have played a role, during working hours. Similarly, the increase in the total accident rate was to a great extent related to an annual maintenance programme of production machinery that also took place during this four-week period. It was observed by the researchers that different trades people tended to get in each other's way when working, causing various types of injury. This method of working was simply the result of a lack of planning the maintenance according to a predetermined schedule. Thus, both organizational and societal non-safety variables are likely to impact upon an organization's accident rate, and as such will intervene in the relationship between a measure of safety performance and accident rates. The relationship between sickness absenteeism and the casting department's wet break average with accidents does, however, suggest that (*a*) attempts to validate a safety performance measure should focus on actual concurrent safety performance and accidents, not previous accident rates; (*b*) that baseline data do not exhibit similar levels of safety performance prior to instigating interventions (Herson & Barlow, 1976; Komaki, 1977) due to organizational and other contextual factors; and (*c*) that the nature of the task, sickness absenteeism and other non-safety variables may have larger impacts upon accident rates than previously recognized (Sheehy & Chapman, 1987).

In addition to the reduction in checklist-related accidents, substantial cost savings resulting from the study have been estimated. In the year (April to April) prior to the introduction of the programme there had been 22 lost-time accidents, which according to the company's own figures, cost on average between £10–20 000 each, thus totalling on average between £220–440 000. Four lost-time accidents had occurred by the end of the intervention, which is a significant reduction on the previous year, and suggests that if the LTI rate holds, savings from accident costs will be in the region of £180–£360 000. In terms of total savings, these figures are likely to be conservative, given that they do not include the costs of minor injuries, which in themselves can be substantial (HSE, 1993). If the following stages, which focus on different behaviours, are as successful in impacting on the accident rate as the implementation stage, there should be significant lasting reductions in the occurrence of accidents, with concomitant costs, year on year.

In summary, this study has demonstrated that the application of goal-setting and feedback techniques to occupational safety, utilizing a participative bottom-up approach within manufacturing industries, has considerable merit. Positive effects upon safe behaviour, methods of working, communications and industrial relations, in addition to reductions in accident occurrence and costs, were found. These findings extend previous research of this type in the UK (Duff *et al*., 1993). Perhaps even more importantly, the study results have demonstrated that the relationship between safety performance and accident rates is mediated by organizational variables there are not normally associated with safety. This latter finding provides empirical support to the Health and Safety Executive's recent change of emphasis to the auditing of systems, rather than an inspection of sites approach (HSE, 1992). Because the impact of non-safety variables on accident rates has been demonstrated to be of considerable importance, research needs to be rapidly undertaken to identify the main forms of these non-safety variables, and the interaction(s) between them to identify those combinations with the most potent impact upon accident rates. It should be recognized, however, that this is only one important but underresearched area in the field of safety that the discipline of occupational psychology is uniquely suited to undertake. For example, it may be the case that the long-term maintenance of improved safety levels might require some form of incentive, rather than relying solely upon the provision of information feedback. Within a goal-setting paradigm, it might be useful if future research compared the effects on safety performance of providing incentives vs. feedback, or comparing one with combinations of both. Moreover, the impact of introducing formal competition needs to be assessed, as does the effectiveness of goal-setting and feedback interventions when applied to other areas of organizational life, such as quality, productivity, absenteeism, etc. Additional research is also necessary to ascertain the effects of this type of safety programme in other UK manufacturing industries, and 'heavy' industries such as mining, energy extraction and steel.

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