A multilevel analysis of organisational factors related to the taking of safety initiatives by work groups

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Abstract

This article is about the propensity of workgroups to take safety initiatives and various organisational factors that may impact on workers' safety behaviour. Empirical data concern 1061 workgroups drawn from a random sample of 97 manufacturing plants. A model combining micro and macro organisational factors is developed and tested by a multilevel analysis. Micro level factors refer to variables measuring work processes and hazards, workgroup cohesiveness and cooperation, supervisor's experience and approach to safety management, while macro level factors consist of variables measuring top management commitment in occupational safety and socio-economic characteristics of firms. Results support the hypothesis that micro organisational factors are the primary determinants of the propensity of workgroups to take safety initiatives, with supervisory participative management of safety being the best predictor. Results also suggest that many micro level predictors can be substantially influenced by managerial action, particularly the top management commitment to develop the safety program and joint regulation mechanisms. However, the socio-economic context of the secondary labour market for the firm may act as a structural constraint for such a management commitment and the other shopfloor predictors of workers' safety initiatives behaviour.

1. Introduction

In a recent article, Simard and Marchand (1994) provided empirical evidence that the propensity of workgroups to take safety initiatives at the shopfloor level was a major factor positively correlated with lower frequency rates of lost-time work accidents. Following a distinction introduced by Andriessen (1978) between carefulness and initiative dimensions in the workers' safety behaviour, the Simard and Marchand study showed that the latter

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rather than the former was a predictor of effectiveness in occupational safety. These results emphasize the importance of a neglected aspect of workers' safety behaviour, since the predominant stream of behavioural research still focuses on workers' carefulness and compliance with safety rules (McAfee and Win, 1989; Peters, 1991; Ray et al., 1993), following the influential Heinrich (1931) dominos' theory which contends that most work accidents are caused by workers' unsafe acts.

In order to get a better understanding of this workers' initiatives dimension, we present here the results of a multilevel analysis of the relationships between micro–macro organisational factors and variations in the propensity of workgroups to take safety initiatives. The analysis is conducted on a sample of 1061 workgroups from 97 manufacturing plants of the Canadian Province of Quebec.

2. Previous studies

Studies that examine workers' propensity to take initiatives in occupational safety are rare, and some of these few do so in passing. For example, studies on human error and reliability show how frequent deviations in the work process require workers to develop a capacity of adaptation that leads them to take unplanned safety measures in the execution of their tasks, thus suggesting that the propensity to safety initiatives may be influenced by the actual conditions of work (Leplat and DeTerssac, 1990; Rasmussen et al., 1987). Also, studying the responses of industrial workers to workplace hazards, Brody (1988) and Goldberg et al. (1991) show that the workers' readiness to involve in various actions aimed at improving the health and safety of working conditions, is influenced by the perceived level of risks. Other studies emphasize the combined influence of the workgroup's and work organisation's characteristics: when cohesive and relatively autonomous in the organisation of its work, a workgroup is in a better position to take informal safety initiatives and become involved in the process of safety regulation at the shopfloor level (Carpentier-Roy, 1991; Cru, 1987; Cru and Dejours, 1983; Dwyer, 1992; Goldberg et al., 1991; Trist et al., 1977). Finally, in his study of construction workers, Andriessen (1978) finds that the motivation to go beyond carefulness and take personal safety initiatives in the execution of work is closely related to the perceived safety norms of the supervisor.

However, all the above-mentioned factors are micro organisational, in that they operate at the shopfloor level, and practically no study has tried so far to go beyond and explore the impact of more macro organisational factors. One exception to this is Andriessen (1978) who shows that the workers' perceptions of the safety attitudes and leadership of senior management is an important factor influencing workers' motivation to behave safely.

3. Theoretical model

Based on previous studies and other considerations, we develop the following model of micro–macro organisational factors hypothetically influencing the propensity of workgroups to take safety initiatives (Fig. 1).
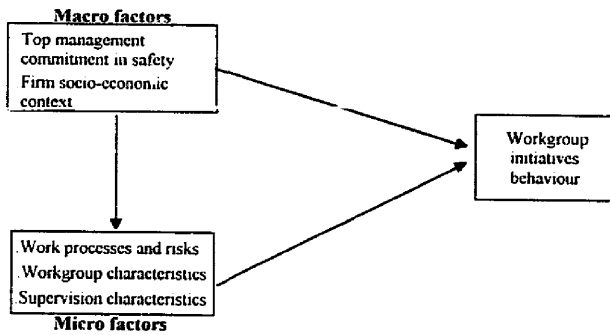
Fig. 1. Model of micro–macro organisational factors hypothetically influencing the propensity of workgroups to take safety initiatives.

Workgroup's propensity to safety initiatives is the dependent variable in the model. Taking into account various kinds of workers' safety initiatives found in the literature, this variable is defined as the extent to which members of the workgroup take informal initiatives to improve the safe execution of their work as well as make suggestions to and exert pressures on the supervisor for improving the work environment's safety. We expect that the propensity of workgroups to safety initiatives should vary within and between organisations.

Micro organisational factors are conceptualized as the primary determinants of the propensity to safety initiatives. Since these factors are defined at the plants' lowest level, they can explain within and between plants' variation in the propensity to safety initiatives' behaviour. These factors are grouped under three (3) vectors of variables aimed at measuring the major socio-technical components of the work situation.

The first micro level vector tries to capture some relevant characteristics of the work process, organisation and hazards, with three variables. The first two variables refer to work process and organisation at the workgroup level, using as a reference the sociological distinction between routine and non-routine technologies that characterize processes of work (Perrow, 1967; Withey et al., 1983). Routine work process refers to a situation where most aspects of the work are predictable, generally because they are technologically predetermined, while a non routine process is characterized by a high level of uncertainty and requires more autonomous initiatives from the workers to face exceptions and solve problems. Based on previous studies, it can be hypothesized that non routine work process and organisation should be positively associated with workgroup's propensity to safety initiatives, because such a type of work organisation provides more scope for initiative and fosters workers' general capacities for adaptation. However, these variables do not measure as such the level of risks in the working conditions. That is why we use a third variable to measure the level of safety and health hazards facing the workgroups, hypothesizing that the more hazardous is the perceived work environment, the more the workgroup should be prone to take safety initiatives, as supported by previous studies (Brody, 1988; Goldberg et al., 1991).

The second vector deals with some social characteristics of the workgroup itself, with two variables. Following some previous studies (Cru and Dejours, 1983; Dwyer, 1992), one of these characteristics is the workgroup cohesiveness, measured by our fourth variable,

which should positively impact on the propensity of workgroups to take safety initiatives under the assumption that the norms of the group are safety oriented. Another characteristic captured by our fifth variable is cooperation among members of the workgroup and with the supervisor. We hypothesize that cooperation should have a positive effect on workgroups' propensity to safety initiatives, because cooperation means better communication and openmindness that should make it easier for workers to make suggestions to and even exert pressures on the supervisor for improving workplace safety.

The third micro level vector precisely concerns the supervision, with two variables. Thus, our sixth variable is the level of participative management approach used by supervisors in occupational safety, which refers to the supervisor's influence in the safety decision making process and his involvement, jointly with workers, in accident prevention activities. Since previous empirical studies have found an association between supervisory participative management and lower lost-time accident rate (Chew, 1988, Cohen and Cleveland, 1983; Simard and Marchand, 1994), we expect a positive impact of this safety management approach on workgroups' propensity to safety initiatives, which is a positive predictor of effectiveness in occupational safety. The seventh variable is supervisor's experience. Though this factor has not been documented in previous studies, we hypothesize that senior (length of service) supervisors might be more open to workers' participation in occupational safety, hence having a positive impact on workgroups' propensity to safety initiatives, because of their higher position in the power structure of the workplace.

Macro organisational factors are conceptualized as secondary determinants of workgroups' propensity to safety initiatives and effect modifiers of micro organisational factors. Macro organisational factors are plant level variables whose effects may explain only between plants' variations in workgroups' propensity to safety initiatives. These factors are grouped under two (2) vectors of variables aimed at measuring major safety and socio-economic characteristics of firms.

The first macro level vector refers to the top management commitment in occupational safety which is viewed as a key factor in accident prevention (Chew, 1988; Cohen, 1977; Cohen and Cleveland, 1983; Davis and Stahl, 1967; Simard and Marchand, 1994; Simonds and Shafai-Sahrai, 1977; Smith et al., 1978). One aspect of this commitment that is captured by our first macro level variable is the personal leadership top managers exhibit by their attitude and behaviour in occupational safety. The other aspect of the top management commitment, which is measured by our second variable, is more structural and refers to the development of the safety program (accident prevention activities) and structures of joint regulation (safety committee and delegates). Positive impacts on workgroups' propensity to safety initiatives are expected, since both aspects of top management commitment help raise the safety consciousness and motivation at the shopfloor level, hence encouraging workers to participate in the upgrading of workplaces' occupational safety.

The second macro level vector refers to the plant's larger organisational context. Some authors have stressed the importance of taking into account the socio-economic characteristics of firms and industries in relation with workforce safety behaviour and work accidents (Abeytunga, 1978; de Jong et al., 1988; Kjellen and Larsson, 1981; Landeweerd et al., 1990). With this view, for our third macro organisational variable, we use the labour market segmentation theory in order to measure the socio-economic context of our plants (Gislain, 1986; Gunderson and Riddell, 1993; Gordon et al., 1982; Osterman, 1987; Piore, 1983).

According to this theory, firms operating within the secondary labour market segment provide worse working conditions (salary, job status and security, etc.) and have a higher workforce turnover rate than firms operating within the primary segment. Consequently, we hypothesize that workgroups' propensity to safety initiatives should be significantly lower in secondary segment's firms, because in this latter context leaving the company (exit) rather than trying to change it (voice) is the logical choice for workers dissatisfied with their working and safety conditions. In order to enlarge the approach and capture additional socio-economic determinants, we developed a fourth macro level variable to measure the level of instability in the plant's internal (labour–management relations) and external (market) context. We hypothesize that such an internal/external instability should impact negatively on the propensity of workgroups to safety initiatives, because of more pressures on production in order for the firm to survive (Simard and Marchand, 1995).

4. Description of data

Data were collected by questionnaires administered to various categories of respondents working for a sample of 100 randomly selected plants of the manufacturing industries in Quebec, Canada. A detailed presentation of the sample can be found in Simard and Marchand (1994). In each plant, depending on the structure of the organisation, closed format questionnaires were filled in by upper managers, middle level line managers, first line supervisors, occupational safety director, members of the joint health and safety committee, medical personnel, union leaders and representatives. In this article, data from 97 plants are analysed due to some missing values. The sample represents a total of ± 23615 production workers grouped in 1061 workgroups, with a plant average of 10.94 workgroups.

5. Measures

5.1. Workgroup level variables (n = 1061)

Workgroup's propensity to safety initiatives is measured by summing three fourth point Likert-type scales of first-line supervisor's perception of the following three behaviours of his workgroup: employees take personal initiatives for improving the safe execution of their work, make suggestions to supervisor for improving safety of the work environment, and put pressures on the supervisor for improving safety of the workplace. This measure is scaled to the proportion of the total score. It ranges between 41.67 and 100, with a mean of 71.74, a standard deviation of 14.19 and an alpha (Cronbach) of 0.69.

Work processes measures are based on first-line supervisor's perception of the following four elements: (1) level of workers' autonomy (2 Likert-type items: workers decide the way to do their work, workers control the quality of their work; alpha = 0.70, square root transformation applied); (2) level of uncertainty in the work process (2 Likert-type items: workers encounter exceptional cases in their work, exceptional cases are solved on the basis of intuition) based on a K-Means cluster analysis with 1 = high level of uncertainty (48,5%) and 0 = low level of uncertainty (51,5%); (3) level of mechanical determination of work

(machines fix the work pace, the work procedure, the sequence of tasks, the work load; alpha = 0.84, square root transformation applied); and (4) supervisor's span of control, which is the log of the number of workers supervised by the supervisor. These four indicators have been submitted to a principal component (PC) analysis with one component capturing a non routine work process (NON ROUTINE) (indicators 1, 2) and a second component capturing a routine work process (ROUTINE) (indicators 3, 4). Summing indicators for each component and standardisation of the resulting scales provide two variables of work processes with mean 0 and standard deviation of 1. Level of risks facing the workgroup (RISK) is measured by summing eight Likert-type indicators of supervisors' perception of the proportion of their employees working in the following risky conditions: high level of noise, heat, cold, humidity, dust, high physical workload, numerous mechanical hazards, heavy objects to move frequently. A square root transformation has been applied to achieve normality. The scale has a range of 2.24–5.57, with mean of 4.19, a standard deviation of 0.68 and an alpha of 0.74. It is standardized to a mean of 0 and a standard deviation of 1.

Workgroup's variables refer to cohesiveness and cooperation which have been constructed by a PC analysis of the following ten fourth point Likert-type items of supervisor's perceptions of the workers' behaviours: workers (1) support anyone of them who has a problem, (2) rarely have conflicts among themselves, (3) are able to present collective claims or demands, (4) are able to exert group pressures, (5) rarely have internal disputes when exerting pressures, (6) cooperate easily to reach production targets, (7) help in creating a good work climate, (8) do not use goldbricking to make pressures, (9) do not complain without valid motive, and (10) do not try to bypass company's regulations. The first component (items 2, 5, 6, 7, 8, 9, 10) provides a measure of cooperation among the workgroup and with the supervisor (COOP) ranging from 13 and 28 with a mean of 20.62 a standard deviation of 3.51 and an alpha of 0.81. The second component (items 1, 3, 4) measures group cohesiveness (COHE) with a range of 5–12, a mean of 8.52, a standard deviation of 1.66 and an alpha of 0.62. These two variables are standardized to a mean of 0 and a standard deviation of 1.

The measure of supervisory participative management in occupational safety (PARTOS) comes from a PC analysis combining the following three measures constructed from the supervisor's responses: (1) level of supervisor's involvement in the process of making various decisions in occupational safety (concerning changes for safer equipments and environment, safer work methods and procedures, development of safety activities, choice of persons to be assigned responsibilities in safety matters, alpha = 0.81); (2) level of mutual influence between the supervisor and his immediate superior (who regularly calls for supervisor's opinion to find ways to solve safety problems, regularly gives suggestions to supervisor on ways to improve safety, values safety more than production, alpha = 0.70, square root transformation applied); and (3) supervisor's participatory involvement in accident prevention (Simard and Marchand, 1994) which has the value 1 when the supervisor brings his employees to participate, jointly with himself, in accident prevention activities (47,5%), and otherwise has the value 0. Summing the latter three measures and standardization of the result provides a variable with a mean of 0 and a standard deviation of 1. The last supervision variable is called supervisor's experience (SUPEXP) and is measured by three indicators (supervisor's age, education, seniority in the plant) submitted to a PC analysis which yields one component with age and seniority positive and education

negative. The resulting variable is standardized to a mean of 0 and a standard deviation of 1.

5.2. Plant level variables (n = 97)

Two variables measuring the top management commitment in safety are obtained from a PC analysis of the following five scales: (1) level of development of the safety program, which includes employees and supervisors' safety training activities, alpha = 0.76 (Simard and Marchand, 1994); (2) level of development of joint regulation structures (presence of a joint OHS committee, presence of safety delegates), where 1 = presence of both structures, and 0 = all other situations; (3) level of regular involvement of senior managers (plant manager, human resources manager, production manager) in safety activities like inspection, safety analysis of critical task and working methods, accident investigation, safety training of new employees (Simard and Marchand, 1994); (4) level of regular involvement of middle-level line managers in the abovementioned safety activities (inspection, etc..) and their participation in the process of making various decisions in occupational safety (see the list of decisions mentioned above for supervisor); and (5) level of senior and middle-level line managers' supportive attitude towards safety (Simard and Marchand, 1994). A PC analysis of the latter five scales results in two components labelled structural safety commitment (STRUCTOS) (scales 1, 2) and safety leadership (LEADER) (scales 3, 4, 5). Summing scales for respective components provides two variables standardized to a mean of 0 and a standard deviation of 1.

The last two macro organisational variables refer to the plants' socio-economic context and are constructed by a PC analysis of the following six measures: (1) the average age of production workers; (2) the workforce turnover rate (number of production workers having left and been replaced/number of production workers); (3) the labour relations climate measured on a fourth point Likert-type scale ranging from very conflictual to very collaborative; (4) the plant's industrial sector used in reference to the labour market segmentation classification developed by Gislain (1986), where 1 = primary segment, 2 = lower primary segment, 3 = intermediate segment, 4 = lower intermediate segment, 5 = secondary segment; (5) the log of the plant' size; and (6) the level of plant's market instability measured by a scale aggregating several indicators of the frequency of changes in the type of products, level of demand for products, products of competitors, supply of raw materials, technological and engineering innovations (alpha = 0.84). The PC analysis of the latter six measures provides two components. The first one is labelled secondary labour market segment (SEC-MARKET) in which measures 1, 5 are negative and 3, 4 are positive. The second component combines measures 3 negative and 6 positive and is labelled plants' internal/external instability (INSTAB). Summing respective components' measures and standardization of the results provide two variables with mean 0 and standard deviation of 1.

6. Model and estimation method

Since the data set has a hierarchical structure in which workgroups (level 1, $n = 1061$) are nested in their respective plant (level 2, $n = 97$), we used multilevel models to analyse

the variation in workgroups' safety initiatives that comes from level 1 and 2 in relationship with a set of independent variables from both levels (Bryk and Raudenbush, 1992; Goldstein, 1986, 1987; Goldstein and McDonald, 1988; Hox and Kreft, 1994; Prosser et al., 1991). Multilevel models are designed to cope with this kind of analysis and have the properties of producing stable estimates of the parameters and unbiased standard errors compared to ordinary least squares models, as well as having less restricting assumptions than ANACOVA (Hox and Kreft, 1994). See the appendix for a full description of these models.

The analysis approach consists of fitting 5 models. The first one analysed the distribution of the variance between levels. Two analysed the effect of each level on the outcome, conditional on their respective level. The fourth included all variables in order to get a full conditional model and to observe variations in parameters. The last model tried to restrict to only significant variables ($p \leq 0.05$) in order to get a more parsimonious picture of the data. Since all variables are scaled to a common metric, contrasts analysis (Prosser et al., 1991) of rate of increase in workgroups safety initiatives behaviour will be done at the end to order the importance of each independent variables.

7. Results

Table 1 and Table 2 presents two matrices of correlations of the variables in the model. The first one is a correlations matrix between micro organisational variables ($n = 1061$ workgroups).

It can be seen that six, out of the seven variables, are positively correlated with workgroups' propensity to safety initiatives: non routine work process (NON ROUTINE), level of work hazards (RISK), cooperative relationships between workers and supervisor (COOP), workgroup cohesiveness (COHE), supervisory participative management of safety (PARTOS), and supervisor's experience (SUPEXP).

The second matrix includes correlations between aggregated micro level variables and macro organisational variables ($n = 97$). Some of the previously mentioned micro organi-

Table 1
Correlations matrix for level 1 variables

Level 1 $n = 1061$								
Initiatives	1.00							
Non routine	0.08[a]	1.00						
Routine	0.05	0.02	1.00					
Risk	0.09[b]	−0.02	0.05	1.00				
Coop	0.15[b]	0.03	−0.07[a]	−0.07[a]	1.00			
Cohe	0.21[b]	−0.03	0.00	0.12[b]	−0.04	1.00		
Partos	0.31[b]	−0.05	0.01	0.04	0.18[b]	0.15[b]	1.00	
Supexp	0.09[b]	0.02	0.05	0.10[b]	0.04	0.10[b]	0.17[b]	1.00

Note: [a] $p \leq 0.05$.
[b] $p \leq 0.01$.

Level 2
n = 97

Initiatives	1.00										
Non routine	0.20[a]	1.00									
Routine	0.11	−0.17	1.00								
Risk	0.30[b]	0.08	0.27[b]	1.00							
Coop	0.18	0.13	−0.03	−0.14	1.00						
Cohe	0.41[b]	−0.06	−0.02	0.28[b]	−0.16	1.00					
Partos	0.39[b]	0.07	−0.13	0.14	0.30[b]	0.14	1.00				
Supexp	0.18	0.09	0.25[a]	−0.00	−0.09	0.33[b]	0.17	1.00			
Structos	0.25[a]	0.07	−0.07	0.27[b]	0.04	0.26[b]	0.24[a]	0.20[a]	1.00		
Leader	−0.01	−0.10	−0.07	0.07	−0.10	0.07	0.17	0.05	0.13	1.00	
Secmarket	−0.37[b]	−0.22[a]	0.04	−0.22[a]	−0.11	−0.26[a]	−0.35[b]	−0.28[b]	−0.41[b]	−0.05	1.00
Turbu	0.11	0.16	−0.19	−0.00	−0.17	0.27[b]	−0.01	0.18	−0.01	−0.11	−0.03 1.00

Note: aggregated mean for each level 1 variable.
[a] $p \leq 0.05$.
[b] $p \leq 0.01$.

sational variables are still correlated with the dependent variable (NON ROUTINE, RISK, COHE, and PARTOS), in addition to the following two macro organisational variable; top management commitment to develop safety program and structures of joint regulation (STRUCTOS), and firm status in the secondary segment of the labour market (SECMARKET).

Results of the multilevel analysis with the five fitted models are given in Table 3.

In model 1, the simple variance component model, the overall mean is estimated at 71.48, indicating a relatively high level of workgroups' safety initiatives, with significant variance for both levels. The intraclass correlation is estimated at 0.05, that is 5% of the variance in groups' initiatives is between plants and 95% is within plants.

Models 2 and 3 give the effects of level 1 and 2 independent variables. In model 2, NON ROUTINE, COHE, COOP and PARTOS are significant since their respective T ratio (estimate/standard error) values are greater than 2. Positive slopes are associated with an increase in workgroup's safety initiatives. The resulting chi-square for the model shows that level 1 variables have substantially improved the fit of the model. Although it has been criticized by Snijders and Bosker (1994), we can estimate the proportional decrease in the model variance via an approach proposed by Bryk and Raudenbush (1992, pp. 65, 70) and Prosser et al. (1991, p. 13). According to this approach, level 1 independent variables account for 74% of the variance at level 2 and 15% at level 1. The remaining variance at level 2 appears to be not significant. In model 3, only SECMARKET is significant. Chi-square value shows that level 2 variables improve the fit of the model and account for 45% of the variance at level 2. Remaining variance at level 2 appears to be borderline significant.

Model 4 is the full conditional model depicted by Eq. (8) in the appendix. Overall, the effects of level 1 predictors are roughly the same with NON ROUTINE, COHE, COOP, and PARTOS significant, but RISK has gained a borderline significance ($p = 0.06$). For level 2 predictors, SECMARKET has lost its significance while LEADERSHIP has gained a borderline significance ($p = 0.10$). Model Chi-square shows that inclusion of all of the

Table 3
Results of the five fitted models

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Estimate	T	Estimate	T	Estimate	T	Estimate	T	Estimate	T
Fixed part										
level 1										
Constant	71.48	120.26[a]	71.87	157.06[a]	71.92	131.43[a]	71.74	182.13[a]	71.88	151.61[a]
Non routine			1.50	3.72[a]			1.44	3.59[a]	1.50	2.84[a]
Routine			0.50	1.22			0.52	1.30		
Risk			0.67	1.62			0.79	1.90		
Coop			2.22	5.47[a]			2.25	5.51[a]	2.16	5.32[a]
Cohe			2.10	5.16[a]			2.05	5.04[a]	2.21	5.44[a]
Partos			4.19	9.88[a]			4.31	9.93[a]	4.28	10.14[a]
Supexp			0.33	0.80			0.30	0.74		
Level 2										
Structos					−0.04	0.07	−0.76	1.54		
Leader					0.02	0.03	−0.48	1.14		
Secmarket					−1.86	3.25[a]	−0.40	0.85		
Turbu					0.35	0.71	0.48	1.20		
Random part										
σ_μ^2	10.75	$p=0.01$[b]	2.76	$p=0.25$	5.91	$p=0.08$	0.00	$p=1.00$	3.77	$p=0.12$
σ_ϵ^2	192.10	$p=0.00$	163.10	$p=0.00$	192.70	$p=0.00$	164.60	$p=0.00$	163.10	$p=0.00$
Statistics										
Deviance	8,630.07		8,431.30		8,618.04		8,426.02		8,436.13	
Chi-square	–		198.77		12.03		204.05		193.94	
DF	–		7.00		4.00		11.00		4.00	
P	–		0.00		0.02		0.00		0.00	

[a] $p \leq 0.01$.
[b] p values for random part are based on likelihood ratio test (Bryk and Raudenbush, 1992).

Table 4
Contrast analysis

Comparisons	Difference	Chi-square (df = 1)	p
Non routine-Coop	− 0.66	1.29	0.26
Non routine-Cohe	− 0.71	1.55	0.21
Non routine-Partos	− 2.78	23.15	0.00
Coop-Cohe	− 0.05	0.01	0.92
Coop-Partos	− 2.12	11.11	0.00
Cohe-Partos	− 2.07	10.90	0.00

Simultaneous contrasts, Chi-square = 24.07, df = 6.

variables has improved the fit of the model but variance at level 2 is now set to 0 and, thus, no longer significant.

Model 5 applies only to significant variables ($p \leq 05$) in model 4. A likelihood ratio test gives a Chi-square = 10.11, df = 7, $p = 0.18$. Model 5 is, therefore, not different from model 4 and it provides a more parsimonious explanation of workgroups' propensity to safety initiatives with NON ROUTINE, COHE, COOP, and PARTOS as predictors. This final model accounts for 65% of the variation at level 2 and 15% at level 1. Again, variance at level 2 appears to be not significant.

Results of contrasts analysis of the rate of increase in workgroups' propensity to safety initiatives are given in Table 4.

PARTOS produces the most important increase over all other variables, while NON ROUTINE, COHE and COOP have statistically the same rate.

8. Discussion

Before interpreting the results of this study, some limitations to its validity should be kept in mind:

(1) The data are based on questionnaires. In particular, the dependent variable and other workgroup's variables are measured from supervisors' responses. Though no systematic bias attributable to various characteristics (age, education, seniority) of respondents has been detected in the sample, the internal validity of this method of data collection and measurement may be questioned, compared to the method of direct observation by trained observers that is more frequently used in behavioural studies. However, the large size of our sample, which would have been impossible with the latter method, may compensate for the potentially less reliable measures of these variables.

(2) Though the workgroups' sample is fully representative of the plants selected, the latter are not representative of the total population of industrial firms of the Canadian province of Quebec, since only firms having more than 70 employees ($N = 1428$) have been sampled. In particular, this exclusion of very small size plants may explain the relatively high mean level of safety initiatives observed among workgroups in the sample, though there are significant within and between plants variations.

In this study, we have estimated the influence of various micro–macro organisational factors on the propensity of workgroups to take safety initiatives, hypothesizing that micro level variables should be the primary determinants. To a certain extent, this hypothesis is supported by the results, though not all micro level factors are significant predictors of the propensity to safety initiatives. However, it should be emphasized that variables included in each of the three vectors of micro level independent variables are supported by the results. This is encouraging since it brings support to this part of the model we proposed for analysing the "initiative" dimension in the safety behaviour of workers, while results help put the vectors in order of importance.

Thus, the vector of supervision, particularly the participative approach in supervisory management of safety (PARTOS), clearly appears to be the most important predictor of workers' propensity to safety initiatives. Though in line with the results of Andriessen (1978) that emphasize the influence of supervision on workers' motivation to safety initiatives, our results brings some new elements of knowledge about safety effective supervisory behaviour. Indeed, workers' propensity to take safety initiatives is higher when the supervisor: (1) has some power and influence over decisions that affect the safety of his workgroup, and (2) practices joint involvement with his workteam in the conduct of accident prevention activities. Actually, these latter two elements suggest that safety management should be decentralized in order to support safety initiatives at the shopfloor level. Not only does such a result on the effect of supervisory participative management on workers' propensity to safety initiatives help to understand the mechanism through which the supervisors' pattern of behaviour influence lost-time accidents rate, as some previous studies have shown (Chew, 1988; Davis and Stahl, 1967; Cohen and Cleveland, 1983; Simard and Marchand, 1994), it also has some practical implications for the management of occupational safety to which we shall return later on. Moreover, it is important to keep in mind that supervisory participative management of safety is positively correlated (see Table 1 and Table 2) with two other important predictors of the workgroup's propensity to safety initiatives, namely the group cohesiveness (COHE) and cooperative relationships between group members and with the supervisor (COOP).

These latter two variables refer to the vector of workgroup's social characteristics, whose positive impact on the taking of safety initiatives by workers is thus supported by the results. Some previous studies have emphasized the importance of group cohesiveness for workers' safety initiatives behaviour, because it gives a capacity to act collectively, but generally this relationship has been documented empirically through qualitative case studies (Carpentier-Roy, 1991; Cru, 1987; Cru and Dejours, 1983; Dwyer, 1992). The fact that our results go in the same direction adds to the external validity of this knowledge concerning the impact of group cohesiveness, since data are based on a large sample of firms and workgroups and the analysis controls for a number of potentially confounding variables. However, results concerning the positive impact of cooperative relationships among group members and with supervisor on safety initiatives by the workgroup clearly improve our knowledge of the determinants of this latter behaviour, since this factor has been neglected in previous studies. Since safety initiatives behaviour, as defined and measured in this study, involves a social interaction dimension, particularly between the workgroup and its supervisor, the positive impact of cooperation means that better communications and openmindness facilitate the

social process of making suggestions and even pressures for improving workplace safety, because workers are listened to by their supervisor.

Finally, the last significant predictor of workgroups' propensity to safety initiatives is NON ROUTINE that refers to a vector of variables capturing some characteristics of the work process, organisation and hazards at the shopfloor level. These results support our hypothesis, derived from previous qualitative studies (Leplat and DeTerssac, 1990; Rasmussen et al., 1987; Trist et al., 1977), that non routine work process and organisation should impact positively on the taking of safety initiatives by workgroups, because such a type of work organisation allows workers autonomy at work and more scope for initiatives and requests them to develop a general capacity of adaptation in order to face exceptions and problems of the work process. RISK is another variable of this vector that goes in the hypothesized direction, without however reaching the level of significance in the multilevel analysis, though it is very close to it and is statistically significant in the bivariate analysis (see Table 1 and Table 2 and 3). It is possible that our instrument for data collection and measurement of this variable, based on supervisors' perceptions of the risks their workers are exposed to, may be inadequate to completely capture the effect of this factor, contrary to the ones used by Brody (1988) and Goldberg et al. (1991) which are based on workers' perceptions.

More surprising though are the results concerning the macro organisational factors, since none of them reach the level of significance in relation to the workgroups' propensity to safety initiatives. However, in the plant level matrix of correlations (Table 1 and Table 2), it can be seen that two macro organisational variables (STRUCTOS and SECMARKET) referring to the two vectors of macro level variables, are correlated in the hypothesized direction with the dependent variable. These correlations disappeared when tested in the multilevel analysis which suggests that the influence of macro level variables on the dependent variable is not a direct one, but an indirect one through the micro level predictors. For example, results of Table 1 and Table 2 show that STRUCTOS, which refers to the management commitment via the development of the safety program and structures of joint regulation, is positively correlated to the workgroup cohesiveness factor (COHE) and to the supervisory participative management of safety (PARTOS) which are two micro level predictors of workers' safety initiatives behaviour. Conversely, these latter two predictors, and a third one, namely NON ROUTINE work process and organisation, are negatively correlated with a socio-economic context of the secondary segment of the labour market for the firm (SECMARKET), which itself is negatively correlated with STRUCTOS. These latter intercorrelations suggest that companies operating in the secondary segment of the labour market face economic constraints that impact negatively of the management's capabilities to develop the safety program and possibly honour initiatives from workgroups who will rapidly stop giving suggestions if they see them all rejected for reasons of economy. Consequently, these results concerning SECMARKET are encouraging, because they are the first ones, to our knowledge, that empirically support the validity of applying the theory of labour market segmentation to accident prevention and safety, which opens an interesting avenue for future research on the macro level factors impacting on occupational safety.

Finally, it may be concluded from this study that even though workers' safety initiatives behaviour seems to be primarily determined by socio-technical factors operating at the shopfloor level, this behaviour can also be substantially influenced by managerial action at

two different levels. Firstly, at the micro level, the participative approach in the supervisory management of safety is not only the most important predictor of the workers' safety initiatives behaviour, but is also the most important factor associated with two other predictors, namely group cohesiveness and cooperation. Consequently, developing a participative approach to safety management among supervisors is certainly a first requirement to be met by managerial action in order to increase the propensity of workers to exhibit safety initiatives behaviour, and benefit from its positive impact on the reduction of lost-time accident rate (Chew, 1988; Cohen and Cleveland, 1983; Simard and Marchand, 1994). Secondly, at the macro level, the commitment of top management to develop the safety program and joint regulation mechanisms appears to be an effective way for senior managers to impact indirectly on workers' safety initiatives behaviour by influencing positively supervisory participative management of safety and workgroup cohesiveness. This means that top management should favour a decentralized approach to safety management, rather than a centralized and bureaucratic one. To this end, action steps regarding the safety program and structures should be flanked by other appropriate measures in order to constitute a systemic strategy aimed at developing a participative approach to safety management among supervisors (Simard and Marchand, 1995) and in order to impact positively on workers' safety initiatives behaviour. Realistically though, our results suggest that such a managerial strategy might be easier to adopt in firms that do not operate within a socio-economic context of the secondary labour market. because such a context seems to have adverse effects on top management commitment in occupational safety, supervisory participative management, workgroup cohesiveness and workers' autonomy in the work process and organisation.

Acknowledgements

Appendix A

A.1. Formalisation of the multilevel model

We have a dependent variable Y_{ij} at level 1 with $j = 1...K$ level 2 and $i = 1...nj$ level 1. Without any other information, we write for level 1

$$Y_{ij} = \beta_{0j} + \epsilon_{ij}, \tag{1}$$

where the intercept β_{0j} is the expected value for of Y for plant j and ϵ_{ij} the residual for workgroup i in plant j. β_{0j} is treated as a random variable at level 2 so we write for level 2

$$\beta_{0j} = \gamma_{00} + \mu_{0j}. \tag{2}$$

where γ_{00} is the overall intercept and μ_{0j} is the plant level residual which varies randomly between plants. Substitution of (2) in (1) gives

$$Y_{ij} = \gamma_{00} + \mu_{0j} + \epsilon_{ij}. \tag{3}$$

which leads to a variance component model (Bryk and Raudenbush, 1992; Prosser et al., 1991). μ_{0j} and ϵ_{ij} are random quantities whose means are equal to 0. They are assumed to be uncorrelated and to follow a normal distribution with variances σ^2_μ and σ^2_ϵ that are estimated by the data. In this model, the intraclass correlation is given by

$$\rho_i = \frac{\sigma^2_\mu}{\sigma^2_\mu + \sigma^2_\epsilon}, \tag{4}$$

which measures the proportion of variance in Y_{ij} that is between plants (Bryk and Raudenbush, 1992).

Now, we add independent variables in Eqs. (1) to (3). We have P variables X_{pij} ($p = 1...,P$) at level 1 and Q variables ($q = 1...,Q$) at level 2. The level 1 equation is written as:

$$Y_{ij} = \beta_{0j} + \beta_{pj}X_{pij} + \epsilon_{ij}, \tag{5}$$

where β_{pj} are slopes for X_{pij}. For the level 2, we write:

$$\beta_{0j} = \gamma_{00} + \gamma_{0q}Z_{qj} + \mu_{0j}, \tag{6}$$

$$\beta_{pj} = \gamma_{p0}, \tag{7}$$

where $\gamma_{0q} = $ slopes for Z_{qj}, $\gamma_{p0} = $ average effect of X_{pij}. Only the intercept β_{0j} is allowed to vary between plants. The slopes β_{pj} are considered to have the same value in every plant. Substitution of (6) and (7) into (5) gives

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + (\mu_{0j} + \epsilon_{ij}). \tag{8}$$

Terms in parentheses in Eq. (8) refer to the random errors structure while other terms refer to the fixed part of the model. Gammas can be interpreted as raw regression coefficients in a multiple regression (Hox, 1994). It should be clear from the above equations that level 1 independent variables explain within and between plants variations while level 2 independent variables explain only variations between plants.

Parameter estimations have been done with iterative generalized least square (IGLS) provided with ML3 2.3 program (Prosser et al., 1991). IGLS treats the fixed coefficients as known quantities when computing the random parameters. A full description of IGLS could be found in Goldstein (1986 and Goldstein (1987). ML3 2.3 also produces standard errors for parameters (fixed and random) and a deviance value (− 2 log-likelihood) that can be used to compute a likelihood-ratio test which has a chi-square distribution with degrees of freedom equal to the number of extra parameters in the model (Bryk and Raudenbush, 1992).

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