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DEVELOPMENT OF A MEASURE OF SAFETY CLIMATE*

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ABSTRACT

A measure of safety climate was developed to aid management in identifying safety problems and responding proactively to safety issues; to assess the general mood of the workforce to safety; and as a standard for comparison with other organizations. The measure of safey climate was based on items extracted from the Chamber of Mines "Loss Control" audit manual. Reliability analyses performed on the scale indicated consistently high reliability coefficients across three ethnic groups. Factor analysis gave support for the construct validity of the scale.

OPSOMMING

'n Meting vir veiligheidsklimaat is ontwikkel ten einde bestuur in staat te stel om veiligheidsprobleme te identifiseer en om pro-aktief op te tree; om die algemene gevoel van die werkskragte rakende veiligheid te bepaal en om 'n maatstaf vir vergelyking met ander organisasies daar te stel. 'n Betroubaarheidssanalise wat op die skaal uitgevoer is het daarop gedui dat daar konsekwent hoë betroubaarheidskoefisiënte vir drie etniese groepe verkry word. 'n Faktoranalise het die konstrukgeldigheid van die skaal bevestig.

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Recent events in gold mining indicate that there is an increased awareness of safety amongst employees, both black and white, and management, and highlight the need for greater efforts to be made to investigate these issues. Evidence for such awareness comes from the occurrence of unrest incidents stemming from major accidents on a number of mines.

An important development which has also taken place in the gold mining industry is the implementation of a comprehensive "Loss Control Programme", the aim of which is to reduce wastage of resources, both human and material, through the application of more efficient management principles.

The development of a technique which will tap employees' safety knowledge will help management to respond proactively and avoid costly accident situations. The purpose of this article is to describe the development of a measure of perceived safety awareness or safety climate amongst employees.

A number of reasons have been put forward for the importance of measuring "climate". For example, a measure of climate may help to understand factors influencing the performance of employees (Schneider, 1975), while to the extent that climates affect work related attitudes and performance, the management of climate acquisition has important practical implications (Schneider and Reichers, 1983). The study of organizational climate also leads to a better understanding of how the organization is a psychologically meaningful environment to its members (Payne and Pugh, 1976). According to Litwin and Stringer (1968), studies of climate provide managers with a link between the organization's procedures, practices and concerns, and the needs of individual workers. Managers learn to appreciate subtle causal relations between their own managerial behaviours and the motivational behaviour of their workforce. The concept of organizational climate may also provide a conceptual linkage between analyses at the organizational and individual level (Payne and Mansefield 1973). Finally, Petersen (1984), in a review of research, suggested that safety climate may be linked to organizational success and safe behaviour in organizations, while Zohar (1980) showed that a measure of safety climate could be used as a common denominator in comparing the safeTy achievements of different industries.

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With regard to a definition of climate, Payne and Pugh (1976) suggested that climate is:

> A molar concept reflecting the content and strength of the prevalent norms, values, attitudes, behaviour and feelings of the members of a social system which can be operationally measured through the perceptions of system members or observational or other objective means (p. 1141).

In this definition, no distinction is made between objective measures of climate based on structural properties of organizations (size, structure, leadership style), and subjective measures based on employees' perceptions of their organizations. Zohar (1980) adopted a definition of safety climate as a "summary of molar perceptions that employees have about their work environments" (p. 96). This approach will be used in the present paper.

In order to understand safety climate, this research utilised findings from previous studies to develop a relevant model.

According to Zohar (1980), research has identified several features of successful safety programmes. These are: strong management commitment to safety, high rank and status of safety officials, strong emphasis on safety training, open communication links and frequent contacts between workers and management, general environmental control and good housekeeping, a stable, older workforce, promotion of safety guidance and counselling rather than enforcement, individual praise or recognition for safe performance, and enlisting workers' families in safety promotions. Based on these dimensions a safety climate scale was developed by Zohar and applied to a randomly selected sample of twenty chemical, metallurgical, food and textile industries in Israel. A one-way analysis of variance showed that industries differed markedly in their safety climate scores. Discriminant analysis was also used to identify the smallest number of climate dimensions sufficient to discriminate between different factories. The two dimensions most influential in determining climate levels were the percieved relevance of safety to job behaviour, and the percieved attitude of managment towards safety. In particular, management commitment to safety appeared to be a major factor affecting the

success of a safety programme. Zohar (1980) concluded that:

> "Safety should be regarded as an integral part of the production system, closely related to the overall degree of control management has over production processes" (p. 101)

Brown and Holmes (1986) subjected the 40 item climate scale created by Zohar (1980) to confirmatory factor analyses and discovered that the original proposed climate model was not supported by their data. A smaller safety climate model was, however, extracted in which the eight factor model proposed by Zohar was reduced to three factors. These were:

- Employee perceptions of how concerned management was with their well-being;
- Employee perceptions of how active management was in responding to this concern;
- Employee physical risk perception.

As mentioned, the mining industry in South Africa has been in the process of implementing a "Loss Control Programme" for a number of years. This programme is based on the classical model put forward by Heinrich in 1959, and updated by Bird and Loftus (1981). In this the accident process is visualised as a set of dominoes standing next to each other. If one domino is pushed, all the domino's fall. An analogy can be drawn between the above model and the accident as a sequence of events, one triggering another until an accident occurs and possible damage to property or injury to persons. If one of the events is controlled or removed from the sequence, however, the causal chain is interrupted, and the accident is prevented. In his updated model, Bird suggests five dominoes or interrelated events in the accident sequence. Managment control is the first and most important, and refers to management's ability to curb or restrain losses. The second involves the control of basic causes, including personal and job factors (Personal factors include lack of knowledge or skill, improper motivation, and physical or mental problems while job factors involve inadequate work standards, purchasing standards, wear and tear, and abnormal usage). The third includes immediate causes defined as the occurrence of unsafe acts and conditions; the fourth domino is the occurrence of an accident or incident resulting in the fifth domino, physical injury or property damage.

The programme consists of twenty organizational functions or elements (see Table 1).

Mine management's job is to ensure that these elements are properly maintained through a system of monitoring and correcting of deficiencies. Regular internal audits of the programme are conducted, and external audits are carried out by the Mine Safety Division of the Chamber of Mines. Evidence indicates that mines implementing the programme have shown declines in accident rates, and improved productivity (Strobach, 1983; Van Vuuren, 1982).

METHOD

The Chamber of Mines Loss Control audits are conducted using a manual which contains an extensive set of items for evaluating the degree to which each organizational function in the Loss Control Programme is currently being implemented. Forty-one items were extracted from this manual to form a safety climate measure, the "Loss Control Climate" or "Loss Control Implementation" scale, designed also to be adaptable to organizations outside of the mining industry.

Subjects were asked to evaluate, on a three-point scale, the frequency or adequacy with which each item was implemented on their particular mine and scoring of the items was done in such a way that a high score coincided with a good rating of a particular item.

TABLE 1
ORGANIZATIONAL FUNCTIONS COMPRISING THE LOSS CONTROL PROGRAMME

1. Leadership and Administration
2. Management Training
3. Planned Inspections of Workplace
4. Organizational Rules
5. Accident/Incident Investigation
6. Accident/Incident Analysis
7. Emergency Preparedness
8. Care of Injured and Ill
9. Task Analysis and Procedures
10. Skills Training
11. Planned Task Observations
12. Protective Equipment
13. Personal Communications
14. Group Meetings
15. Physical Conditions Evaluation
16. Purchasing and Engineering Controls
17. General Safety Promotion
18. Physical Capability Screening and Monitoring
19. Off-the-job Safety
20. Programme Monitoring System

Sample

Respondents were selected using a classification of jobs developed by Veldsman, De Kock, and Sathekge (1982). Using this procedure, mining jobs could be grouped into three broad categories. These were:

- transformative — concerned with converting raw inputs into products;
- maintenance — concerned with mainaining inputs;
- supportive — concerned with procuring inputs.

Using the above classification, jobs were also classified according to rank. The procedure used in this study sampled 46 white and 11 black supervisory job categories in four mines geographically located on the West Rand. This gave a sample of 489 respondents, the composition of which is shown in Table 2. This sample was used for the reliability and the factor analyses. The sample was later expanded to 961 respondents on 10 mines for the purposes of a larger study on safety climate.

TABLE 2
SAMPLE COMPOSITION FOR THE RELIABILITY AND FACTOR ANALYSES

Job Function	Ethnic Grouping			
	English	Afrikaans	Black	Totals
Transformative	20	59	96	175
Maintenance	43	83	37	163
Supportive	38	60	53	151
Totals	101	202	186	489

RESULTS

In order to test the reliability of the Loss Control Climate Scale, use was made of the SPSS programme "Reliability" (Hull and Nie, 1979).

Cronbach alpha reliability coefficients were computed for the

initial sample of 101 English, 202 Afrikaans and 186 black Supervisory respondents. After removal of items with low item-total correlations, Cronbach alphas of 0,93 were obtained for black supervisors; 0,94 for the English group; and 0,95 for the Afrikaans group. These were within an acceptable range and the scale thus exhibited a reasonable degree of reliability, as the three divergent social groupings tested gave comparable results.

The factor structure of the scale was also evaluated using a principal components analysis with varimax rotation, for a combined sample of black and white employees. The factors in Table 3 were revealed.

TABLE 3
FACTORS REVEALED FOR A COMBINED SAMPLE OF RESPONDENTS (N = 489)

Factor	Eigenvalue	% Variance	Cumulative %
1	12,44	66,8	66,8
2	1,57	8,4	75,2
3	1,49	6,2	81,4
4	0,93	5,0	86,4
5	0,77	4,2	90,6
6	0,69	3,7	94,3
7	0,65	3,5	97,7
8	0,42	2,3	100,0

In order to decide which factors to retain, use was made of the Kaiser criterion. According to Weiss (1971), this specifies that only factors with factor contributions (eigenvalues) of 1,0 or greater should be retained. The varimax rotation showed that three factors (of a total of eight) met this criterion. These factors contributed 81,4 percent of the variance of scores on the scale. Factor 1 contained 12 items and could be labelled "management effectiveness in controlling safety". Factor 2 contained nine items and was labelled "management concern for employee safety". Factor 3 contained six items and appeared to relate to "safety training". Factors 4 to 8 are mentioned for interest's sake, although they only contributed another 19,6 percent of the variance. For example Factor 4 contained four items related to "safety promotion"; Factor 5 four items related to the "proper use of safety equipment"; Factor 6 contained two items related to "physical working conditions", and Factor 7 related to "transfers and absenteeism of employees". Factor 8 contributed 2,3 percent of the variance.

The stability of the factor structure of the scale was established through the use of separate principal component factor analyses with varimax rotation. These were performed on larger samples of English (202), Afrikaans (404), and black respondents (355). It was expected that similar factor structures would be obtained across these culturally distinct groups, and thus further weight would be given to the reliability of the factor structure. Table 4 shows the eigenvalues extracted for these groups.

The values obtained were similar for the three groups. Examination of the actual loadings of items for Factors 1 and 2, for each group revealed that similar items loaded on the factors although the relative importance of Factors 1 and 2 changed between the groups. In each case, however, the above two factors contributed between 64 and 71 percent of the variance of scale items. Thus the character of the factors, that is, "management effectiveness in controlling safety", and "management concern for employee safety", was similar to the analysis for the combined English, Afrikaans and Black

TABLE 4
EIGENVALUES OBTAINED FOR THE LOSS CONTROL CLIMATE SCALE ACROSS ETHNIC GROUPS

Factor	English	Afrikaans	Black
1	10,64	10,86	11,10
2	1,75	2,02	3,13
3	1,25	1,57	1,37
4	1,13	1,08	1,20
5	0,96	0,95	0,91
6	0,867	0,75	0,67
7	0,79	0,56	0,55
8	0,64	0,49	0,54
9	0,57	0,46	—
10	0,53	—	—
Totals	202	404	355

samples and thus gave support for the reliability of the factor structure. Factors 3 and 4 for the English group related to safety promotion, and safety instruction; for the Afrikaans group, the effectiveness of the Loss Control Department; and for the Black sample, the Loss Control Department, and use of safety equipment.

DISCUSSION

A comparison between results discovered by Brown and Holmes (1986), and the present study is encouraging. The first two factors extracted from the present scale are similar to those from the Brown and Holmes scale. Thus management's concern about safety, and their active involvement appear to be the two most important factors influencing safety climate as perceived by employees. In the present situation, other factors also appeared to be relevant, such as maintenance of equipment, training, and safety promotion. The stability of the factors of the Loss Control Climate Scale was supported through tests conducted across three distinct social groupings.

This article has only touched on the broader issues related to the study of safety climate. One area which has not been discussed, for example, is the effects of job structure and rank on safety climate. In other words, climate may vary across certain groupings in the work situation. Another potential area of research centres around the effects of organizational style, job satisfaction and safety motivation on safety climate and performance. At the moment, research into the development of models of factors influencing safety climate in gold mining is being undertaken by Human Resources of the Chamber of Mines Research Organization, and promises to throw light on these issues.

REFERENCES

Bird, F.E. & Loftus, R.G. (1981). *Loss control management*, loganville: Institute Press.

Brown, R.L. & Holmes, H. (1986). The use of a factor analytic procedure for assessing the validity of an employee safety climate model. *Accident Analysis and Prevention, 18*(6), 455–470.

Hull, C.H.H. and Nie, N.H. (1979). *SPSS update: new procedures and facilities for releases 7 and 8.* McGraw-Hill.

Litwin, G.H. and Stringer, R.A. (1968). *Motivation and organizational climate.* Boston: Harvard Business School, Division of Research.

Maughan-Brown, E.A. (1974). *The NIPR batch processing programme system (NP 50).* CSIR Special Report Pers 211, Johannesburg, South Africa, July.

Payne, R.L. and Mansefield, R. (1973). Relationship of perceptions of organizational climate to organizational structure, context, and hierarchical position. *Administrative Science Quarterly, 18,* 515–526.

Payne, R. & Pugh, D.S. (1976). Organizational structure and climate. In M.D. Dunnette (Ed.), *Handbook of industrial and organizational psychology.* Chicago: Rand McNally.

Petersen, D. (1984). The safety profession: concept and programmes. *Professional Safety,* December, 26–29.

Schneider, B. & Reichers, A.E. (1983). On the etiology of climates. *Personnel Psychology, 36,* 19–39.

Schneider, B. (1975). Organizational climates: An essay. *Personnel Psychology, 28,* 447–479.

Strobach, H. (1983). *The benefits exceed the costs: a loss control management study.* Unpublished report by Group Safety Engineer, Anglo American Corporation.

Van Vuuren, P.I. (1982). The effects of a professionally evaluated Loss Control Programme on the production objectives and profits of a large gold mine. *NOSHCON (National Occupational Safety and Health Conference),* Bophuthatswana.

Veldsman, T.H., De Kock, R. & Sathekge, P. (1982). *The organizational structure of a gold mine.* Unpublished Research Report, Chamber of Mines of S.A., Johannesburg.

Weiss, D. (1971). Further considerations in applications of factor analysis. *Journal of Counselling Psychology, 18*(1), 85–92.

Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology, 65*(1), 96–102.