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Occupational Safety Climate and Shift Work

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Developing and maintaining a rich safety culture is an important factor in achieving a safe workplace with low injury rates. Safety climate measures provide a snapshot of the safety culture, as they reflect workers' shared perceptions of how management and workers deal with safety on a daily basis. There is however, research evidence that safety may be compromised for shift workers during night shifts. The role of safety culture has been documented in major accidents such as Three Mile Island, Chernobyl and Exxon Valdez, all of which involved work activities at night. There is also evidence that workers who work in close proximity to production lines have increased injury risks. This study investigates whether the level of safety climate is lower among shift workers, who work both days and nights compared to daytime workers.
The Nordic Occupational Safety Climate Questionnaire (NOSACQ-50) is used to evaluate the safety climate. The questionnaire contains 50 positively formulated and negated (reversed) items using a four-point Likert scale. The items are distributed across seven scales dealing with: Perceptions of management and worker commitment and priority to safety, safety empowerment from management, safety justice, safety communication and trust in safety systems. Data are derived from workers at two chemical plants in Sweden, both of which employ daytime workers and shift workers. Two-tailed t-tests of the data are carried out in SPSS, and are supplemented with injury data and the type of work with proximity to production lines.
The level of safety climate is relatively high at both plants, compared to other international studies using NOSACQ-50. Shift workers at the two plants have significantly lower scores on all seven safety climate scales, compared to daytime workers at the two plants. Separate analyses for each plant reveal that shift workers have significantly lower scores on five safety climate scales at the first plant, whereas there were no differences between shift workers and daytime workers at the second plant. Several of the daytime workers at the first plant are located further away from production lines and laboratories than the other three groups, and they experience fewer direct accidents and/or dangerous situations at work. Greater risk exposure and experience with injury events may play more important roles than shift work itself, in explaining lower ratings of safety climate.

1. Introduction

Over the past century focus concerning factors influencing safety and safety improvements within industries has changed and expanded. Hale and Hovden (1998) describe three ages of safety: the technical age (1920's), the human factor age (1970's) and the management system age (1980's). A similar development of safety was presented by Hudson (2007) who describes three waves instead of ages: the technical wave, the systems wave and the cultural wave. The third wave or age of safety expanded the focus to include safety culture, and the concept of safety culture was first truly introduced and defined after the Chernobyl accident in 1986 (INSAG, 1992).
Safety culture and safety climate are concepts that today attract much attention across a broad number of industries and sectors (Clarke, 2000), including the chemical industry (Goncalves et al., 2010). One of the reasons for this is that a rich safety culture and a mature safety climate are some of the most important factors in achieving a safe workplace. In order to improve the level of safety culture and safety climate it is important to: a) determine the current level of safety culture and safety climate, b) decide what level of safety culture and safety climate is needed, attainable and wanted, and c) to create a plan to achieve the safety culture and safety climate that is wanted (AIChE, 2012).

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A challenge with safety culture and safety climate is that no universal agreement on the definitions of these concepts exists – neither between nor within the various academic disciplines. The lack of theoretical background for this definition has resulted in the development of numerous definitions (Cooper, 2000), and there is an on-going academic debate about the differences and similarities between these two concepts (Clarke, 2000).
A number of studies provide evidence that safety may be compromised for shift workers during night shifts. Safety culture deficiencies have been documented in major accidents such as Three Mile Island, Chernobyl and Exxon Valdez, all of which involved work activities at night (Huang et al., 2007). There is also evidence that workers who have experienced dangerous situations, or an accident at work, have a lower level of safety climate compared to those who have not experienced any of these (Milczarek and Najmiec, 2004; Wu et al., 2007).
This study included a safety climate survey in the chemical industry in Sweden, involving two plants (plant A and plant B), both situated at the same site. The plants belong to two different companies, yet both belong to the same international mother company. As part of the international company's continuous safety work, there is a strong global focus on improving and strengthening its safety culture within all daughter companies, in order to reduce accidents and injuries. To improve a safety culture, the existing level of the safety culture and its "problem areas" has to be identified (diagnosed) in order to define the starting point for improvements. Identifying the level of a safety culture is difficult and takes a long time, and it is therefore more common to evaluate the safety climate, which provides a "snap-shot" and an indication of the safety culture (Canso, 2008). This snap-shot, when based on a safety climate questionnaire, often provides a number of unique dimensions e.g. management's priority of safety and workers' priority of safety, that allow for comparisons within and between groups.
The aim of this study is to evaluate and compare the safety climate within with two chemical production plants, and tested the following hypotheses:

Hypothesis A: There are no differences (null hypothesis) in the level of safety climate between managers/supervisors and workers.
Hypothesis B: There are no differences in the level of safety climate between plant A and plant B.
Hypothesis C: The level of safety climate is lower amongst shift workers.

2. Method

In this study, safety climate is defined as respondents' perception of how management and workers deal with safety on a daily basis.

2.1 Questionnaire

The questionnaire chosen for the study was the recently developed Nordic Occupational Safety Climate Questionnaire (NOSACQ-50, 2012; Kines et al., 2011), which with its 50 items across seven dimensions has proven reliable and valid in various sectors and countries. It contains positively and negatively (reversed) formulated items using a four-point Likert scale. The scale challenging respondents to take a stand as to what degree they agree with each item, and are scored as follows: Strongly disagree=1; Disagree=2; Agree=3; Strongly agree=4. It has currently been use in over 100 international studies, and the results are collected in an international database, which allow for benchmarking with this study. The seven dimensions contain 22 items dealing with three managerial dimensions: management 'safety priority and ability' (9 items, of which 4 are negated or reversed), 'safety empowerment' (7 items, 2 negated) and 'safety justice' (6 items, 2 negated). The remaining 28 items deal with the respondents' and their colleagues' 'safety commitment' (6 items, 3 negated), 'safety priority and risk non-acceptance' (7 items, 6 negated), 'peer safety communication, learning, and trust in safety ability' (8 items, 1 negated) and 'trust in the efficacy of safety systems' (7 items, 3 negated).
When calculating the results from the questionnaires a mean score is calculated for each dimension and participant. These figures are then used to calculate the mean scores for each dimension, for the groups and sub-groups. A mean score over 2.5 is generally considered a positive result, as this is the mathematical mean value of the highest and lowest score.
In addition to the original background variables, gender (M/F), year of birth and position (Worker/Manager), respondents in this study were also asked to provide information regarding length of tenure (5 year categories), number of previous jobs, which plant they worked in, whether they worked shift work (Yes/No), if they had heard the term 'safety culture' (Yes/No), and if they knew what the term 'safety culture' meant (Yes/No, free text).

2.2 Cases

The study was performed at a site in Sweden which includes two plants belonging to two different companies, yet belonging to the same mother company. The mother company is a large international chemical company with approximately 55,000 employees working in more than 80 countries, 3,600 of which work in Sweden. Further numerical breakdowns of number of employees and questionnaire respondents are not presented here due to the anonymity and confidentiality of the participating company.

Plant A manufactures chemicals in a continuous process, and is divided into two minor plants, each having their own shift team. The two teams work in the same control room and are not separated in the study. Plant B produces chemicals using two manufacturing and refinement units. The units have two control rooms, but only one shift team. Historically, there were two shift teams, one for each unit, but at the time for the study they had recently been merged together. The shift workers at plant A and B worked 12-h shifts for two or three days in a row. A working period involved either daytime shifts or night shifts. Between the working periods workers were off work for at least two days, and every fifth week the workers were off work for seven days.

2.3 The procedure

All employees at plant A and B (excluding entrepreneurs) were asked to fill in paper versions of the questionnaire. This included approximately 300 employees (the exact number is not presented for confidential reasons). Information about the survey was sent out via e-mail approximately one and a half months in advance, and posters with the same information as in the e-mail were put up at different locations throughout the plants.

The questionnaires were sent out via inter-office mail to everyone who did not work shift work, and were delivered personally to employees working shift work (one delivery per shift). Questionnaires were also left in the control rooms for shift workers who did not work at the time of the delivery. Participation in the survey was voluntarily and no direct, personal, identifiable information (e.g. names or employee numbers) were collected. English and Swedish versions of NOSACQ-50 (2012) were used, as there were employees at the site who did not read or speak Swedish. The questionnaires could be returned via the inter-office mail, the regular mail (advanced postage) or by handing the questionnaire directly to the first author of this article. Data collection took place over a four-week period during March/April 2011. The return rate was 69.4 %, however some of the respondents did not check off the informed consent box on the front page of the questionnaire, (which was a prerequisite for this study), which resulted in an overall response rate of 60.0 %. The data were typed into an Excel file by the first author of this article for further analysis.

2.4 Data analysis

The data collected through the background questions and the NOSACQ-50 (2012; Kines et al., 2011) items were analysed in SPSS Statistics (IBM-SPSS Statistics, 2010) and Microsoft Office Excel (2003 and 2007). The raw data from the items were used to calculate mean scores for each dimension and individual. Only answered items were used in the calculations. All answers for a dimension were excluded from the calculation if less than 50 % of the items in that dimension were answered. The mean scores for each dimension and individual were then used to calculate mean scores for each dimension and sub-group. A minimum group size of 18 respondents was chosen in order to ensure anonymity and for statistical power.

The internal consistency of each of the seven questionnaire dimensions was tested by calculating Cronbach's alpha coefficients (coefficients of reliability) (Table 1). The statistical test used was an independent samples t-test (two-tailed). A *p*-value (probability value) less than 0.05 from the two-tailed t-test was considered statistically significant for all tests. Non-significant *p*-values are referred to as NS (non-significant) in the tables presented in the results.

3. Results

There was a generally high level of internal consistency in the responses of both workers and managers/supervisors (Table 1). Workers had significantly lower ratings ($p<0.01$) of the three safety management dimensions (dimensions 1-3) than managers/supervisors (hypothesis A). The mean scores for the workers at both plants were significantly higher than the mean scores from the NOSACQ-50 (2012) international database. The evaluation of the safety climate at plant A and plant B indicates that the overall safety climate at the site was relatively high (Table 1). On the scale of 1 (low/poor) to 4 (high/rich) the mean scores for workers at the two plants ranged from 3.01 to 3.56. There was only a significant difference between the two plants on the first dimension – 'management safety priority and ability' (hypothesis B). Notice that the results only concern workers and not managers/supervisors.

The results presented in Table 2 show that there are significantly lower scores on all seven safety climate dimensions for those workers who worked shift work (hypothesis C). The results presented in Table 2 also show that there are significantly lower scores on the first five of the seven safety climate dimensions for those workers who work shift work at plant B, compared to those who work daytime at plant B. When comparing the level of safety climate for daytime workers and shift workers at plant A, no significant differences can be found for any of the dimensions. Notice again that the results only concern workers and not managers/supervisors.

Table 1: Safety climate dimension (Dim) mean scores and their Cronbach alpha coefficients for workers and managers/supervisors at two chemical plants[1] in Sweden.

	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5	Dim 6	Dim 7
Cronbach's alpha[2]							
Workers	0.86	0.83	0.86	0.69	0.81	0.83	0.80
Managers/Supervisors	0.81	0.71	0.69	0.73	0.67	0.82	0.78
Mean safety climate scores[3]							
Workers	3.13	3.22	3.35	3.44	3.09	3.48	3.53
Managers/Supervisors	3.48	3.51	3.70	3.42	3.26	3.56	3.59
p-value	0.001	0.004	0.003	NS	NS	NS	NS
Workers	3.13	3.22	3.35	3.44	3.09	3.48	3.53
NOSACQ-50[4] (n=11,167)	2.91	2.85	3.01	3.16	2.95	3.10	3.21
p-value	0.000	0.000	0.000	0.000	0.010	0.000	0.000
Plant A - workers	3.01	3.16	3.34	3.42	3.04	3.46	3.56
Plant B - workers	3.20	3.26	3.36	3.46	3.10	3.50	3.52
p-value	0.049	NS	NS	NS	NS	NS	NS

[1] The number of respondents is not presented due to the anonymity and confidentiality of the participating company; [2] A Cronbach's alpha coefficient greater than 0.7 is considered ideal (Pallant, 2007); [3] Safety climate dimension mean scores, scale 1 (poor) to 4 (high/rich); [4] NOSACQ-50 international database benchmark data for workers as of June 2012 (www.nrcwe.dk/NOSACQ); NS=Non-significant

4. Discussion

4.1 Method

As mentioned in the methodology chapter, only questionnaires returned with a checked off informed consent box were included in the compilation of the results. This resulted in a lowered response rate in comparison to the return rate. It is possible that some respondents unintentionally missed checking off the informed consent box, while others may not have wanted to participate in the survey (for different reasons), but felt group pressure to hand in the questionnaire. It should be noticed though that both the return rate and the response rate can be recognized as being fairly high. According to IaR (2011), a response rate over 50 % can be considered as adequate, over 60 % as good and over 70 % as very good, when the survey has been administrated via mail. It has also been concluded that the response rate and return rate are fairly high compared to other response rates from other surveys within other organizations where NOSACQ-50 (2012) have been used (Krogh-Pedersen and Bjerg, 2009; Kinik, 2010).

Table 2: Safety climate dimension (Dim) mean scores[1] for shift workers and daytime workers at two chemical plants[2] in Sweden[3]

	Dim 1	Dim 2	Dim 3	Dim 4	Dim 5	Dim 6	Dim 7
Shift workers	2.94	2.99	3.14	3.33	2.86	3.40	3.46
Daytime workers	3.33	3.47	3.57	3.59	3.35	3.59	3.63
p-value	0.000	0.000	0.000	0.000	0.000	0.012	0.040
1. Plant A: Shift workers	3.04	3.05	3.27	3.32	2.95	3.42	3.55
2. Plant A: Daytime workers	3.01	3.25	3.40	3.50	3.11	3.49	3.56
3. Plant B: Shift workers	2.97	2.98	3.13	3.32	2.85	3.41	3.46
4. Plant B: Daytime workers	3.40	3.50	3.58	3.58	3.34	3.59	3.59
p-value: 1-2	NS	NS	NS	NS	NS	NS	NS
p-value: 1-3	NS	NS	NS	NS	NS	NS	NS
p-value: 1-4	0.010	.000	0.022	0.022	0.017	NS	NS
p-value: 2-3	NS	0.042	NS	NS	NS	NS	NS
p-value: 2-4	0.002	0.018	NS	NS	NS	NS	NS
p-value: 3-4	0.000	0.000	0.001	0.014	0.001	NS	NS

[1] Scale 1 (poor) to 4 (high/rich); [2] The number of respondents is not presented due to the anonymity and confidentiality of the participating company; [3] The results only concern workers and not managers/supervisors; NS=Non-significant

4.2 Results

The overall level of safety climate at the two plants can be considered as relatively high. The mean scores from the survey are all higher than 2.5 (which is the mathematical mean of the scale), and are therefore considered as positive results. All of the mean scores from the survey are also higher than the mean scores from the NOSACQ-50 (2012) database. It is though important to remember that the results from the survey should first and foremost be compared to the results of the current survey, and not with the results from the NOSACQ-50 database. One of the reasons for this is that the current NOSACQ-50 database is not based on a representative sample. The sample is bias towards companies interested in evaluating their safety climate, of which many have a fairly high level of safety climate and established safety organisations. Another reason is that no chemical company is yet represented in the NOSACQ-50 database.

When investigating the two companies separately there was evidence for there being greater variance in the level of safety climate for plant B compared to plant A. The results presented in Table 2 reveal a significant difference in the level of safety climate between the shift workers and the daytime workers at plant B. There is therefore evidence that at least two sub-climates exist at plant B, one including shift workers and another including daytime workers. These findings were also concluded in another similar survey performed in 2008 at the site (the reference is not presented for confidential reasons). The results in Table 2 do not reveal any differences in the level of safety climate between the shift workers and the daytime workers at plant A, and therefore no evidence of any sub-climates within plant A. Since there are no differences in the levels of the safety climate dimensions between the shift workers and the daytime workers at plant A, the difference at plant B seems not to have to do with the fact that the workers work shifts. When investigating the level of safety climate for all shift workers at the site, the results reveal that they seem to have similar perceptions of the safety climate. The survey performed at the site in 2008 also pointed out that sub-cultures exist between different shift teams at plant B. This was not investigated in this survey, since it would not be possible to present such results without jeopardizing participants' identity, as the sizes of the shift teams are smaller than the minimum group size used in this study (minimum 18 respondents).

When comparing the results presented in Table 2, it can be seen that the actual differences in the levels of safety climate lie between the daytime workers at plant B compared to the rest (the daytime workers at plant A and the shift workers at both plant A and B). It is difficult to say why the daytime workers at plant B perceived the level of safety climate higher than the rest of the workers. Sub-climates and sub-cultures are though likely to develop when employees experience different working conditions. Two studies (Gadd, 2002; Milczarek and Najmiec, 2004) have investigated the relationship between the level of safety climate, and whether employees had experienced dangerous situations or an accident at work. They found that employees who had experienced dangerous situations, or an accident, at work had a lower level of safety climate compared to those who had not experienced any of these incidents. Wu et al. (2007) also found a relationship between accident experience and safety climate. When reviewing the statistics of accidents at the site from the site's reporting system, it was seen that employees working closer to the production line and in laboratories appeared to experience more accidents at work compared to other workers. The reason for this could be that the shift workers are those who work closest to the production line at the site. This could explain why the level of safety climate is lower for shift workers than it is for daytime workers at plant B.

The variation in the level of safety climate between the daytime workers at plant A and B, as well as why there is no variation within plant A, is more challenging to explain. One theory is that a large part of the daytime workers at plant A are located closer to the production line compared to the daytime workers at plant B. If this is the case, then is it also possible that the daytime workers at plant A have experienced dangerous situations or an accident at work which would lower their perceived level of safety climate.

4.3 Limitations and recommendations

In order to increase the response rate it may be necessary to emphasize even more that only questionnaires with a checked off informed consent will be included in the results. The questionnaires could also be handed out personally and filled out in connection with e.g. a meeting. By doing so, the drop-off linked to lack of time or lack of interest to complete the questionnaire may be reduced. It is also possible to drop the requirement of a filled in informed consent. Sub-climates between different shift teams were not investigated, as it would not be possible to present such results without jeopardizing the respondents' anonymity.

5. Conclusion

The results from the evaluation revealed that workers had significantly lower ratings than managers/supervisors on the three safety management dimensions (Hypothesis A). The level of safety climate is relatively high at both plant A and B. After a comparison of the level of safety climate of the two plants a significant difference on dimension (Dimension 1 – Management safety priority and ability) was found (Hypothesis B). Two sub-climates within plant B were revealed, one including shift workers and the other daytime workers (Hypothesis C). Both sub-climates had a relatively high level of safety climate, but the level was higher for daytime workers compared to shift workers. No sub-climates between daytime workers and shift workers at plant A were found. There is evidence that greater risk exposure and experience with

injury events may play more important roles than shift work itself, in explaining lower ratings of safety climate.

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