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Implementation of Cold Risk Management in Occupational Safety, Occupational Health and Quality Practices. Evaluation of a Development Process and Its Effects at the Finnish Maritime Administration

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Cold is a typical environmental risk factor in outdoor work in northern regions. It should be taken into account in a company's occupational safety, health and quality systems. A development process for improving cold risk management at the Finnish Maritime Administration (FMA) was carried out by FMA and external experts. FMA was to implement it. Three years after the development phase, the outcomes and implementation were evaluated. The study shows increased awareness about cold work and few concrete improvements. Concrete improvements in occupational safety and health practices could be seen in the pilot group. However, organization-wide implementation was insufficient, the main reasons being no organization-wide practices, unclear process ownership, no resources or a major reorganization process. The study shows a clear need for expertise supporting implementation. The study also presents a matrix for analyzing the process.

cold work   ergonomics development   occupational safety and health   cold risk management   implementation   evaluation

1. INTRODUCTION

1.1. Cold Work

Cold is a physical risk factor in the workplace. It is common in outdoor work especially in countries in the circumpolar region. According to occupational safety and health (OSH) standards, work can be considered cold work already when the ambient temperature is below +10 to 15 °C or when a person has cold-related symptoms at work [1, 2].

Cold exposure may have adverse effects on human health, performance and safety. Cold impairs physical and mental performance in many ways. Muscle co-ordination and manual dexterity are impaired, physical load is increased, strength and velocity are decreased and postural sway is increased by cold exposure [3, 4, 5]. Mental performance is also affected, especially performance

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in complex tasks [6, 7, 8]. Wind, wetness and cold materials increase the cooling rate of skin and tissues, and thus increase the adverse effects of cold [9]. On the other hand, heavy and bulky cold-protection clothing and personal protective equipment (PPE) may also decrease performance [10]. Unsafe work behavior has been shown to increase when the ambient temperature is below or above +20 °C [11]. In northern regions, the cold winter season is also connected to darkness and icy conditions. All these factors increase the risk of occupational accidents [12, 13]. Cold conditions also affect human health by worsening the symptoms of many chronic diseases [14, 15]. In addition, the prevalence of frostbite among Finnish people is high [16]. The effects of cold on human are also reflected in the quality and productiveness of work [11, 17].

The term “cold risk management” refers to the policies and practices used in managing cold-induced health and safety risks at a company’s workstations. It includes cold-related risk assessment, planning work, technical preventive measures, protective clothing and PPE, training personnel, and occupational health care (OHC) practices related to cold work [18, 19]. Cold risk management and practices should be integrated in the organization’s OSH management system, such as the OHSAS system [20].

1.2. Development, Implementation and Evaluation Processes

Several development process models have been created to facilitate and guide development and implementation processes. Many of them follow the principle of continuous development [21, 22]. One of the most well-known is the quality management method known as the PDCA cycle or the Deming wheel. PDCA stands for the Plan–Do–Check–Act phases of a continuous development process [21]. The PDCA phases may also be divided into more detailed tasks [23]. Development projects or interventions with the intention of making changes in several aspects of work and the work environment have proved to be the most effective [24, 25]. The implementation of such a multicomponent development process takes time and requires several contributing factors, the most important being organizational change and culture, management support, personnel’s participation in and acceptance of change, thorough planning, reliable equipment suppliers, training, and support before and after the implementation phase [26, 27, 28, 29, 30].

Due to several influencing factors, it is often difficult to evaluate the long-term economic, quality, productivity, safety or well-being effects of a multicomponent development project. To form a comprehensive picture both quantitative and qualitative methods should be used in the evaluation [31].

1.3. OSH Management and Practices at Finnish Maritime Administration

A development project for improving cold risk management in OSH practices was carried out at the Finnish Maritime Administration (FMA) in 1999–2001. FMA offers services for the maritime industry. At the time of the development project, ~1 000 FMA employees worked outdoors. The organization was divided into four divisions according to their geographic location. On the other hand, several occupational sections were identified on the basis of the various tasks of FMA, such as channel maintenance, piloting and icebreaking. FMA’s central administration’s OSH unit was responsible for the OSH management system of the whole organization. Practices such as workplace risk assessment were carried out in each division and section by their own occupational safety (OS) personnel. The personnel’s OHC was organized in co-operation with local external OHC units; the central OSH unit of FMA co-ordinated it.

2. AIMS

The aim of this study was to evaluate the implementation of cold risk management in OSH practices at FMA and the effects of the development and implementation. The evaluation was carried out by assessing (a) outcomes of the development stage; (b) changes in cold risk management activities; (c) influential factors during the development and implementation phases; and (d) changes in the perceived cold-related problems among FMA personnel.

The study aimed to find changes at four levels of interest: (a) OSH management and practices (organization level); (b) concrete development actions taken at workstations (action level); (c) personnel's awareness and knowledge about cold work (awareness level); and (d) supporting activities, such as OHC practices (support level).

3. DEVELOPMENT, IMPLEMENTATION AND EVALUATION PROCESSES AT FMA

The development, implementation and evaluation processes at FMA are presented in Figure 1. This

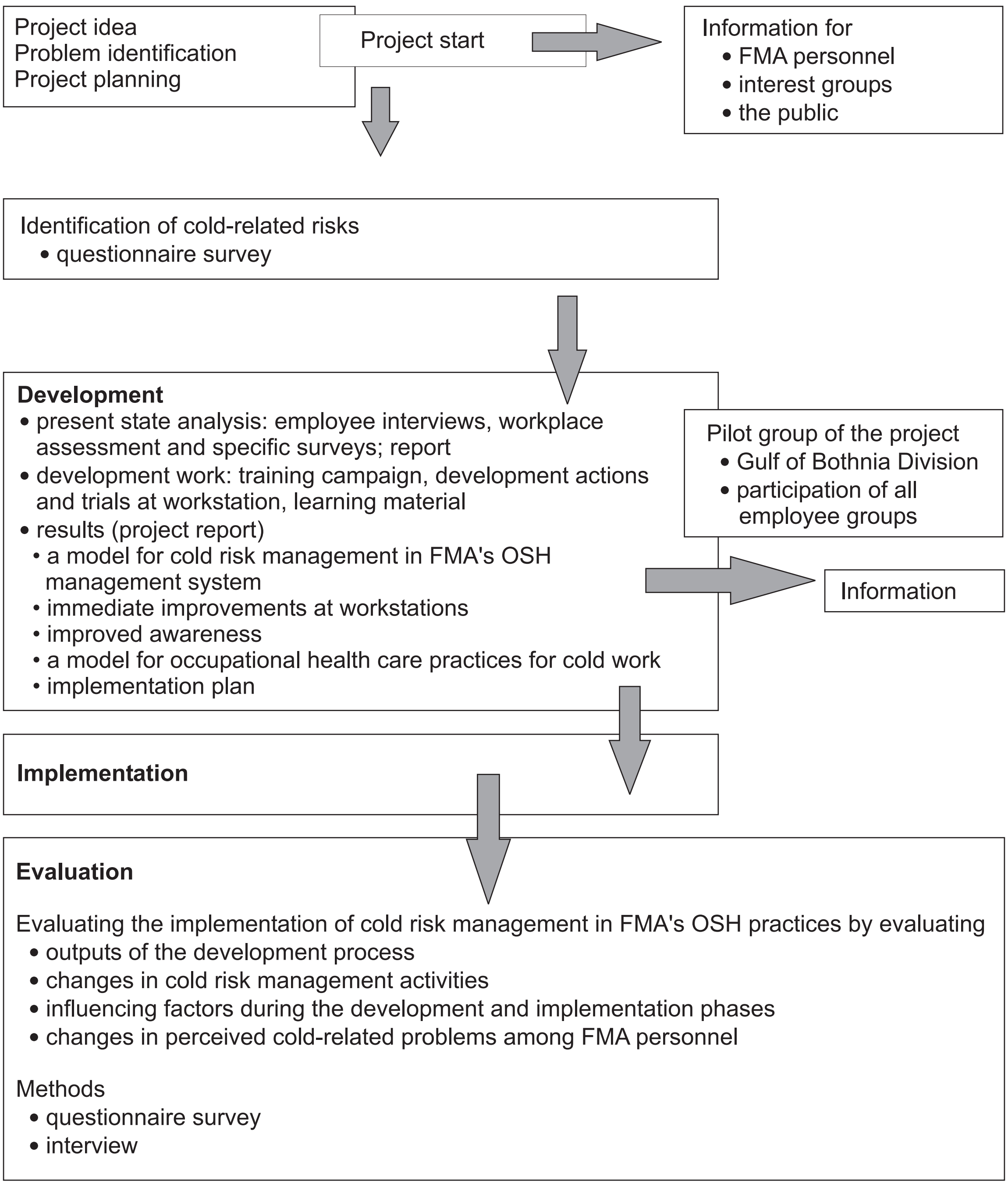

Figure 1. Implementation of cold risk management in occupational safety and health practices at the Finnish Maritime Administration (FMA). The development, implementation and evaluation processes. *Notes.* OSH—occupational safety and health.

paper is focused on the evaluation study, which was carried out 3 years after the development phase.

4. DEVELOPMENT AND IMPLEMENTATION CASE

4.1. Development Project at FMA

A development project for improving OSH in cold work was carried out at FMA in 1999–2001. It was to cause changes in the OSH management system, in concrete cold risk management practices at workstations, in the personnel's awareness and knowledge about cold work, and in external supporting activities such as OHC services. The project was carried out in co-operation with the nationwide Cold Work Action Program (CWAP) of the Finnish Institute of Occupational Health. During the CWAP, methods and practices for assessing and managing cold risks in OSH care activities were developed, and those practices were used as tools in the development and implementation work [19, 32, 33]. The Gulf of Bothnia Division (GBD), which is geographically the northernmost division of FMA, served as a pilot division in the development project.

4.1.1. Assessing cold work at FMA

At the beginning of the pilot development project, the environmental risk factors of cold-related work and perceived cold-related health and safety effects were identified among FMA personnel with a questionnaire survey [34]. The questionnaire was targeted at all FMA employees with outdoor work. Most respondents worked mostly outdoors, but the study group also included office workers. The questionnaire was re-sent to the study group to obtain more responses. The respondents ($N = 631$, 65% response rate) perceived numerous symptoms or adverse effects caused by cold work, such as discomfort (74%), pain in the fingers (61%), decreased work motivation (56%), performance degradation (44%) and increased risk of occupational accidents (64%). Wind, wetness and cold ambient temperatures were perceived as the most problematic work environment factors. In the northern GBD, as many as 78% of the respondents perceived an increased risk of occupational accidents and 57% perceived performance degradation due to cold [34].

4.1.2. Development activities and results

In the development stage of the project, the identified cold-related problems, work tasks and the work environment were first observed and assessed in various workstations. These data formed a basis for development actions. A training campaign was organized, accompanied by immediate cold prevention measures and trials with protective clothing and PPE. Specific surveys and development actions were conducted in the most challenging work tasks, such as diving and channel maintenance. The key results and implementation tools of the development projects were (a) a model and practices for assessing and managing cold risks at the whole FMA, its divisions and workstations; (b) immediate improvements at workstations at the pilot division of GBD and recommendations for further development; (c) a training campaign at GBD and a Cold Work Guide booklet [35] to be used as learning material; (d) a model and practices for OHC activities for cold work at FMA and (e) a plan for implementation of sustainable results and organization-wide dissemination.

4.2. Implementation Plan and Process

On the basis of the findings made during the development stage, a plan for implementation was made in co-operation with FMA's key people and CWAP's experts. The plan included recommendations for implementation activities, responsible actors and a schedule. Information and training materials were also provided for the implementation process.

First, the OSH unit at FMA's central administration had to integrate cold risk management into the OS program and the quality management system. An action plan had to be made for disseminating the results in the divisions, and the resources for concrete activities had to be allocated. Local OS representatives had to then integrate cold risk management into each section's OS plan. A specific FMA implementation team (Cold Team) had to be established for training and information tasks.

Second, feedback from the development trials had to be utilized in continuous concrete development activities. Cold risk assessment and prevention activities had to be carried out continuously and systematically at the workstations, first in GBD and then in other divisions. Co-operation had to increase between units and people responsible for purchasing protective clothing and PPE in the various divisions. These activities had to be co-ordinated and planned by FMA's OSH management unit, managers of divisions and the key people in the workplace. The Cold Team had to provide relevant information to support the activities.

Third, a cold work training campaign for the whole FMA had to be included in the FMA training program during the following 2 years. The training campaign had to be planned and carried out by the FMA Cold Team. Information and training material had to be produced by the Team and the central administration's information officer. Instructions for cold work had to be added to the training practices of new employees. Information on the project results had to be disseminated in the divisions by the divisions' information officers.

Fourth, the cold-related OHC practices had to be integrated into the OHC program of FMA, as well as into the instructions and training given to the external local OHC units. The OHC management of FMA was responsible for carrying out those tasks. The local external OHC units had to then carry out the practices in their everyday work and also assist FMA divisions in their cold-related training sessions.

The implementation process was scheduled to take place within the 2 years after the development process. The need for external expert support in dissemination was brought up, but it was not possible in practice. The Cold Team also suggested evaluating long-term impact and the economic effects of the process [36].

5. EVALUATION STUDY. MATERIALS AND METHODS

5.1. Design

In accordance with its aims, the study was carried out by evaluating the development outputs, changes in cold risk management activities, factors that had influenced the implementation and changes in perceived cold-related risks and effects. Changes were evaluated at four interest levels: (a) OSH management and practices (organization level); (b) concrete development actions at the workstations (action level); (c) the personnel's awareness, attitudes and knowledge about cold work (awareness level) and (d) supporting activities during the development and implementation phases (support level). Data were collected in two ways: with a questionnaire and through interviews. The activities and influential factors during the development and implementation process were analyzed according to the four interest levels by using the PDCA cycle as a chronological framework. The presumption was that changes were needed at all four interest levels during the whole process to ensure sustainable improvements.

5.2. Population

The evaluation survey reported in this study was conducted in 2003, 3 years after the development project. A questionnaire was sent to 1 024 employees who worked outdoors in different units of FMA. The number of people working outdoors at FMA was roughly the same as in 2000, when the first survey was done (Table 1). The number of respondents was 314 (31% response rate). The questionnaire was not re-sent to the study group, which may partly explain the lower number of respondents than in the case of the questionnaire in 2000. However, the characteristics of the respondents were similar in the questionnaire surveys in 2000 and 2003, and the study population can thus be considered as the same (Table 1). The percentage of GBD respondents among all respondents (16–17%)

was equal to the percentage of GBD employees among all FMA employees.

TABLE 1. Characteristics of Respondents to the Cold Work Questionnaire at the Finnish Maritime Administration in Questionnaires 2003 (*N* = 314) and 2000 (*N* = 631) [34]

Respondents	Questionnaire 2003* (%)	Questionnaire 2000** (%)
Personnel groups		
pilots	19	23
pilot cutter drivers	11	11
channel maintenance personnel	12	8
vessel personnel	34	26
other personnel (mostly working onshore)	24	31
Total	100	100
Personnel of Gulf of Bothnia Division	16	17
Physical activity at work		
light physical work	28	26
intermediate physical work	31	32
heavy or very heavy physical work	20	18
office work	21	23

Notes. *—*N* = 1 024, questionnaire not re-sent, average age—48.4 years; **—*N* = 975, questionnaire re-sent once, average age—46.8 years.

In addition to the questionnaire, 20 persons from various personnel groups and divisions of FMA were selected for an interview. There were 9 persons from GBD and 11 persons from other divisions. All 20 interviewees had responded to the cold questionnaires in both 2000 and 2003. Nine GBD interviewees and 6 interviewees from other divisions had participated in the training, field studies or trials of the development project. Two interviewees had been actively involved throughout the development process. Five persons had not participated in the development activities.

5.3. Method I. Questionnaire

The questionnaire consisted of structured, quantitative questions and open questions, targeted to find out changes in cold risk management practices at workstations and changes in the perceived environment risk factors, symptoms and adverse effects caused by cold. The statistical methods used were cross tabulations of variables (Pearson chi-square test) and Fisher's exact test (2-sided) statistics for independence. Qualitative content analysis was used to analyze open questions. The results were compared with the results of a similar cold questionnaire conducted in 2000 [34].

5.4. Method II. Interview

An interview was carried out to evaluate the development outputs, implementation practices and their effectiveness, and factors that had influenced the implementation process. A semistructured interview form was sent beforehand to the interviewees. The answers were then complemented with a phone interview carried out by the occupational health expert of FMA. Each phone interview lasted 10–20 min. Data were analyzed using qualitative content analysis.

6. RESULTS

6.1. Outcomes, Implementation and Influential Factors

In the evaluation questionnaire, the respondents reported some improved cold risk management activities. Those activities had been initiated by FMA's OSH organization, by OHC units and by the cold work development project. GBD respondents reported significantly more activities started by the cold work development project than did the respondents from other divisions (Table 2). The most concrete improvements had occurred in the availability and quality of protective clothing (46% of the respondents). Improved technical cold prevention actions, such as availability of spot heaters and improved machinery, were reported. Awareness and occupational safety in general also improved.

In the interview, 18 persons out of 20 considered cold work as an important or very important topic at FMA. The interviewees recognized many successful outcomes of the development phase, such as the Cold Work Guide booklet (19 comments), the

TABLE 2. Cold Work Questionnaire at the Finnish Maritime Administration in 2003. Reported Improvements in Cold Prevention Activities During the Past 4 Years. Responses From the Gulf of Bothnia Division (GBD) Compared With Responses From Other Divisions

Improvements	GBD (%)	Other Divisions (%)	Total (%)	Fisher's Exact Test (2-sided)
Activities initiated by the development project	**51**	**21**	**26**	**$p < .001$**
New cold protection clothing	40	45	44	$p = .617$
Activities initiated by occupational safety personnel	35	31	32	$p = .704$
Activities initiated by occupational health care personnel	30	21	22	$p = .285$
Technical improvements	26	29	28	$p = .847$

Notes. Bold signifies statistical significance.

TABLE 3. Main Findings of the Interview (*N* = 20)

Outcomes and Affecting Factors	Interest Level			
	Organization Level	Action Level	Awareness Level	Support Level
Successful project outcomes		Cold Work Guide (19)* Questionnaire study (11) Training sessions (7)	General awareness has improved, high motivation for implementation (2)	A development project, carried out together with an external expert organization, was considered important (19)
Incomplete or unsuccess-ful project outcomes	Standardized instructions and common rules for cold work (10)	Need for more advance information and longer training periods (6)	Need for more discussions and information (1)	
Changes after the project		Improvements in protective clothing (7) Planning of work and overall occupational safety and comfort improved (3) No changes (3)		The effects of cold work have been taken into account in occupational health care services (3) The issue has not been taken into account (3)
Factors help-ing imple-mentation		Good practices to be disseminated (1) Further implementation of the results needed and suggested (1) Need for further training and information suggested and suggestions made (10)		Occupational safety personnel were recognized as initiators of concrete activities (4)
Factors hinder-ing imple-mentation and diffusion	No or unclear common rules for the whole organization (1) Large organizational changes (2) No funding (2) Limited time resources (2)	No common practices for purchasing protective clothing and personal protective equipment (10). More information about the properties of protective clothing needed to support purchases (4) Different workstations need tailored instructions (1)	Need for more knowledge, especially at the supervisory level (2) The management's attitudes towards further implementation were positive, but they did not lead to concrete actions (4)	Shortage of occupational safety personnel (2)

Notes. *— number of comments.

questionnaire (11 comments) and the training sessions (7 comments). The booklet, which everybody received, was considered a versatile and clear information package. The training was considered to be in-depth and based on the newest knowledge available. On the other hand, according to 13 interviewees, the establishment of standardized instructions and common rules was carried out unsuccessfully or incompletely already in the initial development phase. Six of these responses were from GBD, and seven from other divisions.

According to the interviews, the most notable concrete improvements in the implementation phase were better availability and quality of protective clothing (7 comments), improved awareness and motivation, better planning of work and improved overall work safety. However, further training and implementation of the recommendations and results were carried out insufficiently. According to one respondent, just a small number of project results had been utilized. More information was needed.

There were several influential factors that had either helped or hindered the implementation of the development results. After the development phase, there were positive expectations regarding implementation and continuous development. OS personnel were suggested to be the responsible actors in the continuous development process. The hindering factors were mostly related to lacking or unclear common rules, practices and knowledge at various levels of the organization. The purchase of protective clothing and PPE was considered problematic due to no common practices or knowledge. The management's attitudes towards further implementation of the results were considered positive in theory, but they did not lead to concrete actions. Moreover, during the follow-up survey, FMA was undergoing a major reorganization, which may have taken most of the attention. Other hindering factors were lack of resources and no co-ordinated training. The number of full-time OS staff members was also considered to be too low. The main findings of the interviews are reconstructed in Table 3.

6.2. Changes in Perceived Cold-Related Risk Factors and Effects

In the questionnaire survey, no significant changes were found in perceived cold-related environmental risk factors among all FMA respondents (N = 314) compared with the earlier questionnaire study (Figure 2). The only significant change was in the

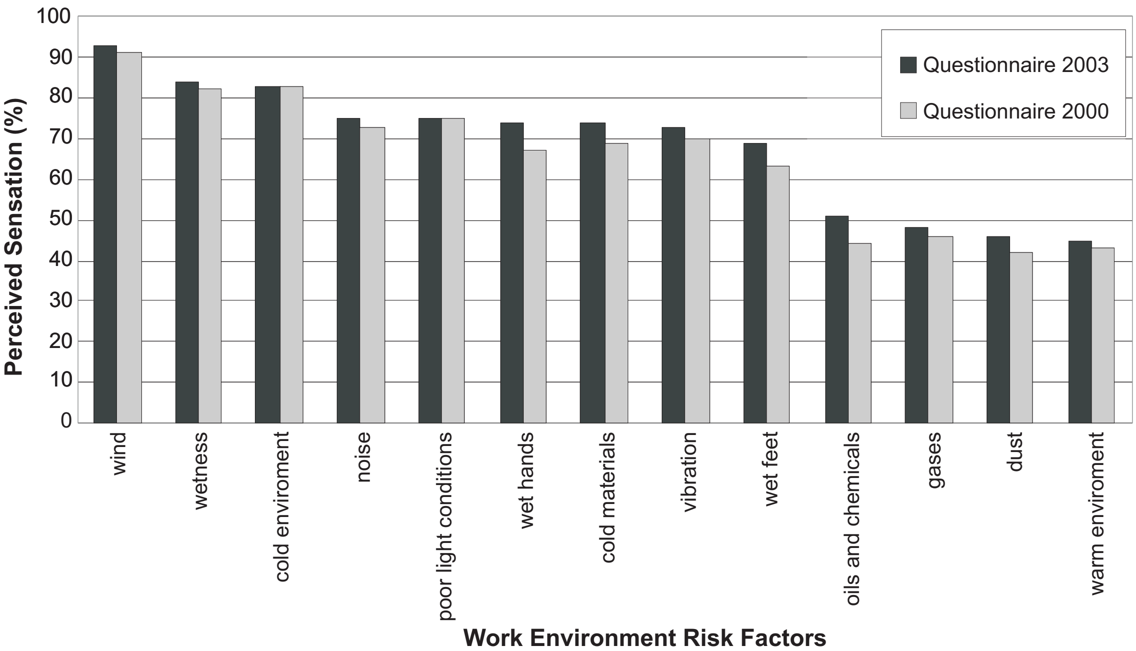

Figure 2. Cold work questionnaires at the Finnish Maritime Administration. Perceived work environment risk factors in questionnaires 2000 and 2003 [34].

perceived sensation of wet hands, which increased from 67 to 74% (p = .047).

There were no significant changes in perceived cold-related environmental risk factors among the GBD respondents only or among the respondents from other divisions compared with the earlier questionnaire study (Tables 4–5). In a comparison between responses from the northernmost division GBD and from other divisions, the respondents from GBD reported significantly higher ratings in wetness (98 versus 81%, p = .001), cold environment (96 versus 80%, p = .007) and cold materials (88 versus 71%, p = .020) than the respondents from other divisions. The same phenomenon was seen in the earlier questionnaire survey.

In comparison with the earlier questionnaire, there was a significant change in the perceived adverse effect of cold on work performance among all FMA respondents (Table 6). However, this change was not seen in the subgroup of GBD. On the other hand, no significant differences in

TABLE 4. Cold Work Questionnaires at the Finnish Maritime Administration. Changes in Perceived Work Environment Risk Factors Between Questionnaires 2000 (N = 50) and 2003 (N = 105) Reported by Respondents from the Gulf of Bothnia Division

Work Enviroment Factor	Questionnaire 2003 (%)	Questionnaire 2000 (%)	Change	Fisher's Exact Test (2-sided)
Wind	96	97	–1	p = .660; *ns*
Wetness	98	93	5	p = .439; *ns*
Cold enviroment	96	92	4	p = .500; *ns*
Noise	82	78	4	p = .673; *ns*
Poor light conditions	78	78	0	p = 1.000; *ns*
Wet hands	84	78	6	p = .400; *ns*
Cold materials	88	77	11	p = .129; *ns*
Vibration	74	76	–2	p = .843; *ns*
Wet feet	78	70	8	p = .336; *ns*
Oils and chemicals	58	51	7	p = .394; *ns*
Gases	50	49	1	p = 1.000; *ns*
Dust	46	41	5	p = .601; *ns*
Warm enviroment	36	35	1	p = 1.000; *ns*

TABLE 5. Cold Work Questionnaires at the Finnish Maritime Administration. Changes in Perceived Work Environment Risk Factors Between Questionnaires 2000 (N = 264) and 2003 (N = 508) Reported by Respondents From Other Divisions Than the Gulf of Bothnia Division

Work Enviroment Factor	Questionnaire 2003 (%)	Questionnaire 2000 (%)	Change	Fisher's Exact Test (2-sided)
Wind	93	90	3	p = .234; *ns*
Wetness	81	80	1	p = .846; *ns*
Cold enviroment	80	81	–1	p = .769; *ns*
Noise	74	72	2	p = .666; *ns*
Poor light conditions	74	74	0	p = 1.000; *ns*
Wet hands	72	65	7	p = .070; *ns*
Cold materials	71	67	4	p = .275; *ns*
Vibration	72	68	4	p = .239; *ns*
Wet feet	68	61	7	p = .092; *ns*
Oils and chemicals	49	43	6	p = .102; *ns*
Gases	47	46	1	p = .697; *ns*
Dust	46	42	4	p = .346; *ns*
Warm enviroment	47	45	2	p = .696; *ns*

TABLE 6. Cold Work Questionnaires at the Finnish Maritime Administration. Adverse Effects Caused by Cold as Reported in Questionnaires 2003 (N = 314) and 2000 (N = 631) [34]

Adverse Effects	Questionnaire 2003 (%)	Questionnaire 2000 (%)	Fisher's Exact Test (2-sided)
Cold increases risk of occupational accidents	66	64	p = .820*
Cold-related discomfort hinders work	65	59	p = .055
Cold decreases work motivation	58	56	p = .727
Cold decreases work performance (all respondents)	**52**	**44**	**p = .031**
Cold decreases work performance (respondents from Gulf of Bothnia Division)	56	57	p = 1.000

Notes. *—Pearson chi-square test; bold signifies statistical significance.

TABLE 7. Evaluation of the Outputs, Implementation and Effects of the Development Process at Finnish Maritime Administration (FMA). Plan, Do and Check Describe the Development Phase, Act Describes the Implementation Phase

	Interest Level			
Phase	Organization Level	Action Level	Awareness Level	Support Level
Plan	Analysis of the present state: several different quality and occupational safety (OS) management practices in the organization Need for common cold risk management practices at FMA	Cold questionnaire Workplace assessments in the pilot division Plan for immediate cold risk management activities	Need for information recognized throughout FMA	OS and occupational health care (OHC) personnel participated as key actors in the project
Do	Workshops for a cold risk management model for FMA	Training and cold risk management trials made in the pilot division and its workstations	The Cold Work Guide produced and delivered to everyone at FMA	OHC practices for cold work developed. Recommendations given to OHC units
Check	Recommendations given for establishing standardized instructions and common practices for cold work	Immediate positive feedback about the activities. Recommendations given for further development and training	Immediate positive feedback. Information exchange between divisions and workstations	Recommendations given for OHC practices in cold work Need for expert support expressed by FMA project team
Act	OS organization noted as an initiator of the development However, OS rules and practices for the whole organization are not clear Further implementation of the results done only partially. Reasons: limited funding and time resources, large organizational changes, shortage of full-time, OS personnel	Improvements noted: planning of work, technical actions, cold protection clothing, overall OS and comfort in cold work However, further implementation of the results done only partially. Reasons: clothing purchasing system, no co-ordinated training or suitable instructions for different workstations No measurable improvements in perceived cold-related problems compared with earlier questionnaire	Improved general knowledge, awareness and attitudes towards development More beneficial activities reported in the pilot division than in other ones However, positive attitudes did not lead to further concrete actions at the organization level Need for still more information	Supporting actors (e.g., OHC units and the cold work expert team) noted as initiators of development activities during the project However, the role of internal and external expert organizations after the development project not clear in the survey Need for more expert support

perceived cold-related adverse effects were seen between responses from GBD and other divisions, despite the fact that the GBD respondents reported more cold-related risk factors at their workstations. A summary of the development and implementation activities, outputs and perceived effects is presented in Table 7.

7. DISCUSSION

7.1. Outcomes and Methodological Considerations

This study provides long-term evaluation information from a multicomponent ergonomics development and implementation process. It stresses the importance of a well-planned and well-managed implementation and dissemination process to ensure the sustainability and diffusion of the results in a large organization. Although the size of the case population may limit generalizations, the study data well represent the various employee groups, divisions and personnel's age profile at FMA. The interview confirmed and complemented the quantitative questionnaire data. The factors helping and hindering development work can thus be applicable in various types of ergonomics development and implementation processes. To our knowledge, this is also the first study to use the matrix formed by the development framework of PDCA and the different interest levels to analyze the processes, outputs and effects.

7.2. Discussion of Results

According to the evaluation, the outcomes from the initial development phase were useful and usable. The implementation of the good practices succeeded well in the pilot GBD group. At the action level, positive changes in concrete cold risk prevention activities were found in GBD. This is most probably due to successful development and information activities during the development phase, as was also reported in the interview.

However, at the organization level, there were no improvements in organization-wide rules and practices. Ownership of the implementation was not clear; managerial commitment and allocation of resources were vague. At the support level, internal experts, such as OS and OHC personnel, were recognized as key actors in the implementation process, but their role did not become clear or visible. External supporting expertise was also needed. The recommended OHC practices were not adopted sufficiently by the external OHC units.

Awareness of cold-related problems and cold work increased among all FMA employees. Motivation and expectations towards implementation were thus high after the development phase. However, there were no improvements in perceived cold-related adverse effects among all FMA personnel in general. This may be due to increased awareness combined with insufficient organization-wide implementation. In a large, hierarchically multilevel organization such as FMA, the time span for implementation and diffusion of new practices may also be longer than 3 years [27].

The number of the respondents in the evaluation questionnaire was lower than in the questionnaire 3 years earlier. There are several reasons for this. First, the evaluation questionnaire was not re-sent to the study group, as was the first one. Second, in the large reorganization process at FMA, OSH management and co-ordination of external OHC activities were re-organized, too. Some of the new OSH key people had not participated in and were not committed to the initial development and implementation processes. For this reason their motivation for carrying out the evaluation study may have been weak. Third, the lower rate of responses may also be a sign of selecting too broad a study group from the beginning. Most probably there would have been a higher response rate and more positive changes in the end if the evaluation survey had been focused to the pilot group only.

Previous studies support the results. This study points out the importance of joint management practices, commitment and ownership of the process, visibility and concrete development of activities, and information and awareness as the most important factors facilitating an implementation process in a large, hierarchically multilevel and geographically widespread organization [26, 27, 29, 30, 31]. One of the biggest hindering factors was also the major reorganization of FMA, which started a year after the development phase. The implementation process should be planned at a very early stage of the development process with allocated resources and a clear ownership of the process. To ensure sustainability of the results, internal and external expertise should be used after the initiation phase, too [37, 38].

While multicomponent development and implementation processes are always complex issues with many influential factors, the interaction between the elements and the actors of the process needs to be studied further [39]. A specific question for further study is the optimal role of internal and external experts in different phases of the processes. We suggest that the presented matrix formed by the development framework of PDCA and the different interest levels could be utilized to analyze development and implementation activities, actors and outputs during the planning, development and implementation processes.

7.3. Conclusions

This study has shown that the following points should be emphasized to enhance the development process and ensure the implementation process in a large, hierarchically multilevel organization: the target groups and the goals for the pilot development project and the implementation stage should be set clearly from the beginning. Organization-wide rules and practices for implementation should be set as early as possible. Concrete activities and information should be emphasized for visibility and improved awareness and motivation. The ownership of the implementation process should be clear from the beginning and it should be updated according to possible organizational changes. Necessary resources should be allocated for the implementation process. Finally, supporting internal and external experts should be committed and involved in all stages of the process. This study also presents a matrix model for analyzing the development and implementation activities during the process.

REFERENCES

1. British Standards Institution (BSI). Ergonomics of the thermal environment—guide to design and evaluation of working practices for cold indoor environments (Standard No. BS 7915:1998). London, UK: BSI; 1998.
2. Deutsches Institut für Normung (DIN). Klima am arbeitsplatz ind in der arbeitsumgebung. Teil 5. Ergonomische gestaltung von Kältearbeitsplätzen [Climate at workplaces and their environments. Part 5. Ergonomic design of workplaces] (Standard No. DIN 33403-5:1997). Berlin, Germany: DIN; 1997.
3. Enander A. Performance and sensory aspects of work in a cold environment: a review. Ergonomics. 1984;27:365–78.
4. Mäkinen TM, Rintamäki H, Korpelainen JT, Kampmann V, Pääkkönen T, Oksa J, et al. Postural sway during single and repeated cold exposures. Aviat Space Environ Med. 2005;76(10):947–53.
5. Oksa J. Cooling decreases neuromuscular performance in man [doctoral dissertation]. Jyväskylä, Finland: University of Jyväskylä; 1998.
6. Ellis HD. The effects of cold on the performance of serial choice reaction time and various discrete tasks. Hum Factors. 1982;24(5):589–98.
7. Enander A. Effects of moderate cold on performance of psychomotor and cognitive tasks. Ergonomics. 1987;30(10):1431–45.
8. Palinkas LA, Mäkinen TM, Pääkkönen T, Rintamäki H, Leppäluoto J, Hassi J. Influence of seasonally-adjusted exposure to cold and darkness on cognitive performance in circumpolar residents. Scand J Psychol. 2005;46:239–46.
9. Holmér I. Cold indices and standards. In: Stellman JM, editor. Encyclopaedia of occupational health and safety. Geneva, Switzerland: International Labour Office. 1998. p. 4248–55.
10. Berquist K, Abeysekera J. Research needs to improve wearability of personal protective devices and clothing (ppds) in the cold

climate. In: Proceedings of Polar Tech '94. Luleå University of Technology: Luleå, Sweden. 1994. p. 369–75.

11. Ramsey JD, Burford CL, Beshir MY, Jensen RC. Effects of workplace thermal conditions of safe work behavior. J. Safety Res. 1983;14:105–14.
12. Klen T. Accidents in the Arctic. A psychological point of view. Arct Med Res. 1992; 51(suppl 7):71–6.
13. Pekkarinen A. Occupational accidents occurring in different physical environments with particular reference to indoor and outdoor work [doctoral dissertation]. Oulu, Finland: Acta Universitatis Ouluensis; 1994.
14. Mercer J. Cold—an underrated risk for health. Environ Res. 2003;92:8–13.
15. Hassi J, Rytkönen M, Kotaniemi J, Rintamäki H. Impacts of cold climate on human heat balance, illnesses, and injuries in circumpolar areas. Int J Circumpolar Health. 2005;64(5);459–67.
16. Juopperi K, Hassi J, Ervasti O, Drebs A, Näyhä S. Incident of frostbite and ambient temperature in Finland, 1986–1995. A national study based on hospital admission. Int J Circumpolar Health. 2002;61:351–62.
17. Juopperi K, Hassi J, Risikko T, Hussi T, Ahonen G. Kylmän lisäkustannukset rakennusalan henkilöstökustannuksiin [Personnel costs at a construction site occasioned by cold working environment]. Työ ja ihminen. 2003;1:61–71.
18. Malchaire J,Gebhardt HJ, Piette A. Strategy for evaluation and prevention of risks due to work in thermal environments. Ann Occup Hyg. 1999;43(5):367–76.
19. Risikko T, Mäkinen TM, Påsche A, Toivonen L, Hassi J. A model for managing cold-related health and safety risks at workplaces. Int J Circumpolar Health. 2002;62(2):204–15.
20. British Standards Institution (BSI). Occupational health and safety management systems—specification (Occupational health and safety assessment series No. OHSAS 18001:1999). London. UK: BSI; 1999.
21. Deming WE. Out of the crisis. Cambridge, MA, USA: Massachusetts Institute of Technology; 1986.
22. Goldenhar L, LaMontagne AD, Katz T, Heaney C, Landsbergis P. The intervention research process in occupational safety and health: an overview from the National Occupational Research Agenda Intervention Effectiveness Research team. J Occup Environ Med. 2001;43:616–22.
23. Hutchison D. Safety health and environmental quality systems management. strategies for cost-effective regulatory compliance. Sunnyvale, CA, USA: Lanchester Press; 1997.
24. Silverstein B, Clark R. Interventions to reduce work-related musculoskeletal disorders. J Electromyogr Kinesiol. 2004;14(1): 135–52.
25. Lindbeck L, Eklund J, Hansson B. Do work environment interventions really change anything? In: Saarela KL, Nygård C-H, Lusa S, editors. Proceedings of NES 2006. Promotion of Well-Being in Modern Society. 38th Annual Congress of the Nordic Ergonomics Society. Tampere, Finland: Pk-Paino Oy; 2006. p. 41–5.
26. Eason K. New systems implementation. In: Wilson JR, Corlett EN, editors. Evaluation of human work. A practical ergonomics methodology. 2nd ed. London, UK: Taylor & Francis; 1990. p. 1055–70.
27. Fullan M. The new meaning of educational change. New York, NY, USA: Teacher College Press; 1991.
28. Podgórski D. Workers' involvement—a missing component in the implementation of occupational safety and health management systems in enterprises. International Journal of Occupational Safety and Ergonomics (JOSE). 2005;11(3):219–31.
29. Väyrynen S, Nevala N, Päivinen M. Ergonomia ja käytettävyys suunnittelussa [Ergonomics and usability in design]. Helsinki, Finland: Teknologiateollisuus ry; 2004.
30. Whysall Z, Haslam C, Haslam R. Implementing health and safety interventions in the workplace: An exploratory study. Int J Ind Ergon. 2006;36(9):809–18.
31. Rissanen P, Pitkänen S, Arnkil R. Just on time. Main findings of assessment of the effects of the Finnish Workplace Development Programme projects. Helsinki, Finland: Ministry of Labour; 2003.

32. Hassi J, Raatikka V-P, Huurre M. Health-check questionnaire for subjects exposed to cold. Int J Circumpolar Health 2003; 62(4):436–43.
33. Mäkinen TM, Hassi J. Usability of isothermal standards for cold risk assessment in the workplace. Int J Circumpolar Health 2002;61(2):142–153.
34. Juopperi K, Remes J, Raatikka V-P, Hassi J, Risikko T, Toivonen L. Cold exposure and cold related symptoms and injuries among the personnel of the Finnish Maritime Administration [report]. Oulu, Finland: Oulu Regional Institute of Occupational Health; 2000.
35. Risikko T, Hicks A, Toivonen L, Huurre M, Rintamäki H, Hassi J, et al. Merenkulkulaitoksen kylmäopas [Finnish Maritime Administration's guide to cold work]. Oulu, Finland: Finnish Maritime Administration, Finnish Institute of Occupational Health, Cold Work Action Program; 2001.
36. Holmér I, Louhevaara V. Evaluation of the Cold Work Action Program. Lund, Sweden: University of Lund/Kuopio, Finland: University of Kuopio; 2003.
37. Gyekye SA, Salminen S. Workplace safety perceptions and perceived organizational support: do supportive perceptions influence safety perceptions? International Journal of Occupational Safety and Ergonomics (JOSE). 2007;13(2):189–200.
38. Ljungström M. A model for starting up and implementing continuous improvements and work development in practice. The TQM Magazine. 2005;17(5):385–405.
39. Anderson RA, Crabtree BF, Steele DJ, McDaniel RRJ. Case study research: the view from complexity science. Qual Health Res. 2005;15(5):296–320.