Work environment development using cognitive work analysis' decision ladders

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Introduction

1.1 Background

When asked to define "work environment," a group of safety professionals agreed on "the place where workers perform their work and the overall work conditions." One can say that definition is rather simplistic. A more comprehensive elaboration is that work environment is "a combination of job characteristics defining the setting where workers operate [...] and encompasses a broad range of nonpecuniary characteristics of a job, ranging from the nature of the work tasks assigned to each worker to the physical and social conditions under which these tasks are carried out. In addition, further to the tasks is the characteristic of the firm or organisation where the work takes place, and includes the scheduling of working time, the prospects that the job provides to workers and the intrinsic rewards associated with the job" (OECD 2017, p5).

Work and occupational safety and health (OSH) changes affect managers' organisational context and workplace risks. Workplace management is responsible for overseeing work performance and controlling the work environment. The management must keep pace with OSH developments to ensure continued improvement of workers' safety and well-being (Henshaw et al. 2007). A combination of leadership styles and characteristics contributes to developing and sustaining a healthy work environment (Pearson et al. 2007). In addition, developing managers' OSH competencies and resources support promoting workers' occupational well-being, innovativeness and performance (Tappura et al. 2014).

There have been several studies on intervention programs to promote occupational health. Various studies showed low to moderate interventions effectiveness (Kordsmeyer et al. 2022; Diaz-Benito et al. 2020; Schliemann et al. 2019; Oakman et al. 2018), with low worker participation, lack of resources and management support as the challenges of implementation (Kordsmeyer et al. 2022). Reluctance to change behaviour among older workers is reported as a barrier to the success of the programs (Magnavita 2018). On the other hand, Smith et al. (2015) reported how "culturally compelling" interventions fit well with workers' immediate good work environment conceptualisation, while for managers' the attention is on flexible interventions in the organisational environment. Further, Gray et al. (2019) identified skills/knowledge and leadership development, communication, team building, and employee's

involvement as the basis for promoting mental health and well-being, with cohesive work groups, good communication and agreement harnessing collective resources and employees' participation (Perä et al. 2021).

That said, a functional definition of work environment development is conceptualised here as implementing management practices and interventions designed to positively impact workplace working conditions and improve the existing OSH status and workers' well-being. This functional definition lays the groundwork for workplace intervention programs that effectively improve the OSH paradigms and workers' well-being. However, Hasle et al. (2017) noted that despite several efforts to prevent occupational diseases and accidents, with strong legislation and extensive enforcement resources, the number of cases remains relatively constant. Hence, in designing the content for workplace interventions, it is vital to include the different aspects of the work environment and address workers' and management's responsibilities and role contributions and the regulatory dimension. First, a detailed comprehension of work environment challenges and what would move the management, and the workers, is crucial.

Acquiring such knowledge entails evaluating the work environment practices of different workplaces with a critical point of view, as is the case during regulatory inspections. Reports from inspections provide an empirical elucidation of the work environment systems actuality from which one can determine the changes necessary to improve the conditions. These changes would require both management decision-making and workers' input. With this change requirement in mind, the main research question was, what would be the content of requisite changes in the physical and social conditions and management practices at a given workplace to spearhead work environment development?

The development process is complex due to the multi-dimensional aspects of work environment, i.e., the socio-organisational context and work system (Carayon et al. 2015) and requires a whole system-thinking approach. Enehaug (2014) indicated that different perspectives collectively give a more refined understanding of how the organisation, the individual and the structure interact across different conditions. It is, therefore, crucial to look at the different dimensions of the work environment development together as a complete system.

This study, with the change requirement as the starting point, is built on the work on exploring work environment management boundaries which identified the functional aspects of work environment development (Suleiman 2023). The primary aim of this study was to create content that would be the basis for decision-making on interventions to develop the work environment. Further, as workplaces in different sectors have varied work environment challenges, the next important assessment was on the relevance perception of the identified intervention decision-making content by workers and managers in various sectors. Thus, the study's secondary aim was to conduct a limited evaluation of the identified content to determine its perceived relevance in different sectors.

The change content is designed using control task analysis which is the activity dimension of the cognitive work analysis (CWA), through preparing decision ladders for work functions previously identified as work environment development purpose-related functions (Suleiman 2023). A description of CWA is provided briefly in the next section, detailing on use of decision ladders as a knowledge-based tool to support decision-making through a series of cognitive states and processes.

1.2 Cognitive work analysis (CWA)

CWA is a formative framework for work analysis (Naikar 2013) first developed by Rasmussen and his colleagues at Risø National Laboratory in Denmark (Rasmussen et al. 1994, Rasmussen 1986). CWA supports understanding humans' interaction with complex systems, aiming to describe how the work domain can proceed (Jenkins et al. 2010). Looking into constraints, CWA attempts to support the needs of workers in improving efficiency and safety (Stanton et al. 2013) and promotes adaptation design (Naikar 2011). Naikar (2013, p5) defined constraints as "limits on behaviour which must be respected for a system to perform effectively." Constraints on workers' behaviour are the central unit of design analysis in the CWA framework instead of the workers' behaviour (Vincente 1999, Rasmussen et al. 1994, Rasmussen 1986).

The five phases of CWA, each with its modelling tool, focus on different constraints. The first is work domain analysis (WDA) which identifies the information one may require to deal with various situations, including those not anticipated a priori (Naikar 2013). WDA is often presented as a five levels abstraction in the vertical dimension with varying degrees of decomposition on the horizontal (Lintern 2013a). Structural links from nodes on one level to the other illustrate the path from a specific functional artefact to the overall primary purpose it serves in the organisation structure (Naikar et al. 2005; Porter et al. 2003). Purpose-related functions (PFRs) in the middle of the abstraction hierarchy connect the value measures constrained by the domain purpose on the upper part of the hierarchy to the lower object-related functions afforded by the physical objects/resources, the domain's artefacts useful in conducting the work (Lintern 2013a, Lintern 2013b).

The second phase is the control task analysis (Vicente 1999), also known as activity analysis (Naikar 2013) or work task analysis (Lintern 2010). This phase involves identifying the constraints related to the necessary activities within the available resources. Control task analysis arising from work situations transforms inputs such as the current state into outputs as decision and control action (Sanderson 2003). One of the modelling tools used for activity analysis is the decision ladder, a template for mapping task trajectory, portraying knowledge states, and information-processing activities involved in task execution (Lintern 2013a). A Series of sequential knowledge states and cognitive processes characterising knowledge-based behaviour define the decision ladder, as shown in figure 1.

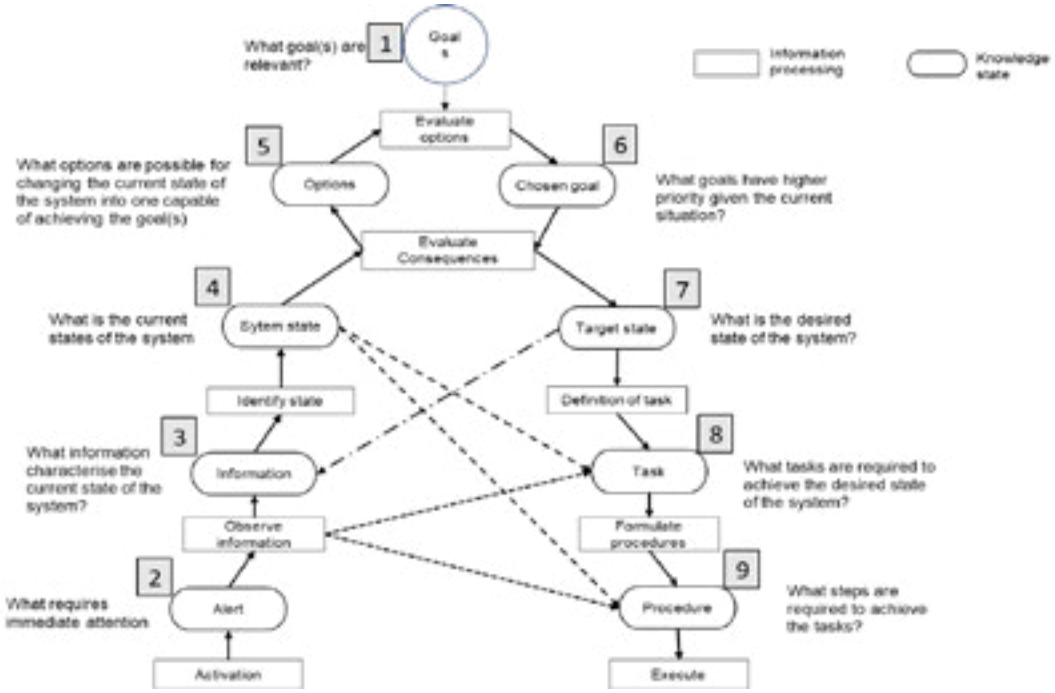

Figure 1: Generic decision ladder (adopted from Elix & Naikar with slight modification) [Elix & Naikar 2008]

The left side of the ladder represents situation analysis and diagnosis, while the right side represents planning, scheduling, and execution, with evaluation between the two (Lintern 2009). The sequence depicted with solid arrows, starting from activation through the steps to execution, would be adopted in instances such as when experts meet unfamiliar tasks or when non-experts are engaged in specific task performance. On the other hand, experienced workers performing familiar tasks may bypass some parts of the decision ladder (as shown by the dotted lines), start at different parts of the ladder, and may move from left to right and right to left (Naikar 2005). The decision ladders embed the complete decision-making activities rather than just the options (Jenkins et al. 2016) and help to think about different work methods (Hassall and Sanderson 2014).

Populating the decision ladder template starts with defining the goal of the system and the constraints that affect the goal. Questions reflecting the actors' recurring concerns can be used to annotate the decision ladder (Elix and Naikar 2008). Answers to the questions framed by actors in situational context indicate the states of knowledge, with the possibility for combinations of work situations, work functions, and control tasks, placing clear demands on actors (Naikar 2013).

The subsequent dimensions of CWA include strategy analysis which identifies the strategies one can employ to achieve the necessary system activities; social organisation and cooperation analysis, involving analysis of work allocation and distribution within the system; and workers' competencies analysis, dealing with how to meet the system demands given human cognitive capabilities and limitation.

1.3 Functional aspects of work environment development

In the study on exploring boundaries of work environment management (Suleiman 2023), six PRFs were identified. PRFs are necessary to attain the work domain purposes (Naikar 2013). For example, in a process industry setting, process preparation and start-up, system cleaning and disturbance analysis would be typical process purpose-related functions (Naikar 2013). Similarly, in a healthcare system, prescribing and patient assessment would be purpose-related functions pertinent to maintaining patients' health (Burns 2012). Figure 2 shows a part representation of the abstraction hierarchy from the analysis of work environment management boundaries focusing on the functional purpose "work environment development".

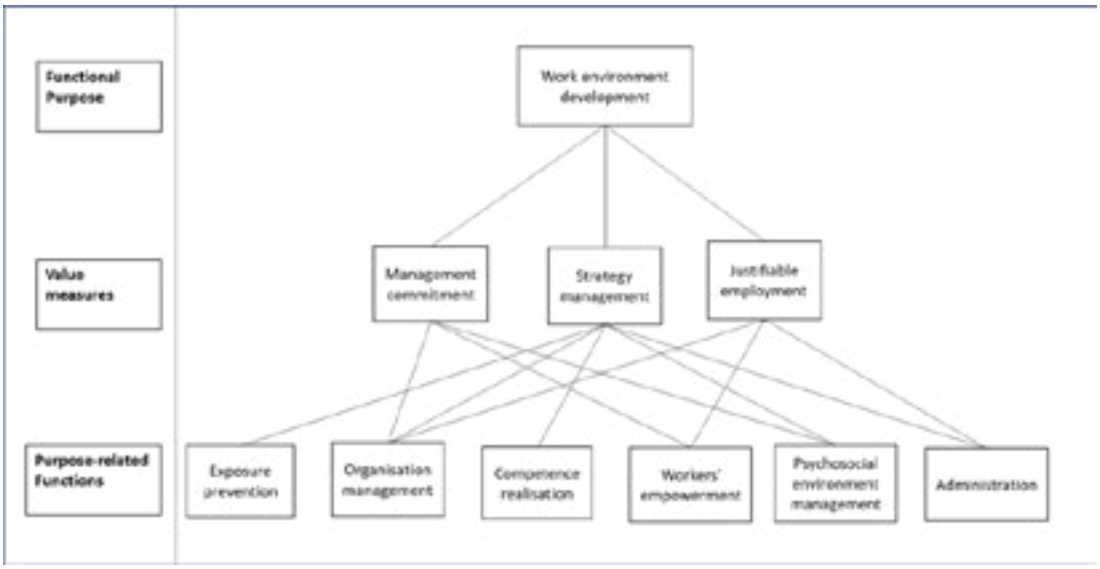

Figure 2: Part abstraction hierarchy focusing on work environment development [from Suleiman 2023]

The identified work environment development PRFs are Exposure Prevention, Organisation Management, Competence Realisation, Workers' Empowerment, Psychosocial Work Environment Management, and Administration. When reading the hierarchy using the "why-what-how" triade, the value measures in the middle (*what*) are connected to the functional purpose (*why*) from above and the PRFs (*how*) from below. These three levels of the WDA allude to humans' functions, whereas the next two (not included in Figure 2) allude to the physical resources and the process these resources afford. Workplace variations and the management's resources may mean different physical resources and processes. However, the purpose-related functions remain the same despite differences in the workplaces.

From the OECD's contextual work environment elaboration (OECD 2017) mentioned above, the functions for work environment development, *Exposure prevention* and *Psychosocial environment management* address the "physical and social conditions" under which the workers carry out the assigned task. *Organisation management* and *Administration* deal with the "characteristics of the organisation where the work takes place." Finally, *Competence*

realisation and *Workers' empowerment* cover the "prospects that the job provides to workers." The juxtaposition of the work environment definition elements to the work environment development PRFs asserts the functions' relevance in developing the work environment. The work functions may be performed in different work situations and are accordingly characterised as activities (Naikar, Moylan and Pearce 2006).

2 Method

2.1 Information gathering and processing

This study's primary source of information was reports from concluded onsite inspections conducted by the Norwegian labour inspection authority (NLIA). Inspection areas covered in the investigated reports included the health and social care sector (n=365), building and construction (n=271), and industrial activities (n=132) for the period 2019-2021 from one of NLIA's geographical regions. Criteria for inclusion were that at least one enforcement/administrative order was decreed in the decisions in the inspection report due to the companies' non-compliance with regulatory requirements and that the company had responded to the orders. The listed orders were aggregated according to the intended purpose and put under the work function that best described the decision's intention, as shown in Table 1.

Table 1: The work functions and the orders aggregated under each function.

Work functions (purpose-related functions)	Areas orders decreed
Exposure prevention	Biological hazards; ergonomics; indoor climate; explosion hazards; measurement taking; use of work equipment; evacuation pathway; noise hazards assessment; chemical substances inventory; ventilation; personal protection; Safety data sheets; work at height; hazards mitigation
Organisation management	Periodic control of machines/work equipment; risk mapping and management; implementation of safety action plan; routines for reporting safety shortfalls; accidents reporting; risk assessment of solo work; workstation safety; resting and restitution; internal control; labelling of stored chemicals; needs adaptation; work plan; areas classification and demarking.
Competence realisation	Workers' training; training documentation; information requirement; work instructions; employers' training
Workers' empowerment	Safety representatives; safety committees; contribution of workers' representatives
Psychosocial environment management	Follow-up on threats and violence; work and emotional load; equal treatment
Administration	Support from occupational health services; work time; employers' OSH responsibilities; routines updating; average time determination; overtime and other types of compensation; disclosure duty; permits; health controls; workers' contracts

Populating the decision ladders started with establishing a primary goal for each of the six work functions, focusing on changing the physical and social conditions and organisational/management practices. For each goal, at least two constraints are required (Elix and Naikar 2008). The subgoals of the prerequisites for effective OSH inspection performance (Suleiman 2022) were applied as the goals' constraints with slight modifications where necessary. This approach aligned the work environment development activities with targets of inspection performance, ensuring regulatory compliance in performance. The orders formed the foundation for existing situational analysis, reflecting on the state of the workplace during the inspections and providing the content for populating the *System* and the *Information* (set of observations) states in the decision ladder for each work function.

The author and three long-serving and experienced NLIA OSH inspectors formulated the content of the system and the information states (nodes 3 and 4) from the regulatory decisions and the questions on inspection checklists. The *Options* (node 5), i.e., what would be necessary to change the system state to attain the identified goals, were then structured based on the content of the system and the information states. The content of the planning, scheduling, and execution processes (nodes 6-9) on the right-hand side of the ladder was then built from the list of options identified.

2.2 Content evaluation

All the *Options* constructs for each work function were put together in a questionnaire designed to evaluate the perceived relevance of the identified content in developing work environments in different work areas. A 1-5 Likert scale was used, with 1 = least important and 5 = most important. The questionnaire was sent to workplaces in different sectors, as presented in Table 2. The management of participating companies had the discretion to identify the participants to participate in the survey.

Table 2: The work areas of the participants in the content evaluation

Sector	Occupation/pursuit
Health	Dental surgery staff Ergo therapists Training and rehabilitation
Technical	Electrical workers Internal structures installation Building construction/maintenance
Service	Sales and customer relations Legal advice
Manufacturing	Prosthetics production Paints formulation Unspecified production
Management (various)	General management Project management
Others	Grocery retailers Janitor and renovation services

Workers from the various work sectors (n=33) evaluated the relevance and importance of the constructs. Participants' demographics, i.e., age group and gender, were also obtained from the data collected. Responses were analysed to determine differences in perceptions of the content for developing work environments in the different work sectors. In general, high average values on the Likert scale would be a positive indication of the perceived relevance and importance of the constructs. Further, the sectors' agreement on constructs' importance in their work environment development would provide some level of validity of the identified content for work environment development in different sectors.

Statistical analysis was used to make sense of the results. Kruskal-Wallis' test was used to compare the indicated perceptions from work areas and age-groups perspectives, while Mann-Whitney U-test was for gender perspective. The gathered data's internal consistency was controlled using α-Cronbach.

3. Results

A decision ladder for the work function "Exposure prevention" with the identified content of each knowledge state is presented in Figure 3. Similarly, the contents of all decision ladders for the other five work functions presented in Table 1 were prepared accordingly.

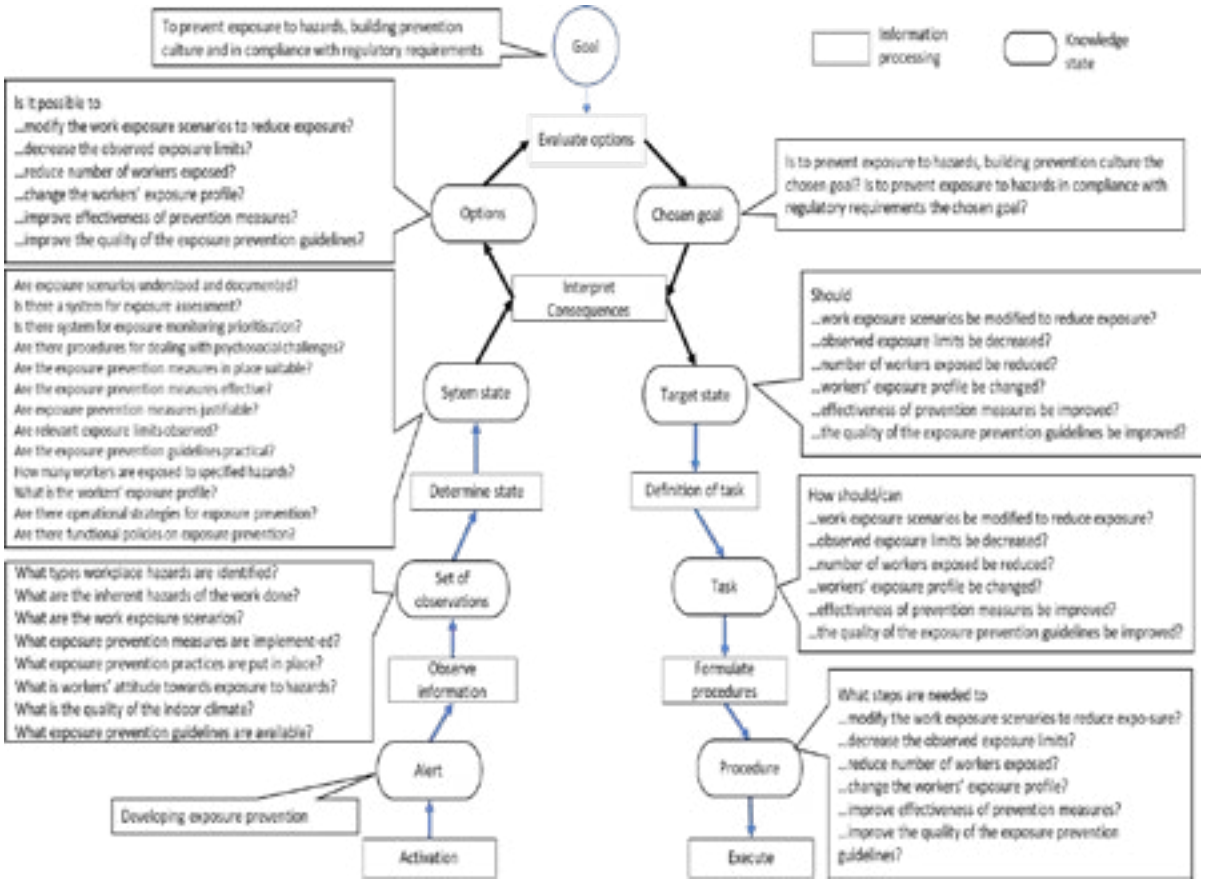

Figure 3: Decision ladder for work function' Exposure prevention.

The knowledge state "Options" is characterised by the constructs that provide for changing the existing state. All the constructs identified under *Options* are added to the question phrase "Is it possible to…," giving questions on the possible change alternatives. These alternatives are processed further on the right-hand side of the ladders, and under the knowledge state "Procedure", are preceded by the question phrase "What steps are needed to…" forming the decision-making content. Collating the constructs from all the decision ladders for the six work functions gave 29 items considered as the content for work environment development per the study objective.

Three categories of requisite change content were envisaged in the research question, i.e., physical and social changes and changes in management practices, with each of the 29 items falling under one or more of these categories. For example, the question "What steps are needed to modify the work exposure scenarios to reduce exposure" (see Table 3) gives the basis for decision-making on the work program to reduce workers' exposure to hazards, giving decision-making content on physical change. On the other hand, the question "What steps are needed to enable work within established OSH standards" as part of the function "organisation management" falls under change in management practice, whereas "What steps are needed to have arenas for workers' cooperation" under the function "psychosocial work environment management" exemplify social change. The same applies to all the constructs listed in Table 3, each falling under one of the change categories as indicated in the table. A bold (✓) shows the main change category for that construct, and a light one (✓) shows that the construct is also relevant in that change category.

Table 3: Presentation of the constructs under each work function with attribution of whether it is a physical change (PC), social change (SC) or management practice (MP)

	Work environment development constructs:	**Change types**		
Work functions	*(**Procedures**): What steps are needed to…*	PC	SC	MP
Exposure prevention	modify the work exposure scenarios to reduce exposure?	✓		
	decrease the observed exposure limits?	✓		
	reduce the number of workers exposed?	✓		
	change the workers' exposure profile?	✓		
	improve the effectiveness of prevention measures?	✓		✓
	improve the quality of the exposure prevention guidelines	✓		✓
Organisation management	design alternative work organisations to emphasise prevention culture?	✓		✓
	enable to work within established OSH standards?	✓		✓
	operationalise management accountability?			✓
	design strategies for regulatory compliance?			✓
	improve the OSH practices?			✓
Competence realisation	enhance workers' OSH competence?			✓
	adapt work instructions to advance good OSH practices?	✓		✓
	establish a system for acquiring new knowledge?	✓		✓
	enhance management's competence on OSH responsibilities?			✓
Workers' empowerment	organise workers' involvement in work environment decision-making effectively?	✓		✓
	enhance workers' comprehension of their work environment responsibilities?	✓		✓
	involve workers in the internal control process?	✓		✓
Psychosocial environment management	have arenas for workers' cooperation?	✓	✓	
	have regular programs for promoting welfare?	✓	✓	
	have a proactive approach to tackle social hazards?		✓	
	use normal management processes to monitor workers' well-being?			✓
	change performance context?	✓		✓
	adapt the workplace to accommodate for diversity?	✓	✓	
Administration	amend the roles and responsibilities to promote belongingness?		✓	✓
	upgrade the type of workers' support?			✓
	improve workers' level of support satisfaction?		✓	✓
	enhance needs adaptation routines?		✓	✓
	widen the scope of workers' cooperation?		✓	✓
Note: PC – Physical change; SC – Social change; MS – Management practice				

The different activities the workplace management needs decision-making on to change the work environment cover all the change categories.

In evaluating the relevance and importance of the 29 items, Table 4 shows the results of the statistical analysis of the evaluation.

Table 4: Results of statistical analysis of the constructs for work development intervention content.

Work functions	Work environment development constructs:	Scores		Anova (Sig. level)		Mann-Whitney U test (Sig. level)	Kruskal-Wallis test (Sig. level)	
	(Procedures): What steps are needed to…	Mean	SD.	Age-group	Work sector	Gender	Age-group	Work sector
Exposure prevention	modify the work exposure scenarios to reduce exposure?	4.18	1.131	0.939	0.615	0.683	0.734	0.569
	decrease the observed exposure limits?	4.15	1.149	0.800	0.215	0.763	0.422	0.151
	reduce the number of workers exposed?	4.03	1.287	0.430	0.106	0.581	0.622	0.131
	change the workers' exposure profile?	3.70	1.237	0.798	0.288	0.465	0.862	0.182
	improve the effectiveness of prevention measures?	4.42	0.751	0.690	0.221	0.817	0.746	0.180
	improve the quality of the exposure prevention guidelines?	4.27	0.839	0.266	0.018	0.557	0.288	0.021
Organisation management	design alternative work organisations to emphasise prevention culture?	3.91	1.071	0.763	0.250	0.790	0.624	0.186
	enable to work within established OSH standards?	4.21	0.696	0.209	0.121	0.102	0.202	0.163
	operationalise management accountability?	4.09	0.765	0.401	0.517	0.631	0.193	0.383
	design strategies for regulatory compliance?	4.03	0.918	0.303	0.275	0.191	0.288	0.308
	improve the OSH practices?	4.09	0.879	0.950	0.699	0.231	0.829	0.436
Competence realisation	enhance workers' OSH competence?	4.27	0.761	0.307	0.106	0.345	0.204	0.148
	adapt work instructions to advance good OSH practices?	4.15	1.064	0.835	0.943	0.873	0.853	0.921
	establish a system for acquiring new knowledge?	3.94	1.059	0.178	0.556	0.309	0.112	0.666
	enhance management's competence on OSH responsibilities?	3.97	0.810	0.185	0.188	0.326	0.188	0.193
Workers' empower	organise workers' involvement in work	4.36	0.742	0.755	0.347	1.000	0.713	0.277

	environment decision-making effectively?							
	enhance workers' comprehension of their work environment responsibilities?	4.52	0.667	0.629	0.102	0.581	0.688	0.222
	involve workers in the internal control process?	4.39	0.659	0.548	0.558	0.179	0.538	0.452
Psychosocial environment management	have arenas for workers' cooperation?	4.42	0.792	0.922	0.190	0.191	0.958	0.100
	have regular programs for promoting welfare?	4.30	0.770	0.897	0.464	0.231	0.634	0.584
	have a proactive approach to tackle social hazards?	4.61	0.659	0.904	0.683	0.488	0.635	0.577
	use normal management processes to monitor workers' well-being?	4.39	0.704	0.817	0.310	0.901	0.795	0.326
	change performance context?	3.70	0.883	0.351	0.944	0.817	0.325	0.939
	adapt the workplace to accommodate for diversity?	4.03	1.380	0.482	0.207	0.217	0.345	0.219
Administration	amend the roles and responsibilities to promote belongingness?	4.06	1.029	0.712	0.166	0.683	0.457	0.083
	upgrade the type of workers' support?	4.21	0.820	0.576	0.800	0.873	0.616	0.757
	improve workers' level of support satisfaction?	4.39	0.704	0.680	0.446	0.929	0.648	0.418
	enhance needs adaptation routines?	4.00	0.829	0.697	0.085	0.581	0.785	0.341
	widen the scope of workers' cooperation?	4.18	0.727	0.417	0.155	0.488	0.326	0.184
Note: SD = Standard Deviation: Sig. Level = Significance level								

The mean scores for all the constructs fall in the range of 3.70 – 4.61, with only 5 (17.2%) constructs having mean scores below four (4). The standard deviations suggest variations in the data, with some of the constructs having a high variance coefficient. These variations are not unexpected due to the numbers and variations of the workers who participated in the evaluation process. However, ANOVA showed no significant differences in the constructs when comparing age groups, as shown in Table 4. On the other hand, a comparison of the work sectors showed a significant difference (p=0.018) for the construct "…improve the quality of

the exposure prevention guidelines (under work function *Exposure prevention*) with Tamhane's T2's multiple comparisons showing differences between Manufacturing-Management and Management-Others (see Table 2), both with p=0.017.

Similarly, Kruskal-Wallis test showed a significant difference for the same construct (p=0.021). Pairwise comparison showed differences between Manufacturing-Technical (p=0.040), Service-Management (p=0.041), Services-Other (p=0.031), and Manufacturing-Management (p=0.008). Meanwhile, the Man-Whitney U test showed no significant differences between the constructs from the gender perspective.

An α-Cronbach analysis showed good internal consistency with a high value of 0.910 rating from age group, gender and work sector.

4 Discussion

4.1 Methodology considerations

The primary aim of this study was to design decision-making content for work environment development using decision ladders, with reports from workplace regulatory inspections as the primary source of information. Applying the formative decision ladders and using regulatory decisions from workplace inspection to develop work environment is a novel strategy that deviates from the more traditional prescriptive pragmatism of OSH professionals, as Zanko and Dawson (2011) noted. Added to the regulatory decisions were aspects of the identified inspection effective performance prerequisites (Suleiman 2022), intertwining workplace OSH management practices and inspection goals. These are two areas customarily dealt with from different perspectives. For example, inspections by national OSH enforcement authorities are typically understood as regulative, while OSH management practices may require line managers to incorporate safety and health into regular business strategies (Mellor and Webster 2013). The merit of using regulatory decisions from inspection reports is in presenting the fundamental aspects the inspectors had identified as insufficiently practised or were non-compliant with regulatory requirements and required correction by the workplace management. Addressing these shortcomings is essential to work environment development. The outcome was identifying 29 items of content for work environment development that can be applied to workplaces across different sectors.

The reports were selected based on the significant work environment challenges workers in the three sectors may experience. Workers in the health and social care sector are reported to have a high prevalence of musculoskeletal disorders, headaches, stomach ailments, mental disorders, physical and mental exhaustion, and the highest incidences of sickness absence (AT1). Building and construction is a high-risk sector with several hazardous activities requiring comprehensive work environment supervision. For industry, workers are particularly exposed to accidents in connection with using and maintaining machines and equipment and ailments

due to chemical and biological hazards, noise and vibration, and high fatalities (AT2). These three sectors comprehensively encompass the most critical work environment challenges. Orders decreed following inspections in these sectors represent the high-end work environment challenges, and effecting work environment development from this perspective also suffices for the other less challenging sectors.

4.2 Development constructs

The decision ladder goal established for the function *Exposure prevention* was "to prevent exposure to hazards, build a prevention culture in compliance with regulatory requirements", the need to build a prevention culture and comply with regulatory requirements being the goal constraints. Progress in exposure prevention is essential and attainable by continuously applying the identified constructs as part of the workplace culture. Moreover, the measures must fulfil regulatory requirements, such as observing the regulatory exposure limits. The development constructs are thus intended to provide content supporting this goal attainment.

The goal for *Organisation management* was to manage work organisation within a prevention culture framework and regulatory compliance. This goal is essential in facilitating the prevention culture development and working according to the regulations. Therefore, the work plans, organisation, and practices must accommodate work environment structures that support the prevention culture and maintain compliance with regulatory requirements. Further, workers have a vital role in the development process, and developing workers' competencies to identify and correct deficiencies in the work environment and as a means of workers' support becomes an important goal of workers' *Competence realisation*.

Furthermore, *Workers' empowerment* is vital in work environment development. Workers' empowerment involves including workers in work environment decision-making, correcting deficiencies and building workers' confidence in the whole development process. The workers need to embrace the process, be part of it, and make contributions to the development process, which in turn, helps in facilitating the goal of the next work function, the *Psychosocial environment management,* where the goal set is to safeguard workers' dignity, supporting well-being and breed mutual confidence. The workplace should have policies against threats and violence; the workers should be content with their work engagement and control their work, with both physical and mental well-being. The policies should help tackle social hazards (Krieger 2012; Krieger et al. 2006) and avoid relations misconceptions (Byron and Landis 2020).

The work function *Administration* puts together all other work functions discussed. The goal set for this function was to promote belongingness, corroborate justifiable organisational and psychosocial measures and improve cooperation. Hagerty et al. (1999, p173) described belongingness as "the experience of personal involvement in a system or environment so that persons feel themselves to be an integral part of that system or environment." Therefore, workers need to have a sense of belonging to their work environment. Lambert et al. (2013)

showed that a sense of belonging was a robust predictor of meaningfulness, and according to Sargent et al. (2002), sense of belonging provided a buffer against depressive symptoms.
This work environment development strategy applies similarly to different workplaces. The results from the evaluation process, showing no significant differences in the relevance and importance perception, indicated the validity and applicability of the content of work environment development at diverse workplaces.

4.3 Execution of the decision-making process

The work environment development constructs would be typically more relevant in the different stages of the intervention process. Table 5 shows under which intervention stage the different constructs would typically be most practical (dark-shaded cells) and when they give additional support (light-shaded cells).

Table 5: Work environment development constructs coded according to the stage of the intervention process.

Work functions	Work environment development constructs:	Intervention cogitation	Intervention management	Intervention evaluation
	(Procedures): What steps are needed to…			
Exposure prevention	modify the work exposure scenarios to reduce exposure?			
	decrease the observed exposure limits?			
	reduce the number of workers exposed?			
	change the workers' exposure profile?			
	improve the effectiveness of prevention measures?			
	improve the quality of the exposure prevention guideline			
Organisation management	design alternative work organisations to emphasise prevention culture?			
	enable to work within established OSH standards?			
	operationalise management accountability?			
	design strategies for regulatory compliance?			
	improve the OSH practices?			
Competence realisation	enhance workers' OSH competence?			
	adapt work instructions to advance good OSH practices?			
	establish a system for acquiring new knowledge?			
	enhance management's competence on OSH responsibilities?			
Workers' empowerment	organise workers' involvement in work environment decision-making effectively?			
	enhance workers' comprehension of their work environment responsibilities?			
	involve workers in the internal control process?			
Psychosocial	have arenas for workers' cooperation?			

environment management	have regular programs for promoting welfare?			
	have a proactive approach to tackle social hazards?			
	use normal management processes to monitor workers' well-being?			
	change performance context?			
	adapt the workplace to accommodate for diversity?			
Administration	amend the roles and responsibilities to promote belongingness?			
	upgrade the type of workers' support?			
	Improve workers' level of support satisfaction?			
	enhance needs adaptation routines?			
	widen the scope of workers' cooperation?			

Considering a case, such as when using chemicals in cleaning work as described by Suleiman and Svendsen (2017), answers to the question of "What steps are needed to modify the work exposure scenarios to reduce exposure" (under Exposure prevention) involves considering the work method, use of tools-of-trade, and changing the work ambience. In addition, changing workers' exposure profiles, such as in the case of exposure to high noise at different workstations, may involve mapping noise sources and controlling the noise levels from the source as appropriate.

The listing of the work development content constructs, as presented in the tables above, is neither indicative of the order of performance nor a compelling checklist for what needs to be included in the intervention process. The order of the constructs' applicability may become apparent during the intervention cogitation stage, and this may vary from one workplace to another according to the workplace challenges. For example, the steps needed to reduce the number of workers exposed (under Exposure prevention) may be preceded by designing alternative work organisations to emphasise prevention culture (Organisation management). For organisation management, steps needed, for example, to design alternative work organisation, would depend on consideration of the practicality of the alternative organisation out from the workers' cognisance, their number, ability and safety paradigm. Hence, before implementing the alternative, it may be necessary to enhance the OSH competencies of the workers and the management on their responsibilities, which are constituents of competence realisation. The constructs' applicability concurs with workplace strategic management.

4.4 Practical implications

Applying the 29 items content for decision-making provides for a system-thinking approach that fosters a complete work environment development process. The level of detail of the change content gives a discernible effect on the management practices and the strategies for effectively changing the tangible work environment practices (physical changes), such as changing work procedures to reduce exposure to workplace hazards and change in interpersonal relationships, well-being and welfare of the workers (social changes), such as by

providing arenas for workers cooperation (also as a physical change). The changes in workplace management practices cover aspects such as "use normal management processes to monitor workers' well-being." The management is responsible for all the work functions and the changes impacting the physical, socio-organisational, and psychosocial aspects of the workplace work environment. Such a holistic approach to work environment development would lead to changes in workplace OSH policies, compliance with regulations and standards, procedures and guidelines, and workers' welfare, effectively impacting both the physical and social changes.

Moreover, implementing the described change content in workplace decision-making sets the groundwork for enhanced cross-sectional internal cooperation, as different content elements may fall under different workplace sections. The generated cross-sectional interdependence to achieve a common workplace objective brings forth effective OSH resource management.

4.5 Limitations

One limitation of the study is that, in aggregating the enforcement/administrative orders to connect with the change work functions/activities, some orders were precise to concrete workplace situations and were not reported repeatedly. Consequently, such could neither be included in aggregates nor was it considered purposive to prepare questions for them. However, comprehensive coverage of the main work environment development functions, as achieved by the content of all the work functions' decision ladder, also affected such isolated outlying aspects.

For each of the goals identified for the preparation of the decision ladder, only two constraints were identified in this study which may have limited the number of outcome content constructs. However, since different subgoals of the prerequisite of effective inspections (Suleiman 2022) were used as constraints for the different goals identified from the work functions, a broader constraints application was possible. Most sub-goals were all the same and reasonably applied in the work environment development.

Another limitation is the small number of participants in the content evaluation process. Although the evaluation results showed high scores for all 29 constructs and no significant differences were identified, the number was small to allow for extensive application of the outcome. However, the consistently high mean scores with no significant differences between the work sectors and high internal reliability strengthen the validity and usefulness of the content constructs for work environment development in different sectors.

Conclusion

The study outcome, in the form of constructs from the decision ladders, provided the content for developing the workplace work environment by creating the basis for changing the existing system status and attaining the goals identified. The 29 constructs provide a foundation for

workplace management's decision-making to develop the work environment. The constructs apply despite the variabilities of workplaces, where making the decisions related to that workplace is made possible for each workplace. The high rate of data internal consistency from raters from the different sectors substantiates the utility of the work environment content across different workplaces. Furthermore, the content constructs designed to attain the goals identified for each decision ladder combine workplace management practices and regulatory requirements, which support applying workplace-specific OSH strategies.

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