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by Christensen JO, Nielsen MB, Finne LB, Knardahl S

Characterizing employees by their patterns of reported psychological/social work factors may provide valuable information about workload that is not directly deducible from studying single factors separately. In the current study, different combinations of levels of 12 different psychological and social work factors were associated with different levels of risk of single- and multi-site somatic pain.

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Key terms: back pain; job control; job demand; latent class analysis; leadership; multi-site pain; neck pain; occupational psychological factor; organizational climate; pain; predictor; profile; psychological factor; psychological work factor; psychosocial work environment; site-specific pain; social factor; social work factor; somatic pain

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Comprehensive profiles of psychological and social work factors as predictors of site-specific and multi-site pain

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Objective Despite the multifactoriality of work and health, studies of psychosocial work factors with pain are typically limited to a few factors. This study examined a wide range of factors to determine (i) typical combinations of work factor levels ("work situations") and (ii) whether "work situations" predicted pain complaints of six anatomic regions.

Methods Questionnaires were distributed to 6175 employees twice over a two-year period. Latent profile analysis was conducted to group employees into profiles of work factor levels. Twelve work factors were measured, reflecting six themes: demands, control, role expectations, leadership, predictability, and organizational climate. Logistic and Poisson regressions compared the groups' risk of pain of the neck, head, back, shoulders, legs and arms, as well as multi-site pain (>1 pain site).

Results Four latent profiles emerged based on relative levels of work factors. Profile 1 reflected relatively "desirable" levels of all factors, demonstrating the lowest risk of pain. Profile 2 exhibited the highest, and profile 3 the lowest levels of both demands and control with similar risks of pain, suggesting high levels of control were insufficient to buffer the impact of the combination of the other factors. Profile 4 exhibited "undesirable" levels of all factors and the highest risk, most notably for multi-site pain [odds ratio (OR) 2.32, 95% confidence intervals (CI) 1.80–2.85 compared with profile 1].

Conclusions Different compositions of psychosocial exposures were differentially related to pain. Future studies should take the complexity of work into account by studying comprehensive arrays of co-occurring work factors with health.

Key terms back pain; job control; job demand; latent class analysis; leadership; neck pain; occupational psychological factor; organizational climate; psychological factor; psychosocial; psychosocial work environment; site-specific pain; social factor; somatic pain.

Some of the most influential theories of occupational health psychology have highlighted multifactoriality. Both the job strain (1) and effort–reward imbalance (ERI) models highlight how *combinations* of factors influence health. However, only a limited number of factors – and factor combinations – are well studied. Building on the notion that the work environment comprises an ensemble of factors that may, as a whole, influence health, the current study examined typically experienced combinations of a comprehensive range of work factors. Furthermore, we wanted to determine whether employees reporting different exposure combinations also differed with respect to somatic pain complaints of six different anatomical sites.

Psychological work factors are thoroughly documented predictors of musculoskeletal pain [see eg, (2–4)]. This evidence pertains largely to factors of the job strain model predicting neck and back pain. The ERI model may be the second most influential model in the field, but a 2015 systematic review of prospective studies relating it to musculoskeletal complaints asserted that limited available evidence did not allow any reliable conclusion (5). Nevertheless, although a limited number of factors have been studied thoroughly, authors often discuss in rather general terms how pain relates to "the psychosocial work environment". However, the "underlying nature" of work is probably multifaceted and continuously changing (6, 7). To harness this complexity and determine its health impact, contemporary approaches to "the psychosocial work environment" may need to explore broader arrays of

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factors within each study. Recently, calls have been made specifically for more inductive explorative approaches to supplement the hypothetico-deductive approaches that have dominated occupational health psychology (8) in order to map out aspects of work that are not adequately captured by prevailing models.

Recent studies have reflected a growing interest in exposure combinations. For instance, one study investigated combined job strain and ERI with medically certified sickness absence due to mental health problems (9). Another study examined effects of combined low support, job strain, ERI, and high over-commitment on long-term sickness absence due to mental illness (10). Yet another study examined the impact of combined ERI and organizational injustice on self-rated health and psychiatric morbidity (11). All of these studies found that the risk associated with combined exposure was higher than the risk associated with each exposure separately. This implies that the studied models indeed represent different aspects of work that may converge and result in particularly aversive work situations.

All work factors co-occur with other work factors. Some of the complexity of work may be captured by considering how different aspects of it unfold together, capturing the "composition of the work situation". The net impact of such constellations of co-occurring work factors may not be readily deducible from separate effects of those factors, as there may be interactions involved. Thus, studying typical configurations of important work factors may provide more complete descriptions of working conditions and their consequences. The typical, real-life impact of co-occurring work factors may be obscured when they are studied separately or mutually adjusted. If a factor is typically a part of a *factor complex* with a substantial net impact on pain, studying that factor separately may conceal its contribution. And when the mutually adjusted unique explained variance is studied, results may not be directly applicable to most real world scenarios. Studying pre-specified combinations of exposure is possible to examine worst case scenarios ("bad jobs") or other combinations derived from specific theoretical models. However, relevant factor combinations may exist that are not known a priori, and the number of possible combinations may be vast with many exposure factors, especially if measured on a continuous scale.

When the aim is to obtain meaningful and manageable classifications of work exposure based on multiple factors, latent profile analysis (LPA) (12) is one appropriate – yet relatively novel – approach that reduces complexity while conserving a necessary level of detail. LPA is a *person-centered analysis* (13, 14) that identifies and characterizes groups of individuals exhibiting distinct patterns of variable levels. Hence, as opposed to variable-centered approaches which describe how *variables* relate to each other (eg, factor analysis), person-centered analyses are centered on the individual and maintain a system view where patterns of components are studied as a whole (15). An assumption is that the sample is heterogeneous, comprising multiple unobserved groups of individuals that share certain patterns of characteristics. After identifying such latent, unobserved groups they can be further examined to determine whether they also differ in other ways – in this case pain reports. Distinguishing between variable- and person-centered approaches may be highly significant to practice as studies have suggested that statements at the variable level rarely apply to the individual case (15).

Person-centered approaches to study have rarely been applied to examine psychological work factors, but some examples can be drawn from organizational psychology. One recent study of 548 managers in Sweden constructed a typology of psychosocial work situations by performing a cluster analysis of the factors *lack of resources*, *conflict of logics, employee conflicts, client conflicts, management support, employee support*, and *client recognition* (16). This resulted in eight distinct clusters of work situations exhibiting different combinations of those factors, which were in turn differentially related to subjective health and work ability. Such findings support the notion that pain can be influenced by the overall experienced work situation.

Unlike work factors, pain does not necessarily co-occur with other pain complaints. However, in practice pain is usually not confined to one specific anatomic site - reporting five or more pain sites has been found to be more common (17). Therefore, recent studies have examined multi-site pain (ie, reporting more than one painful anatomic site) and found it to be predictive of sickness absence (18) and work ability (19). Simply counting the number of painful anatomic sites has been suggested as an effective way of determining disability risk (19, 20). In order to gain a comprehensive overview of the implications of typical work situations for pain the current study included multiple pain sites, studying both separate pain complaints, multisite pain and an index of the number of pain sites.

The current study examined a range of work factors in order to determine how they co-occured and related to pain. The selected factors were all chosen due to their relevance to somatic well-being (21, 22). Some of the factors, eg, job demands and control, are well-established contributors to somatic health while others have been more commonly studied with psychological states, motivation, and satisfaction. However, all of them are specific factors that should be amenable to practical organizational change efforts. Describing typical combinations of work factors should provide general knowledge of how work is experienced and the typical impact that experience has on health. To do this we analyzed data from a large sample of employees of Norwegian companies collected twice with a follow-up period of two years. Multiple validated scales of work factors covering a broad range of psychological challenges and resources associated with job, tasks, and organization, were studied. As is common with LPA, the approach was exploratory (23) in the sense that no specific hypotheses were formulated beyond the notion that different psychological work situations may exert different levels of risk.

Methods

Sampling procedure

The study comprised two waves of data collection over 24 months (mean and median time lag 23 months, range 17–36). Web-based questionnaires were employed for work environment surveys in a wide range of Norwegian companies between 2004 and 2012 (T1) and 2006 and 2014 (T2). Surveys were conducted in collaboration with the companies and they received reports of results to help monitor working conditions. Presentations were given prior to the surveys to inform about study aims and ensure participants were aware of procedures for confidential treatment of information. The survey covered a range of physical, psychological, and organizational factors and health outcomes. Information was treated confidentially in accordance with a specific permission given by the Norwegian Data Inspectorate and information about the permission and the procedures for ensuring confidentiality were disseminated throughout the participating companies. Participation was voluntary after informed consent. The Regional Committees for Medical and Health Research Ethics (REK) in Norway approved the project.

Study population

Subjects were recruited from 62 companies, comprising 742 departments. At the time of the analyses, 14 586 employees had been invited to participate at both T1 and T2. Of these, 9846 (67.5%) provided information about at least one of the study variables at T1, and 6659 (67.6% of those who responded at T1, 45.7% of those invited at both measurement occasions) also provided information about all pain sites at T2, which was necessary to compute the number of pain sites variable.

Analyses were based on full information maximum likelihood (FIML) allowing missing information for dependent variables (in this case the number of pain sites variable at T2 and each work factor at T1, see figure 1), but not for covariates in the model (ie, sex, age, skill level, and T1 number of pain sites). Since the number of pain sites was an outcome variable, we excluded subjects that did not return information about all of the included pain items at T2. Thus, 484 subjects were excluded due to missing information about covariates, pain sites at T2, or no information about work factors at T1, resulting in a final effective study sample of 6175 employees (62.7 % of T1 responders, 42.3 % of employees invited to participate at both T1 and T2).

Outcome variables

Pain complaints were measured as the reported intensity of pain in six anatomic regions: neck, shoulder, back, arm, leg, and head. Subjects were presented a list of various symptoms and asked if they had experienced them during the previous four weeks. Each question was phrased "have you been bothered by ". . . (eg, neck pain) . . . in the last 4 weeks?" Response alternatives were: (i) "not bothered", (ii) "a little bothered", (iii) "rather intensely bothered", and (iv) "very intensely bothered".

The number of pain sites scale was constructed by dichotomizing each pain item to "0 = not troubled" and "1 = troubled" and then summing up the number of regions for which each subject reported the presence of pain. For analyses with single pain sites as outcomes, the dichotomized variables were used. For multi-site pain, a dichotomous variable was constructed that reflected the presence of more than one pain site versus one or none.

Exposure variables

Psychological and social work factors were assessed with the General Nordic Questionnaire for Psychological and Social Factors at Work (QPSNordic) (21), an established, validated instrument comprising specific work factors of

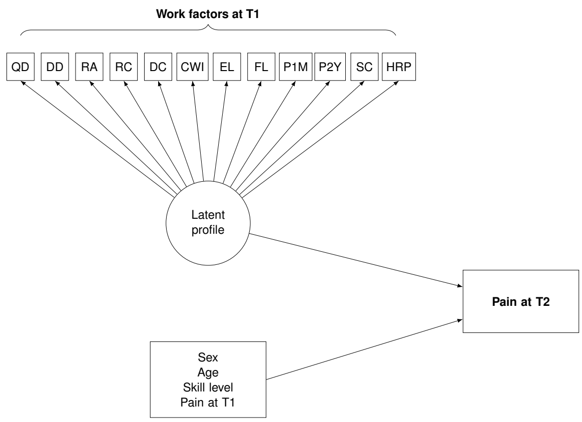

Figure 1. The general conceptual model of the current study. Profiles of occupational psychological factors and pain. [QD=quantitative demands; DD=decisional demands; RA=role ambiguity; RC=role conflict; DC=decision control; CWI=control over work intensity; EL=empowering leadership; FL=fair leadership; P1M=predictability next month; P2Y=predictability next 2 years; SC=social climate; HRP= human resource primacy.]

demonstrated relevance to somatic health. The QPSNordic was developed for research as well as practical organizational change efforts. Twelve specific factors were chosen for the current study, covering six more general themes; job demands, job control, role expectations, leadership, predictability, and organizational climate. A brief description of each factor is given in table 1.

Covariates

Age, sex, skill level, and the relevant pain measure (ie, T1 back pain when T2 back pain was the outcome) at T1 were entered as predictors in all regressions. Age was treated as continuous. Skill levels were defined in accordance with classifications of occupations reported by the companies. These classifications were a Norwegian adaptation of the International Standard Classification of Occupations (ISCO-88), classifying jobs into groups reflecting the tasks and duties typically undertaken. Level of education or equivalent working experience required for the job is also reflected by the ISCO-88, based on the International Standard Classification of Education (ISCED). Thus, skill level categories reflect occupations that normally require "1 = first or postgraduate university degree or college exams of similar level (>16 years of education)", "2 = 1–3 years of college/university education (13–15 years)", "3 = 1–3 years of secondary education (10–12 years)", "4 = primary education (<9 years)", and "5 = unspecified competence level (ie, occupations with no formally required education level)".

Statistical analysis

All analyses were conducted with Mplus 7.4 (24) and R version 3.3.1 (25).

The first objective was to identify different profiles of working conditions. Latent profile analysis (LPA) (12) was employed to obtain "natural" profiles of working conditions by classifying employees according to their similarity of the combination of work factors at T1. Similar to cluster analysis, LPA assumes unobserved sample heterogeneity that can be described by identifying groups of related cases. These groups are latent, ie, not directly observed, but statistically inferred. Unlike traditional cluster analysis, LPA accounts for measurement error due to the groups being inferred rather than observed. This is done by assigning each person a probability of membership of each profile group based on their pattern of observations. Further analyses where the latent profiles are considered independent variables take this uncertainty into account.

LPA specifies a nominal variable representing the "latent profiles" to explain the underlying correlational structure of the observed indicators. Thus, the model is estimated in a way that minimizes covariances between items within profile groups so that differences between individuals are mainly accounted for by the profile groups they belong to (23). The procedure starts with profile enumeration – determining the appropriate number of latent profiles to extract (26). This is done by estimating a model with one latent profile and thereafter adding successive latent profiles until there are no conceptual or empirical improvements of the model. A number of indices were considered in order to judge the fit of the estimated models; Akaike information criterion (AIC), the Bayesian information criterion (BIC), Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR), and the Lo-Mendell-Rubin adjusted likelihood ratio test (LMR) (26, 27). Smaller values for AIC and BIC and P-values of <0.05 for the likelihood ratio tests support

Table 1. Short descriptions of the content covered by each psychological work factor included in the current study.

Theme	Factor	No of items	Cronbach's α	Description
Demands	Quantitative demands	4	0.75	Time pressure and amount of work
	Decisional demands	3	0.63	Demanded attention and quick and complex decisions
Role expectations	Role ambiguity	3	0.80	Lack of clarity of objectives and expectations at work
	Role conflict	3	0.71	Incompatible requests, demands without resources, illegitimate tasks
Job control	Decision control	5	0.72	Influence on decisions affecting one's work tasks, choice of co-workers and clients
	Control over work intensity	4	0.81	Influence on pacing, breaks, and time
Leadership	Empowering leadership	3	0.88	Encouragement to participate in important decisions, to express divergent opinions, and develop one's skills
	Fair leadership	3	0.80	Degree to which the immediate superior distributes work fairly and treats workers equally
Predictability	Predictability next month	3	0.64	Stability of and knowledge about future tasks, co-workers, and superiors
	Predictability next two years	2	0.90	Knowledge about requirements for future employment and employability
Organizational climate	Social climate	3	0.72	Whether the social context is encouraging/supportive, distrustful/suspicious, relaxed/comfortable
	Human resource primacy	3	0.76	The degree to which the organization is seen as genuinely concerned with employee welfare and health

the notion that a model with k profiles fits better than a model with k-1 profiles. Thus, based on statistical criteria alone, the enumeration process should stop when the BIC and AIC stop decreasing and/or the VLMR and LMR become non-significant. However, statistical tests only aid the process of enumeration, the final judgment ultimately relies on the analyst's judgment of utility and parsimony of the resultant profile groups (23, 26). For instance, very small or very similar profile groups may not add useful information.

The second objective of the study was to determine relationships of latent profiles with pain complaints. Separate regression models were estimated for each pain outcome, with covariates and outcomes added after profile enumeration. Hence, pain at T2 was regressed on latent profiles at T1 as well as sex, age, skill level, and the respective pain variable at T1. These conditional models were specified using a manual three-step approach, as outlined by Asparouhov & Muthen (27). This approach enables the researcher to first estimate the latent profile model and then add covariates and outcomes without affecting the latent profiles. In other words, the outcome variables (pain) are treated as conceptually separate from the measurement model and not used to determine the latent profiles.

Associations between latent profile membership and subsequent pain were tested with binary logistic regression when single-site pain complaints or multi-site pain were outcomes. For the number of pain sites, variable Poisson regressions were used to estimate intercepts varying across latent profile groups. These intercepts were then compared using Wald chi-square tests to determine if they differed between groups. All regressions were adjusted for age, skill level, sex, and the corresponding pain outcome at T1. Such baseline adjustment should partial out cross-sectional associations between exposure and outcome at baseline, thereby reducing the likelihood of spurious or reverse causation affecting results. However, it may also partial out cross-sectional association that is due to substantive effects of exposure on outcome at or prior to baseline, and may thus constitute over adjustment. Therefore, analyses were also run without baseline adjustment.

Since analyses were based on data from subjects clustered in departments/units, all analyses were adjusted for the possible biasing effect of correlated responses within units by utilizing a sandwich estimator (28). Individuals who share context may be more similar to each other than other individuals with respect to both exposure and outcome, irrespective of any substantive exposure–outcome effect. This implies that responses from a number of individuals of a department may provide less information about the exposure–outcome association than responses from the same number of independent individuals. Therefore, confidence intervals should be adjusted for this dependency to minimize the risk of type 1 error. The sandwich estimator ensures this, and is also robust to non-normality.

Results

Sample characteristics

As seen in table 2, the sample consisted of 54.9 per cent females, with mean age 44.7 years at T1. The three largest occupational groups were professionals (28.6%), service and sales workers (27.3%), and technicians and associate professionals (23.2%). The majority of participants were distributed across the three highest skill levels, with 28.6% for positions normally reflecting >15 years of education, 23.2% for 13–15 years, and 36.1% for 10–12 years. The most common pain complaints were for the neck (48.6%) and head (48.2%), and the least common was arm pain (23.6%). The most common number of pain sites was 2 (19.6%), and 17.3% reported no pain site of the ones that were assessed. Multi-site pain was experienced by 64.5% of participants.

As shown in table 3, the probability of completing the questionnaire at T1 was higher with age [odds ratio (OR) 1.01, 95% confidence interval (CI) 1.01–1.02], for women (OR 1.19, 95% CI 1.13–1.26), and for skill levels "13–15 years" (OR 1.18, 95% CI 1.09–1.27), "10–12 years" (OR 1.08, 95% CI 1.01–1.16), and "managers and unspecified" (OR 1.27, 95% CI 1.14–1.41) compared to ">15 years".

Table 3 also shows associations of the study variables with response at T2 among T1 participants. Age and skill level were related to T2 participation, with OR ranging from 0.57 (95% CI 0.36–0.90) for skill level "<10 years" versus ">15 years" to 1.57 (95% CI 1.21–1.52) for skill level "10–12 years" versus ">15 years". Of the 12 work factors, 7 were associated with participation at T2, with OR ranging from 0.86 (95% CI 0.81–0.92) for quantitative demands to 1.25 (95% CI 1.18–1.32) for predictability next month. Sex and pain complaints were not associated with participation at T2.

Profile enumeration

The lowest AIC and BIC were observed for a five-profile solution (supplemental table S1, www.sjweh.fi/show_abstract.php?abstract_id=3706). However, the VLMR and LMR were non-significant for the five-profile solution. Inspection of the five-profile solution revealed that the main difference from the four-profile solution was that one of the groups split into two with similar patterns but slightly different levels of exposure. Hence, the more parsimonious four-profile solution was retained for further analyses.

Table 2. Baseline descriptives for the total sample (N=6175). [SD=standard deviation.]

	N	%	Mean	SD
Demographics				
Female	3393	54.9		
Age			44.7	10.1
Skill level (years)				
>15	1763	28.6		
13–15	1432	23.2		
10–12	2227	36.1		
<10	53	0.9		
Managers & unspecified	700	11.3		
Occupation				
Armed forces & unspecified	2	0.0		
Clerical support	306	5.0		
Craft and related trades	229	3.7		
Elementary occupations	53	0.9		
Managers	698	11.3		
Plant & machine operators, assemblers	3	0.0		
Professionals	1763	28.6		
Service & sales	1687	27.3		
Skilled agricultural forestry & fishery	2	0.0		
Technicians & associate professionals	1432	23.2		
Individual pain sites				
Neck	3003	48.6		
Headache	2975	48.2		
Back	2720	44.0		
Shoulder	2687	43.5		
Leg	1630	26.4		
Arm	1460	23.6		
Number of pain sites				
0 (Pain-free)	1071	17.3		
1 (Single-site pain)	1121	18.2		
2	1209	19.6		
3	1160	18.8		
4	855	13.8		
5	518	8.4		
6	241	3.9		
>0 (Any pain)	5104	82.7		
>1 (Multi-site pain)	3983	64.5		
>2	2774	44.9		
>3	1614	26.1		
>4	759	12.3		
>5	241	3.9		

Table 4 shows the overall and profile-conditional means and variances of all work factors and the number of subjects assigned to each group. N varied between 1200 (19.4%, profile 4) and 1930 (31.3%, profile 2). Figure 2 gives a graphical overview of the profiles. Decisional and quantitative demands exhibited little difference between groups, while empowering leadership seemed to vary the most between groups, from 2.07 (profile 4) to 4.14 (profile 1). A deliberate choice was made not to name the profiles, beyond assigning a number from 1 to 4. However, profile 1 reflected scores that may be considered desirable for all factors (relative to the other profiles) – ie, low demands, low role stressors, high control, empowering and fair leadership, high predictability, and high levels of social climate and human resource primacy. Conversely, profile 4 exhibited scores that may be considered adverse for all factors.

Table 3. Multivariable binary logistic regressions estimating associations of study variables with participation in the survey at baseline among all invited and at follow-up among those who participated at T1. [OR=odds ratio; CI=confidence interval.]

	Participation at T1		Participation at T2 (T1 responders)	
	OR	95% CI	OR	95% CI
Age	1.01	1.01–1.02	1.01	1.01–1.02
Skill level (years)				
>15	Ref		Ref	
13–15	1.18	1.09–1.27	0.87	0.78–0.97
10–12	1.08	1.01–1.16	1.36	1.21–1.52
<10	0.82	0.63–1.05	0.57	0.36–0.90
Managers & unspecified	1.27	1.14–1.41	1.03	0.90–1.19
Sex				
Male	Ref		Ref	
Female	1.19	1.13–1.26	1.01	0.93–1.10
Work factors				
Quantitative demands			0.86	0.81–0.92
Decision demands			1.02	0.96–1.09
Role ambiguity			1.02	0.96–1.08
Role conflict			1.17	1.11–1.25
Decision control			1.07	1.00–1.14
Control over work intensity			1.12	1.06–1.18
Empowering leadership			1.10	1.05–1.16
Fair leadership			0.96	0.90–1.03
Predictability next month			1.25	1.18–1.32
Predictability next 2 years			0.95	0.92–0.99
Social climate			1.08	1.01–1.16
Human resource primacy			0.98	0.93–1.04
Pain complaints				
Head			1.08	0.99–1.17
Neck			1.07	0.97–1.17
Shoulder			0.97	0.89–1.06
Arm			0.93	0.84–1.02
Back			0.94	0.86–1.02
Leg			0.94	0.86–1.03

Profile 2 exhibited relatively high demands and control, with medium levels of the remaining factors. Profile 3 exhibited low demands and control, with medium levels of the other factors. Overall, in absolute terms, levels of demands were towards the midpoint of the scale while role stressors tended to be below the midpoint and control, leadership, predictability, and social climate tended to be above the midpoint.

Latent profile group predictors

In order to determine the characteristics of the different latent profile groups, they were regressed on age, sex, and skill level. Compared to profile 4, women were more likely to be classified into profile 1 and profile 3 (OR 1.61, 95% CI 1.30–2.00 and OR 1.38, 95% CI 1.11–1.71, respectively) and less likely to belong to profile 2 (OR 0.80, 95% CI 0.65–0.98) (supplemental table S2, www.sjweh.fi/show_abstract.php?abstract_id=3706). Age was not statistically significantly associated with latent profiles. Compared with the highest skill level (>15 years), the four lower skill levels (ie, 13–15,

Table 4. Means and variances of work factors for the total sample and within each latent profile group (N=6175).

	Total sample	Within groups			
		Profile 1 (N=1319) 21.4%	Profile 2 (N=1930) 31.3%	Profile 3 (N=1726) 28.0%	Profile 4 (N=1200) 19.4%
	Mean (variance)	Mean (variance)	Mean (variance)	Mean (variance)	Mean (variance)
Quantitative demands	2.91 (0.56)	2.78 (0.56) [2,4]	3.10 (0.49) [1,3]	2.72 (0.45) [2,4]	3.02 (0.70) [1,3]
Decisional demands	3.48 (0.48)	3.46 (0.56)	3.50 (0.38)	3.46 (0.45)	3.49 (0.61)
Role ambiguity	1.78 (0.52)	1.31 (0.15) [2,3,4]	1.94 (0.42) [1,3,4]	1.60 (0.25) [1,2,4]	2.31 (0.90) [1,2,3]
Role conflict	2.57 (0.63)	1.97 (0.45) [2,3,4]	2.57 (0.40) [1,4]	2.62 (0.49) [1,4]	3.15 (0.64) [1,2,3]
Decision control	3.04 (0.59)	3.43 (0.60) [3,4]	3.51 (0.29) [3,4]	2.61 (0.28) [1,2]	2.54 (0.47) [1,2]
Control over work intensity	3.31 (1.09)	3.64 (1.14) [2,3,4]	4.00 (0.34) [1,3,4]	2.62 (0.68) [1,2,4]	2.91 (1.06) [1,2,3]
Empowering leadership	3.20 (1.04)	4.14 (0.48) [2,3,4]	3.41 (0.64) [1,3,4]	3.07 (0.57) [1,2,4]	2.07 (0.61) [1,2,3]
Fair leadership	3.98 (0.68)	4.74 (0.10) [2,3,4]	4.02 (0.33) [1,4]	4.04 (0.31) [1,4]	3.00 (0.81) [1,2,3]
Predictability next month	4.17 (0.55)	4.63 (0.15) [2,3,4]	4.32 (0.23) [1,3,4]	3.99 (0.63) [1,2,4]	3.71 (0.88) [1,2,3]
Predictability next 2 years	3.13 (1.28)	3.56 (1.29) [2,3,4]	3.34 (0.97) [1,3,4]	2.92 (1.19) [1,2,4]	2.64 (1.34) [1,2,3]
Social climate	3.79 (0.55)	4.48 (0.18) [2,3,4]	3.79 (0.32) [1,4]	3.80 (0.32) [1,4]	3.04 (0.56) [1,2,3]
Human resource primacy	3.10 (0.79)	3.95 (0.41) [2,3,4]	3.27 (0.39) [1,3,4]	2.99 (0.46) [1,2,4]	2.07 (0.39) [1,2,3]

1,2,3,4 signifies which of the other latent profile means a latent profile mean differs statistically significantly from, according to a Wald test. For instance, for profile 1 the mean of quantitative demands is 2.78 (variance 0.56), which is statistically significantly different from the means of profiles 2 and 4.

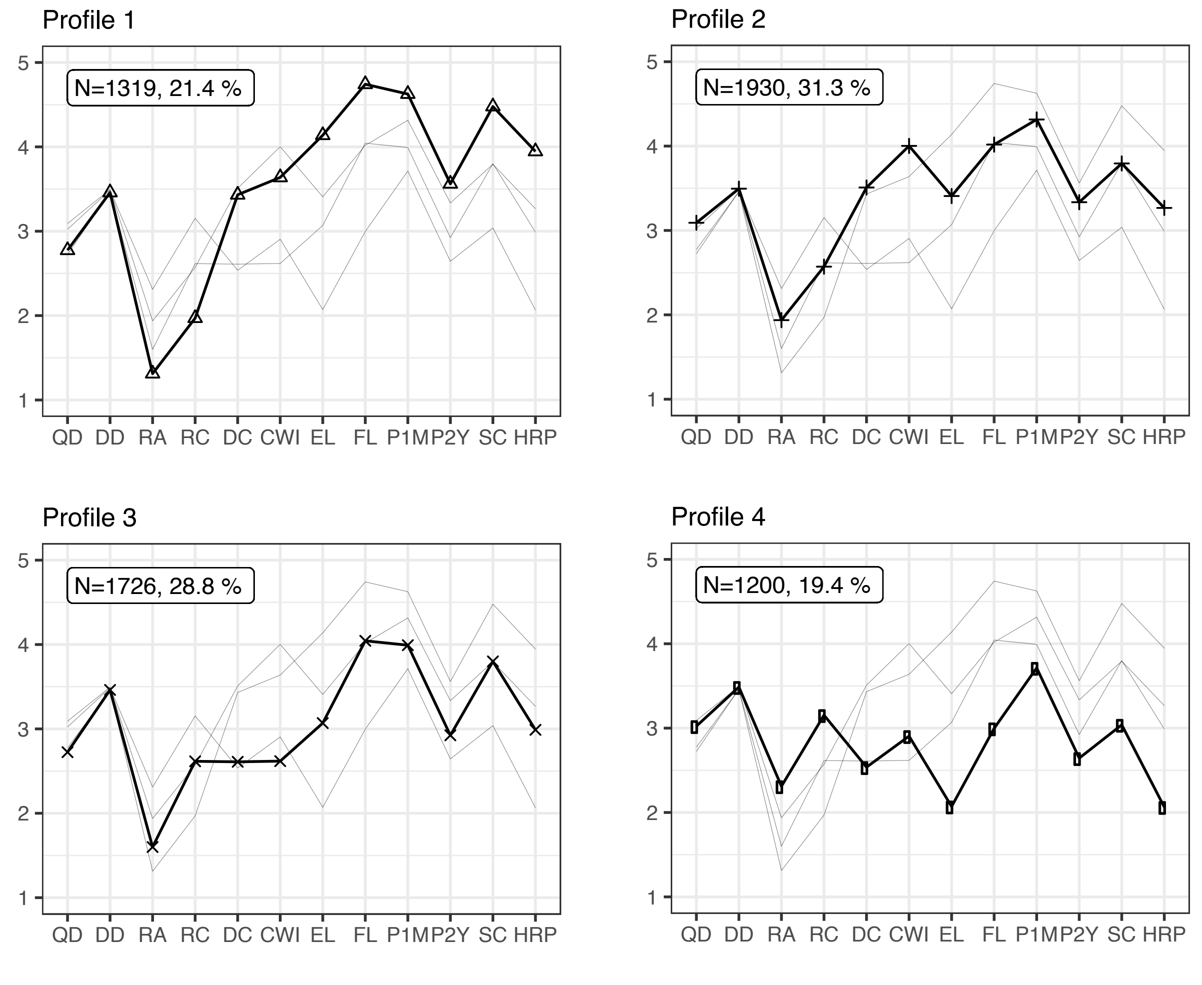

Figure 2. Profile plots of estimated means of the measured work factors within each latent profile group (N=6175). To enhance readability while ensuring comparability all latent profiles are plotted four times, which each separate frame emphasizing a different latent profile. [QD=quantitative demands; DD=decisional demands; RA=role ambiguity; RC=role conflict; DC=decision control; CWI=control over work intensity; EL=empowering leadership; FL=fair leadership; P1M=predictability next month; P2Y=predictability next 2 years; SC=social climate; HRP=human resource primacy.]

10–12, and <10 years) were associated with lower likelihood of belonging to profiles 1 and 2 (statistical significant OR ranging from 0.11–0.67) and higher likelihood of belonging to profile 3 than profile 4 (statistically significant OR ranging from 3.03–4.34) (see supplemental table S2 www.sjweh.fi/show_abstract.php?abstract_id=3706). The "unspecified" category was associated with higher likelihood of being in profiles 1 and 2 (OR 3.32 and 2.27, respectively).

Pain differences between latent profile groups

The latent profile groups exhibited differences in the expected number of pain sites count, with profile 1 exhibiting the lowest count (1.85) and profile 4 the highest (2.07) (table 5). Wald Chi-square tests revealed statistically significant differences in expected pain counts between profiles 1 and 3, 1 and 4, 2 and 4, and 3 and 4 (see table 5).

Binary logistic regressions revealed that the risk of all pain complaints at T2 varied between latent profiles as estimated at T1 (see table 6). The analyses that were not adjusted for baseline outcome exhibited stronger effects, but the patterns of associations were very similar. All statistically significant effects were positive, with profile 4 exhibiting the highest risk when compared with profile 1. Overall, statistically significant ORs ranged from 1.23 (baseline-adjusted: 95% CI 1.02–1.49) for back pain comparing profile 3 with profile 1 to 3.27 (not baseline-adjusted 95% CI 2.62–3.91) for multi-site pain comparing profile 4 with profile 1. For all pain complaints profile 4 exhibited statistically significant increased risk when compared to the three other profiles – with the exception of baseline-adjusted shoulder pain, for which the comparison of profile 4 with profile 3 was not statistically significant (OR 1.24, 95% CI 0.99–1.57). Profile 1 exhibited the lowest probability of pain for all pain measures. However, for baseline-adjusted analyses, only multi-site pain exhibited effects that were statistically significant for all profile groups compared with profile 1. Profile 2 and 3 exhibited similar levels of risk, with no statistically significant differences in odds, regardless of baseline adjustment.

Table 5. Expected counts[a] of number of pain sites at T2 for the different latent profile groups (N=6175)

Latent profile	Expected NPS	Wald χ^2 (P-value)	Wald χ^2 (P-value)	Wald χ^2 (P-value)
1	1.85	ref		
2	1.95	3.85 (0.05)	ref	
3	1.99	9.27 (0.00)	0.92 (0.34)	ref
4	2.07	24.21 (0.00)	8.79 (0.00)	4.094 (0.04)

[a] Computed by Poisson regressions, evaluated at mean age and number of pain sites at T1 for a male of the lowest skill level. Differences between expected counts were tested by a Wald chi-square test of parameter equalities.

Discussion

The current study convincingly demonstrated a strong and consistent link between different types of work situations – defined by the interrelationships of 12 psychological/social work factors – and different pain complaints as well as the number of pain complaints and the presence of multi-site pain. This link was particularly evident when comparing profile groups 1 and 4. Profile 1 was characterized by low levels of demands and role stressors, high control, empowering and fair leadership, high predictability, a positive social climate, and perceptions of the organization as engaged in employee health and well-being (ie, human resource primacy) (see figure 2). Profile 4 may be seen as an opposite to profile 1, reflecting higher demands and role stressors with lower control, less empowering and fair leadership, lower predictability, less positive social climate, and lower human resource primacy. The work factors exhibiting the least difference between profile groups 1 and 4 were quantitative and decisional demands. These factors are among the most studied predictors of musculoskeletal pain, usually as part of a broader dimension ("job demands"). However, despite relatively similar demands, the risk of pain was markedly different between profiles 1 and 4, suggesting the relative contribution of the other work factors to the risk of pain was substantial.

While profiles 1 and 4 diverged on all factors except decisional demands, profiles 2 and 3 exhibited comparable, medium levels of most factors except job control. Profile 2 exhibited the highest control of the sample whereas profile 3 exhibited the lowest. Control, particularly over decisions, has been consistently linked to attenuated risk of pain [see eg, (2, 3)]. Nevertheless, the risk of pain was very similar for profiles 2 and 3 (see table 6), suggesting the higher control of profile 2 was insufficient to buffer the impact of the co-occurring levels of exposure. For instance, the probability of neck pain was identical for the two profiles, with the adjusted OR even suggesting risk might be *higher* with higher levels of control (OR for profile 2 versus 1: 1.29, 95% CI 1.05–1.59, OR for profile 3 versus 1: 1.13, 95% CI 0.91–1.41), although the difference between profiles 3 and 2 was not statistically significant (OR 0.88, 95% CI 0.70–1.10) (table 6). Hence, for work situations reflected by these profiles, a simple assessment of job control may not be sufficiently informative about the risk of neck pain.

Although levels of quantitative demands were similar for all profiles, Wald Chi-square tests revealed statistically significant differences of profiles 1 and 3 with profiles 2 and 4 (table 4). Hence, keeping in mind that differences were limited and absolute values were close to the midpoint of the scale, some observations can be made about combinations of demands and control that

Table 6. Binary logistic regressions comparing the odds of different pain complaints at T2 between latent profile groups estimated at T1. Regressions were run comparing all four profile groups and with and without adjustment for the corresponding pain measure at T1 (N=6175). **Statistically significant odd ratios (OR) are given in bold font**. [CI=confidence interval.]

Pain complaint	Latent profile	Probability of pain	Analyses without adjustment for pain at T1			Analyses with adjustment for pain at T1		
			OR [a] (95% CI)	OR [a] (95% CI)	OR [a] (95% CI)	OR [a] (95% CI)	OR [a] (95% CI)	OR [a] (95% CI)
Headache	1	0.39	Ref			Ref		
	2	0.44	1.35 (1.09–1.61)	Ref		1.17 (0.95–1.43)	Ref	
	3	0.48	**1.44 (1.17–1.71)**	1.07 (0.84–1.29)	Ref	**1.25 (1.02–1.54)**	1.08 (0.86–1.35)	Ref
	4	0.57	**2.33 (1.91–2.75)**	**1.73 (1.39–2.06)**	**1.62 (1.33–1.92)**	**1.73 (1.42–2.11)**	**1.49 (1.21–1.83)**	**1.38 (1.12–1.70)**
Neck	1	0.42	Ref			Ref		
	2	0.48	**1.51 (1.23–1.78)**	Ref		**1.29 (1.05–1.59)**	Ref	
	3	0.48	1.33 (1.06–1.59)	0.88 (0.71–1.05)	Ref	1.13 (0.91–1.41)	0.88 (0.70–1.10)	Ref
	4	0.59	**2.41 (1.98–2.84)**	**1.60 (1.32–1.87)**	**1.81 (1.48–2.15)**	**1.63 (1.33–2.01)**	**1.27 (1.04–1.54)**	**1.44 (1.16–1.79)**
Back	1	0.37	Ref			Ref		
	2	0.40	1.19 (0.95–1.44)	Ref		1.07 (0.86–1.33)	Ref	
	3	0.46	**1.37 (1.13–1.60)**	1.15 (0.92–1.38)	Ref	**1.23 (1.02–1.49)**	1.15 (0.94–1.42)	Ref
	4	0.53	**1.95 (1.61–2.30)**	**1.64 (1.34–1.94)**	**1.43 (1.19–1.67)**	**1.57 (1.29–1.91)**	**1.47 (1.19–1.81)**	**1.27 (1.04–1.55)**
Shoulder	1	0.39	Ref			Ref		
	2	0.42	**1.28 (1.04–1.53)**	Ref		1.09 (0.88–1.34)	Ref	
	3	0.47	**1.47 (1.20–1.73)**	1.14 (0.91–1.38)	Ref	**1.30 (1.06–1.59)**	1.20 (0.96–1.49)	Ref
	4	0.55	**2.14 (1.75–2.53)**	**1.67 (1.36–1.98)**	**1.46 (1.16–1.76)**	**1.61 (1.31–1.98)**	**1.49 (1.22–1.81)**	1.24 (0.99–1.57)
Arm	1	0.19	Ref			Ref		
	2	0.23	**1.40 (1.08–1.71)**	Ref		1.23 (0.97–1.54)	Ref	
	3	0.23	**1.32 (1.03–1.61)**	0.95 (0.74–1.15)	Ref	1.16 (0.92–1.45)	0.94 (0.76–1.17)	Ref
	4	0.32	**2.25 (1.82–2.68)**	**1.61 (1.30–1.92)**	**1.70 (1.36–2.04)**	**1.73 (1.41–2.11)**	**1.41 (1.15–1.72)**	**1.49 (1.21–1.84)**
Leg	1	0.22	Ref			Ref		
	2	0.25	1.21 (0.96–1.46)	Ref		1.23 (0.99–1.53)	Ref	
	3	0.31	**1.49 (1.21–1.77)**	1.23 (0.99–1.48)	Ref	**1.36 (1.12–1.66)**	1.10 (0.89–1.37)	Ref
	4	0.36	**1.84 (1.50–2.19)**	**1.52 (1.24–1.81)**	**1.24 (1.00–1.48)**	**1.70 (1.40–2.05)**	**1.38 (1.13–1.68)**	**1.25 (1.02–1.53)**
Any pain	1	0.76	Ref			Ref		
	2	0.81	**1.52 (1.18–1.85)**	Ref		1.21 (0.95–1.55)	Ref	
	3	0.85	**1.83 (1.39–2.26)**	1.20 (0.87–1.54)	Ref	**1.43 (1.09–1.87)**	1.18 (0.88–1.59)	Ref
	4	0.90	**3.09 (2.32–3.87)**	**2.04 (1.47–2.60)**	**1.69 (1.21–2.18)**	**2.21 (1.69–2.88)**	**1.82 (1.36–2.44)**	**1.54 (1.15–2.08)**
Multi-site pain	1	0.53	Ref			Ref		
	2	0.63	**1.71 (1.39–2.03)**	Ref		**1.49 (1.20–1.86)**	Ref	
	3	0.66	**1.78 (1.45–2.11)**	1.04 (0.84–1.25)	Ref	**1.45 (1.16–1.82)**	0.97 (0.78–1.21)	Ref
	4	0.76	**3.27 (2.62–3.91)**	**1.91 (1.51–2.32)**	**1.84 (1.43–2.24)**	**2.32 (1.85–2.92)**	**1.56 (1.23–1.97)**	**1.60 (1.24–2.06)**

[a] Calculated from binary logistic regressions, adjusted for age, sex, skill level.

may form a basis for hypotheses to be tested in future studies. In line with Karasek and Theorell, one could classify profile 1 as "low strain'' (low demands, high control), profile 2 as "active jobs'' (high demands, high control), profile 3 as "passive jobs'' (low demands, low control), and profile 4 as "high strain'' (high demands, low control). The fact that profiles 1 and 4 exhibited the lowest and highest risks of all pain complaints, respectively (see table 6), is consistent with expectations derived from the job strain model. However, the similar health risk for "active'' and "passive jobs'' may be less expected, since active jobs have been hypothesized to be salutogenic and promote personal growth, mastery and self-efficacy (29). Thus, it appears that the general similarity of profiles 2 and 3 with respect to the other measured factors provides more information about the risk of pain than their levels of demands and control. An interesting implication could be that other factors typically accompanying high demands and low control, such as frequent role stress, lack of empowering and fair leadership, predictability, and a poor social climate, may actually play an equally important role in employee health in typical work scenarios.

Another observation that can be made with reference to the job strain model is that profile 2 exhibited relatively high quantitative demands combined with relatively high role conflict, whereas profile 3 exhibited low demands with high role conflict. The general dimension of job demands as operationalized in the job content questionnaire group those factors together (30). Hence, while high demands and role conflict may be particularly straining, the current results suggested that for many employees quantitative demands are relatively low while role conflict is high and coinciding with other adverse work factors. Hence, a profile of specific factors may convey important information that is obscured by reducing those factors into one general score. This should highlight the utility of the current approach in studying work as a system of integrated components.

A four-profile solution is a fairly general classification and thus one should keep in mind that it does not capture and describe all possible combinations of the work factors that actually occur. The aim was to describe working situations as they typically appear in contemporary work life rather than to impose an arbitrary, pre-defined classification. As such, an important general contribution of the current study is to demonstrate the impact work situations *typically* have on employees. Thus, while effect sizes observed when comparing the current profiles may not seem particularly salient compared to previous studies, one must take into account the general nature of the classification. Hence, the fact that the odds of multisite pain are 2.32 times higher for group 4 than group 1 (table 6) is quite noticeable. The exposure contrast is relatively moderate, but one way in which the results could be utilized is as a starting point for developing future exposure classifications with enhanced contrast.

Many other factors could be studied in the same way in future studies in order to further extend the repertoire of factors that may contribute to work situations influencing pain. Some previous studies have investigated effects of combined biomechanical and psychological/ social work exposure, but typically cross-sectionally with broad summary indices of exposure (31, 32). Such approaches may be effective if included exposures exert similar and additive effects, but the current study reflects no such assumption. Rather, combined exposure is viewed as categorical, allowing qualitative as well as quantitative differences in exposure (ie. the same "sum" may represent different patterns of exposure). Also a strength of the current approach was that while the combination of factors was considered a nominal variable, each factor was treated as continuous. Hence, rather than estimating effects of combinations of categorized exposures (eg, "high" versus "low" demands) in pre-specified subgroups of employees (eg, a very small group exhibiting "high" levels of all 12 factors), the latent profile approach grouped employees according to similarities of mean levels of the included work factors. This facilitated a comprehensive and yet comprehensible overview of types of work situations and their relationship with musculoskeletal health.

Methodological considerations

A typical limitation of panel studies is that measurements are taken only at a few discrete time points, placing specific constraints on interpretation of results within the studied timeframe. The follow-up period must then match the timing of the "wellness-to-illness" transition, which is difficult to ensure when pathogenic processes are unknown. Several aspects of this transition may affect results, such as duration of exposure necessary to produce health effects, duration of health effects (if reversible) after cessation of exposure, and the time period between sufficient exposure and manifestation of a health effect. As neural regions processing social/emotional- and somatic pain may overlap (33), affective responses to working conditions could provoke immediate changes in appraisal of somatic sensations. However, long-term effects could result from dysregulation of neuroendocrine systems that mediate inflammation (34). But, as the nature of the processes involved remains obscure, one cannot know whether the currently observed effects would have manifested differently given a different timeframe. In addition, baseline adjustment for the outcome is likely to constitute over adjustment since processes connecting work and pain may have been in effect already at the first measurement. Thus, effect estimates may be conservative and specific to the timeframe of the study.

Organizations were not recruited by random sampling. The problem of not knowing to whom results apply (external validity) may be attenuated by the diversity of the large sample. Nevertheless, sample characteristics should be kept in mind when interpreting results. Non-response may also affect internal validity, ie, the degree to which observed associations reflected causal processes. However, rather than dismissing evidence on the basis of participation rates alone, one should consider possible reasons for non-response (36). If participation is a common effect of exposure and health, independently of each other, associations may differ spuriously between respondents and non-respondents (35). Attrition analyses suggested that participation was related to some work factors, but not pain. One concern participants commonly communicated was that the questionnaire was time-consuming, and response rates declined gradually throughout the questionnaire, suggesting a "fatigue effect" rather than selection based on item content.

One limitation of the study may be that subjects reported pain referring to the previous four weeks. Recall bias may have affected pain reports since subjects recalled rather than recorded pain as it occurred (37). However, some previous research has suggested that individuals can accurately recall pain for up to three months (38), and it should be kept in mind that participants were not asked to report a specific number of pain occurrences, but rather the degree to which they had experienced pain the previous month.

The present study adjusted for baseline levels of outcome as well as skill level, age, and sex. Nevertheless, the possibility of unmeasured confounding should be kept in mind. For instance, physical exposure may differ between latent profiles. However, skill level adjustment should account for some occupational differences in mechanical load, and as seen in supplemental table S2 there were strong associations between latent profile membership and skill level, suggesting it was appropriate to adjust for this variable.

Studies based exclusively on self-report face limitations due to all information being collected from one source ["common method bias" (39)]. For instance, subjects prone to negative affect may report independent and dependent variables in a similar way, which may inflate associations. Baseline adjustment for the outcome should attenuate such bias if it is stable, by partialing out the cross-sectional part of the exposure-outcome association. Also, communicating respondent anonymity should reduce such bias (39), and this was prioritized during the survey administration. Moreover, the QPSNordic questionnaire has been extensively validated and was constructed with the specific aim of counteracting biases related to affective dispositions and states (21, 22). Nevertheless, future studies can be strengthened by including measurements derived from sources other than self-report, perhaps including them when estimating latent profiles.

Concluding remarks

The current results should be of interest to both scholars and practitioners. In practice, organizational members must continuously face complex arrays of specific levels of co-occurring factors. Any effort to enhance health by improving psychological working conditions should be undertaken with the understanding that while single factors may be important, the context they operate within should also be taken into account by considering other, co-occurring work factors. If not, interventions run the risk of failing even when they successfully target known contributors to health. Theoretically, the impact of alleviating risk factors could be counteracted by other factors that typically accompany them if these complementary risk factors are not responsive to the same intervention. Hence, for instance, when dealing with working conditions that resemble the "high exposure" profile 4 of the current study there should be an awareness that resolving a few of the problems in question may have limited effect. The current study should contribute to such an awareness of the interrelatedness of factors within the work environment. This may be particularly important in order to ensure a continued effort to improve working conditions even when results are seemingly absent.

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