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Safety climate as a predictor of work ability problems in blue-collar workers: Prospective cohort study

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Abstract

Objectives

To evaluate the prospective association between safety climate and work ability in blue-collar workers.

Methods

Blue-collar workers (n=3822) from the Danish Work Environment and Health study replied to questions on safety climate, physical and mental work ability, and health in 2012 and 2014. Using multivariate logistic regression, we estimated the association of number of safety climate problems (0-5) in 2012 with physical and mental work ability in 2014. Potential confounders included sex, age, socioeconomic class, occupational group, lifestyle (smoking habits and body mass index), and previous accidents.

Results

Compared to workers free from safety climate problems, workers reporting two and three safety climate problems, respectively, had higher risk for reporting reduced physical work ability in 2014 (OR 1.29, CI 95% 1.03–1.61 and 1.52, CI 95% 1.27–1.84, respectively). Similar findings were observed with mental work ability as outcome. Using number of safety climate problems as a continuous variable, a dose-response association existed both for physical and mental work ability (trend-test P<0.0001).

Conclusion

A dose-response association between the number of safety climate problems and lower physical and mental work ability two years later. Safety climate problems should be highly prioritized in blue-collar companies to avoid loss of work ability.

Key terms: Occupational health and safety; occupational injury; safety culture; accident; mental health; physical health; mental work ability; physical work ability

Strengths and limitations of this study

- The prospective design that enables implications of the relationship between reported safety climate problems in 2012 and physical and mental work ability in 2014.

- The study is based on self-reported questionnaire data rather than measurements that are more objective.
- The present study was a questionnaire survey with volunteer participation, therefore there might have been selection bias.
- The response rate since 3822 of the 6249 participants that were invited to fill in the questionnaire in both 2012 and 2014 replied, and it is possible that some of the workers did not reply due to long term sickness absence which could be related to physical and mental work ability, which might have resulted in more conservative estimates.
- We did not take job changes from 2012 to 2014 into account, therefore some of the blue-collar workers could have changed jobs during the period.

Funding

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Introduction

Blue-collar workers as a group are exposed to manual physical work and experience problems related to increased risk of accidents, poor work ability and poor safety climate [1].

Safety climate measurements have in recent years developed into a widely recognized predictor for accidents both at local organizational level [2,3] and in the general working population [4,5]. Originally developed by Israeli social scientist Dov Zohar [6] safety climate as a concept now has almost 40 years of tenure to its name. Whereas the focus for safety climate investigations has been on evaluating the construct's capability to foresee the risk for accidents in work, the construct addresses a number of organizational issues, which may, in fact, have a wider impact on health and safety outcomes, which in turn are important for how the workers are able to perform their job.

For instance, a number of questions related to manager's and worker's orientations and practices regarding safety may in fact also be indicators of their orientations and practices concerning other aspects of health

and safety, such as physically exerting work and low job control which over the long term can lead to loss of mental and physical work ability [7].

Work ability is a measure of the workers capacity in relation to the physical and mental work demands [8,9]. Poor work ability has been associated with long term sickness absence, chronic disease, loss of productivity, all-cause mortality and early retirement [10–14]. Whereas good work ability has been shown to bolster against the negative effects of chronic diseases on long term sickness absence [15].

That the safety climate concept may be important for maintaining a good physical and mental work ability seems even further reasonable as earlier qualitative research has indicated that a number of cultural characteristics tied to safety culture within work [16] are much the same as those tied to physical risk factor prevention [17]. For example, managerial attention to as well as priority and support of preventive activities and practices are highly important in all areas of occupational health and safety [18,19]. Thus, a good safety climate may be an important part of primary prevention to maintain a good work ability. If it is, in fact, the case, that safety climate questionnaire items are capable of predicting work ability outcomes of physical and mental character, this may provide an easily accessible indication of the potential benefits to work ability from improving the safety climate. This may be highly beneficial to both researchers, OSH-professionals, organizations, and society.

Hence, in this study, we evaluate whether safety climate problems would be predictive of future physical and mental work ability among blue-collar workers.

Methods

Study design

This prospective cohort study uses questionnaire data on safety climate and physical and mental work ability from the Danish Work Environment and Health study [20,21]. The reporting of this study follows the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE guideline) [22].

Ethics

The study was notified to and registered by the Danish Data Protection Agency (Datatilsynet; journal number 2015-57-0074). According to Danish law, questionnaire and register-based studies need neither approval by ethical and scientific committee nor informed consent. All data were processed and analysed anonymously.

Participants

Baseline characteristics are shown in table 1. The population for the study consisted of blue-collar workers who participated in both the 2012 and the 2014 wave of the DWECS [20,21], which served as baseline and follow up, respectively. A random sample of 6249 blue-collar workers aged 18-64 years was invited to participate in the DWECS in both 2012 and 2014. In total 3822 blue-collar workers participated in both 2012 and 2014 and serves as the study sample, and are representative of the Danish blue-collars working population.

Questionnaire variables

Safety climate

Five items were selected from the Nordic Occupational Safety Climate Questionnaire (NOSACQ-50) and provided a short version of vital aspects of the safety climate concept [6,23–26]. The original NOSAQ-50 survey contains 50 items, but due to practical reasons, only five items were included in the DWECS survey: 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management*

encourages employees here to work in accordance with safety rules – even when the work schedule is tight", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item). The particular selection of these questions was that they are indicative of the true priority of safety and therefore concern managerial level priorities of safety (question 1-3) and group level commitment to work safely (question 4-5). Each question was asked with four options on a 4-point scale of "strongly agree", "agree", "disagree", or "strongly disagree". All responses of "disagree" or "strongly disagree" were interpreted as a safety climate problem, except for question 5 (negated wording), where "agree" or "strongly agree" were interpreted as a safety climate problem. For further analyses, a variable containing information on the number of safety climate problems was generated ranging from 0 to ≥3 problems.

Work ability

Two single-item questions from the Work Ability Index questionnaire [27] were used to evaluate work ability in regard to the physical and mental demands of the job: (i) "How do you rate your current work ability with respect to the physical demands of your work?" (ii) "How do you rate your current work ability with respect to the mental demands of your work?". For each question, respondents replied on a 5-point Likert scale: "excellent", "very good", "good", "fair" or "poor".

Control variables

In the analyses we adjusted for; age (continuous), gender (male, female), socioeconomic class, occupational group, lifestyle and previous accidents in 2012. Furthermore, mental and physical work ability also served as a control variable. Socioeconomic class was coded into a binary variable according to Statistic Denmark's SOCIO13 variable: 1) employees engaged in work that requires basic level skills, and 2) other employees. Occupational group was coded and categorized (1–9) according to the 1988 revision of the Danish version of the International Standard Classification of Occupations register (D-ISCO 08): 1) management work, 2)

work requiring knowledge at the highest level within the area concerned, 3) work that requires medium level knowledge, 4) regular office and customer service, 5) service and sales work, 6) work in agriculture, forestry and fishing (excluding assisting), 7) craftsmanship, 8) operator and assembly work as well as transport work, and 9) other manual work.

Lifestyle factors could potentially affect attention towards accidents and included smoking (never, ex-smoker, yes) and body mass index (BMI (kg/m2)), which was determined from respondents' self-reported height and weight

Statistical analysis

Using general models (Proc Genmod) of SAS version 9.4., multivariate logistic regression was used to model the association between number of safety climate problems in 2012 and work ability in 2014. Work ability was the dependent variable and number of safety climate problems the independent variable. The first model was controlled for age and sex, and the second model was controlled for all the previously mentioned confounders. Estimates are reported as odds ratios (OR) and 95% confidence intervals (95% CI). Furthermore, to test the dose-response association, the number of safety climate problems was introduced as a continuous variable in a separate trend test. Finally, we tested the association between each of the five single-item question about safety climate and ability using the same models as above.

Results

Table 1 shows the demographics, lifestyle, socio-economical class, D-ISCO-categories as well as baseline safety climate, mental and physical work ability. Of the 6249, participants that were invited to participate in the DWECS in both the 2012 and 2014 3822 answered the questions regarding physical work ability in both 2012 and 2014. Therefore the response rate were 3822/6249*100 = 61.2%.

Table 2 shows the number of safety climate problems related to physical and mental work ability. Compared to participants with no safety climate problems, participants reporting two safety problems had a higher risk for reporting reduced physical work ability in 2014 (OR 1.29, CI 95% 1.03–1.61) and the risk was even higher for participants reporting three or more safety problems (OR 1.52, CI 95% 1.27–1.84). The same picture was observed in the analyses with mental work ability as outcome measure. Using number of safety climate problems as a continuous variable, a dose-response association existed both for physical and mental work ability (trend-test P<0.0001).

Table 3 shows physical and mental work ability related to each single safety climate problem in 2012. Of the five single questions all were significant increased odds ratio for reduced mental work ability and all, except one; We who work here consider minor accidents as a normal part of our daily work (negated or reversed item) with an odds ratio of 1.05 (CI 0.90-1.22).

	N	Mean	SD	%
Gender	3822			
Men	1917			50.16
Women	1905			49.84
Age	3822	46.45	10.31	
Body mass index (kg/m²)	3777	26.17	4.42	
Smoking habits	3800			
Smoker	928			24.42
Ex-smoker	1122			29.53
Non-smoker	1750			46.05
Socioeconomic class	3822			
Work that requires basic skills	3215			82.12
Other employees	607			15.88
Occupational group	3822			
Without category	41			1.07
Management work	12			0.31

Work requiring knowledge at the highest level within the area concerned	17	0.44
Work that requires medium level knowledge	42	1.1
Regular office and customer service	761	19.91
Service and sales work	1257	32.89
Work in agriculture, forestry and fishing (excluding assisting)	29	0.76
Craftsmanship	621	16.25
Operator and assembly work as well as transport work	433	11.33
Other manual work	609	15.93
≥1 accident leading to ≥1 day of sickness absence in the 12 months prior to completing the survey in 2012	3808	
No	3511	92.2
Yes	297	7.8
Safety climate problems (% disagreeing)	3557	
Management ensures that everyone receives the necessary information on safety	584	17.19
Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight	814	23.83
Management involves employees in decisions regarding safety	993	28.98
We who work here help each other to work safely	534	15.7
We who work here consider minor accidents as a normal part of our daily work (negated or reversed item)	1016	31.73
Accumulated safety climate problems	3575	
0	1585	44.34
1	1019	28.5
2	355	9.93
≥3	616	17.23
Physical work ability	3822	
Poor	36	0.94
Fair	327	8.56
Good	1178	30.82
Very good	1470	38.46
Excellent	811	21.22
Mental work ability	3818	
Poor	58	1.52
Fair	295	7.73
Good	1109	29.05
Very good	1600	41.91
Excellent	756	19.8

Table 1. Demographics, lifestyle, socio-economical class, D-ISCO-categories as well as baseline safety climate, mental and physical work ability. SD=Standard Deviation, D-ISCO=Danish version of International Standard Classification of Occupations

	Physical work ability				Mental work ability			
	Model 1		Model 2		Model 1		Model 2	
Number of safety climate problems	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
1 vs 0	1.22	1.05-1.41	1.19	1.02-1.39	1.21	1.04-1.40	1.18	1.01-1.37
2 vs 0	1.32	1.06-1.64	1.29	1.03-1.61	1.32	1.06-1.64	1.29	1.03-1.61
≥3 vs 0	1.55	1.29-1.87	1.52	1.27-1.84	1.50	1.25-1.80	1.43	1.19-1.72

Table 2. Number of safety climate problems related to physical and mental work ability. CI=Confidence Interval. Adjustments: Model 1. Gender and age. Model 2. Gender, age, socioeconomic class, occupational group, lifestyle (smoking habits and body mass index), mental and physical work ability in 2012 and previous accident in 2012.

	Physical work ability		Mental work ability	
Question	Odds ratio	CI	Odds ratio	CI
1. Management ensures that everyone receives the necessary information on safety.	1.53	1.27-1.85	1.32	1.09-1.59
2. Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight.	1.39	1.18-1.63	1.28	1.09-1.51
3. Management involves employees in decisions regarding safety	1.26	1.08-1.47	1.26	1.08-1.47
4. We who work here help each other to work safely	1.38	1.14-1.68	1.32	1.09-1.60
5. We who work here consider minor accidents as a normal part of our daily work (negated or reversed item)	1.05	0.90-1.22	1.19	1.02-1.38

Table 3. Physical and mental work ability related to each single safety climate problem in 2012. Adjustments: Gender, age, socioeconomic class, D-ISCO-group (Danish version of international standard classification of occupations), lifestyle (smoking habits and body mass index).

Discussion

The results of the present study shows a dose response association between the number of safety climate problems and decreased physical and mental work ability after two years (from 2012 to 2014). Furthermore, the results suggest that safety climate problems are generally important, since all questions in the safety climate questionnaire; 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease mental work ability after two years. For physical work ability all questions except 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease after two years.

The data in the present study are analysed using two models. Model 1 is adjusted to age and gender, while model 2 further is adjusted to socioeconomic class, D-ISCO-group (Danish version of international standard classification of occupations), lifestyle (smoking habits and body mass index), and previous accident in 2012 (Table 2). This step-wise adjustment for potential confounders did not change the odds-estimates to any significant extent. Thus, it appears, that job group, lifestyle and socioeconomic class does not have a large impact on the relationship between safety climate problems and future work ability. The consequence of safety climate problems on work ability, therefore, seem to be present across occupation and health

behaviour (i.e. lifestyle). Primary and secondary prevention of safety climate problems at the workplace should be highly prioritised among all blue collar workers.

The present study shows a clear dose-response association between the number of safety climate problems and reduced physical and mental work ability. Even experiencing one safety climate problem increases this risk significantly (table 2). In other words, the more safety climate problems experienced, the higher the risk of reporting reduced physical and mental work ability after two years. The data for the five single safety climate questions (table 3), shows an increased risk of experiencing a reduced work ability from all questions, and all except question 5 for mental and physical work ability, respectively. Together the data from the present study suggests that it is not enough to bring focus to one safety climate problem if the companies should have success in reducing the risk of affecting the physical and mental work ability of the workers. Rather, it is important to address each of the safety climate-related issues.
Measurements of safety climate instead of injury claims distinguish by the ability to predict the risks of injury and react before they actually occur, and thereby help workplaces with safety climate problems to target their initiatives before they lead to injury [28]. Safety climate problems have previously been associated with increased risk of accidents among blue-collar workers [5] and in the general working population [29]. Therefore, it is important for companies to prioritise safety climate, since it is associated with not only an increased risk of accidents but also lower physical and mental work ability.

Safety climate problems have previously been associated with occupational accidents [5]. The present study elaborates on this finding by showing that safety climate problems predict risk of decreased work ability. Thus, it could be speculated that our measure of safety climate is a proxy measure for perceived overall working environment among blue-collar workers. Furthermore, measuring safety climate instead of actual accidents provides the advantage for the companies to focus on preventive measures by improving different aspects of the safety climate before an accident occurs [28] and thereby further impacting work

ability. This suggests that companies should bring safety climate into focus and implement initiatives that reduce the safety climate problems.

Strengths and limitations

The present study has both strengths and limitations. A strength is the prospective design that enables implications of the relationship between reported safety climate problems in 2012 and physical and mental work ability in 2014. Nevertheless, a limitation of the present study is that it is based on self-reported questionnaire data rather than measurements that are more objective. The results could, therefore, have been affected by recall bias. The present study was a questionnaire survey with volunteer participation, therefore there might have been selection bias. Another limitation is the response rate since 3822 of the 6249 participants that were invited to fill in the questionnaire in both 2012 and 2014 replied. Therefore, it is possible that some of the workers did not reply due to long term sickness absence which could be related to physical and mental work ability, which might have resulted in more conservative estimates. Furthermore, a limitation is that we did not take job changes from 2012 to 2014 into account, therefore some of the blue-collar workers could have changed jobs during the period.

Conclusion

This study shows a dose response association between the number of safety climate problems and future decrease in physical and mental work ability. Furthermore, the study shows that all safety climate problems are important, since all questions in the safety climate questionnaire 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease mental work ability after two years. For physical work ability all questions

except 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease after two years. Therefore, safety climate problems should be highly prioritized in blue-collar companies, since safety climate can predict physical and mental work ability.

Author contributions

Mikkel Brandt, Jeppe ZN Ajslev and Lars L. Andersen designed the study. Lars L. Andersen performed the statistical analysis. Mikkel Brandt and Jeppe Ajslev wrote the initial draft for the article. Emil Sundstrup and Ninna Maria Wilstrup contributed with valuable feedback and sparring on the interpretation of data. All authors provided feedback on the manuscript, before approving the final version.

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1. p. 8-9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8 & 10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8 & 10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Safety climate as a predictor of work ability problems in blue-collar workers: Prospective cohort study

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Numbers of tables: 3

Abstract

Objectives

To evaluate the prospective association between safety climate and work ability in blue-collar workers.

Methods

Blue-collar workers (n=3822) from the Danish Work Environment and Health study replied to questions on safety climate, physical and mental work ability, and health in 2012 and 2014. Using multivariate logistic regression, we estimated the association of number of safety climate problems (0-5) in 2012 with physical and mental work ability in 2014. Potential confounders included sex, age, socioeconomic class, occupational group, lifestyle (smoking habits and body mass index), and previous accidents.

Results

Compared to workers free from safety climate problems, workers reporting two and three or more safety climate problems, respectively, had higher risk for reporting reduced physical work ability in 2014 (OR 1.29, CI 95% 1.03–1.61 and 1.52, CI 95% 1.27–1.84, respectively). Similar findings were observed with mental work ability as outcome. Using number of safety climate problems as a continuous variable, a dose-response association existed both for physical and mental work ability (trend-test P<0.0001).

Conclusion

A dose-response association between the number of safety climate problems at baseline and lower physical and mental work ability was detected after two years. Safety climate problems should be highly prioritized in blue-collar companies.

Key terms: Occupational health and safety; occupational injury; safety culture; accident; mental health; physical health; mental work ability; physical work ability

Strengths and limitations of this study

- The prospective design that enables implications of the relationship between reported safety climate problems in 2012 and physical and mental work ability in 2014.

- The study is based on self-reported questionnaire data rather than measurements that are more objective.
- The present study was a questionnaire survey with volunteer participation, therefore there might have been selection bias.
- The response rate since 3822 of the 6249 participants that were invited to fill in the questionnaire in both 2012 and 2014 replied, and it is possible that some of the workers did not reply due to long term sickness absence which could be related to physical and mental work ability, which might have resulted in more conservative estimates.
- We did not take job changes from 2012 to 2014 into account, therefore some of the blue-collar workers could have changed jobs during the period.

Funding

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Introduction

Blue-collar workers as a group are exposed to manual physical work and experience problems related to increased risk of accidents, poor work ability and poor safety climate [1].

Safety climate measurements have in recent years developed into a widely recognized predictor for accidents both at local organizational level [2,3] and in the general working population [4,5]. Originally developed by Israeli social scientist Dov Zohar [6] safety climate as a concept now has almost 40 years of tenure to its name. Whereas the focus for safety climate investigations has been on evaluating the construct's capability to foresee the risk for accidents in work, the construct addresses a number of organizational issues, which may, in fact, have a wider impact on health and safety outcomes, which in turn are important for how the workers are able to perform their job.

For instance, a number of questions related to manager's and worker's orientations and practices regarding safety may in fact also be indicators of their orientations and practices concerning other aspects of health

and safety, such as physically exerting work and low job control which over the long term can lead to loss of mental and physical work ability [7].

Work ability is a measure of the workers capacity in relation to the physical and mental work demands [8,9]. Poor work ability has been associated with long term sickness absence, chronic disease, loss of productivity, all-cause mortality and early retirement [10–14]. Whereas good work ability has been shown to bolster against the negative effects of chronic diseases on long term sickness absence [15].

That the safety climate concept may be important for maintaining a good physical and mental work ability seems even further reasonable as earlier qualitative research has indicated that a number of cultural characteristics tied to safety culture within work [16] are much the same as those tied to physical risk factor prevention [17]. For example, managerial attention to as well as priority and support of preventive activities and practices are highly important in all areas of occupational health and safety [18,19]. Thus, a good safety climate may be an important part of primary prevention to maintain a good work ability. If it is, in fact, the case, that safety climate questionnaire items are capable of predicting work ability outcomes of physical and mental character, this may provide an easily accessible indication of the potential benefits to work ability from improving the safety climate. This may be highly beneficial to both researchers, occupational health and safety professionals, organizations, and society.

Hence, in this study, we evaluate whether safety climate problems would be predictive of future physical and mental work ability among blue-collar workers.

Methods

Study design

This prospective cohort study uses questionnaire data on single item safety climate and physical and mental work ability from the Danish Work Environment and Health study [20,21]. The present analyses is part of a larger project, the Danish Work Environment & Health study, of which some articles have already been published, e.g. [5,15]To secure consistency and transparency the reporting of this study follows the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE guideline) [22] and follows the STROBE Statement checklist for Cohort studies [23]

Ethics

The study was notified to and registered by the Danish Data Protection Agency (Datatilsynet; journal number 2015-57-0074). According to Danish law, questionnaire and register-based studies need neither approval by ethical and scientific committee nor informed consent. All data were processed and analysed anonymously.

Patient and Public Involvement

No patient involved

Participants

Baseline characteristics are shown in table 1. The population for the study consisted of blue-collar workers who participated in both the 2012 and the 2014 wave of the DWECS [20,21], which served as baseline and follow up, respectively. A random sample of 6249 blue-collar workers aged 18-64 years was invited to participate in the DWECS in both 2012 and 2014 i.e. the same participants were followed our time. In total 3822 blue-collar workers participated in both 2012 and 2014 and serves as the study sample. A

datamanager of the research institute performed the data management and cleaning of data according to basic and standardized procedures.

Questionnaire variables

Safety climate

Five single items were selected from the Nordic Occupational Safety Climate Questionnaire (NOSACQ-50) and provided a short version of vital aspects of the safety climate concept [6,24–27]. NOSACQ-50 is a reliable tool for measuring safety climate and valid for predicting safety motivation, perceived safety level, and self-related safety behaviour [24]. In this study five items were selected to be particularly indicative of the safety climate, as they address the main themes concerned in the literature: managerial (question 1-3) and employee commitment, participation and engagement (question 4-5) [6,24,27]. The original NOSAQ-50 survey contains 50 items, but, only five items were included in the DWECS survey: 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item).. Each question was asked with four options on a 4-point scale of "strongly agree", "agree", "disagree", or "strongly disagree". Safety climate problems are defined as a negative answer on the questions i.e. all responses of "disagree" or "strongly disagree" were interpreted as a safety climate problem, except for question 5 (negated wording), where "agree" or "strongly agree" were interpreted as a safety climate problem. For further analyses, a variable containing information on the number of safety climate problems was generated ranging from 0 to ≥3 problems.

Work ability

Two single-item questions from the Work Ability Index questionnaire [28] were used to evaluate work ability in regard to the physical and mental demands of the job: (i) "How do you rate your current work

ability with respect to the physical demands of your work?" (ii) "How do you rate your current work ability with respect to the mental demands of your work?" [15,29]. For each question, respondents replied on a 5-point Likert scale: "excellent", "very good", "good", "fair" or "poor". Sub-sequently, these responses were dichotomized into good (excellent, very good and good) and poor (fair and poor) work ability to obtain more statistical power [15].

Control variables

In the analyses we adjusted for; age (continuous), gender (male, female), socioeconomic class, occupational group, lifestyle and previous accidents in 2012. Furthermore, mental and physical work ability also served as a control variable Based on registers from Statistics Denmark, the respondents were classified into two socioeconomic groups according to employment grade, job title, and education [30] (Borg V, Kristensen TS, Burr H. Work environment and changes in self-rated health: A five year follow-up study. Stress Medicine 2000; 16(1):37-47.). White collar workers included managers, academics, people with 3—4 years of vocational education and other salaried workers. Blue collar workers comprised skilled, semiskilled or unskilled workers. In the present study, we included only blue-collar workers. Occupational group was coded and categorized (1–9) according to the 1988 revision of the Danish version of the International Standard Classification of Occupations register (D-ISCO 08): 1) management work, 2) work requiring knowledge at the highest level within the area concerned, 3) work that requires medium level knowledge, 4) regular office and customer service, 5) service and sales work, 6) work in agriculture, forestry and fishing (excluding assisting), 7) craftsmanship, 8) operator and assembly work as well as transport work, and 9) other manual work.

Lifestyle factors i.e. smoking (never, ex-smoker, yes) and body mass index (BMI (kg/m2)), which was determined from respondents' self-reported height and weight

Statistical analysis

Using general models (Proc Genmod) of SAS version 9.4., multivariate logistic regression was used to model the association between number of safety climate problems in 2012 and work ability in 2014. Work ability was the dependent variable and number of safety climate problems the independent variable. The first model was controlled for age and sex, and the second model was controlled for all the previously mentioned confounders. Estimates are reported as odds ratios (OR) and 95% confidence intervals (95% CI). Furthermore, to test the dose-response association, the number of safety climate problems was introduced as a continuous variable in a separate trend test. Finally, we tested the association between each of the five single item question about safety climate and work ability using the same models as above.

Results

Table 1 shows the demographics, lifestyle, socio-economical class, D-ISCO-categories as well as baseline safety climate, mental and physical work ability. In both 2012 and 2014 6249, participants were invited to participate in the DWECS. Of these participants, 3822 answered the questions regarding physical work ability in both 2012 and 2014, therefore the response rate was 3822/6249*100 = 61.2%.

Table 2 shows the number of safety climate problems related to physical and mental work ability. Compared to participants with no safety climate problems in 2012, participants reporting two safety problems in 2012 had a higher risk for reporting reduced physical work ability in 2014 (OR 1.29, CI 95% 1.03–1.61) and the risk was even higher for participants reporting three or more safety problems in 2012 (OR 1.52, CI 95% 1.27–1.84). The same picture was observed in the analyses with mental work ability as outcome measure. Using number of safety climate problems as a continuous variable, a dose-response association existed both for physical and mental work ability (trend-test P<0.0001).

Of the five single safety climate questions all were significant increased odds ratio for reduced mental work ability and all, except one; We who work here consider minor accidents as a normal part of our daily work (negated or reversed item) with an odds ratio of 1.05 (CI 0.90-1.22) (table 3).

	N	Mean	SD	%
Gender	3822			
Men	1917			50.16
Women	1905			49.84
Age	3822	46.45	10.31	
Body mass index (kg/m²)	3777	26.17	4.42	
Smoking habits	3800			
Smoker	928			24.42
Ex-smoker	1122			29.53
Non-smoker	1750			46.05
Socioeconomic class	3822			
Work that requires basic skills	3215			82.12
Other employees	607			15.88
Occupational group	3822			
Without category	41			1.07
Management work	12			0.31
Work requiring knowledge at the highest level within the area concerned	17			0.44
Work that requires medium level knowledge	42			1.1
Regular office and customer service	761			19.91
Service and sales work	1257			32.89
Work in agriculture, forestry and fishing (excluding assisting)	29			0.76
Craftsmanship	621			16.25
Operator and assembly work as well as transport work	433			11.33
Other manual work	609			15.93
≥1 accident leading to ≥1 day of sickness absence in the 12 months prior to completing the survey in 2012	3808			
No	3511			92.2
Yes	297			7.8
Safety climate problems (% disagreeing)	3557			

Management ensures that everyone receives the necessary information on safety	584	17.19
Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight	814	23.83
Management involves employees in decisions regarding safety	993	28.98
We who work here help each other to work safely	534	15.7
We who work here consider minor accidents as a normal part of our daily work (negated or reversed item)	1016	31.73
Accumulated safety climate problems	3575	
0	1585	44.34
1	1019	28.5
2	355	9.93
≥3	616	17.23
Physical work ability	3822	
Poor	36	0.94
Fair	327	8.56
Good	1178	30.82
Very good	1470	38.46
Excellent	811	21.22
Mental work ability	3818	
Poor	58	1.52
Fair	295	7.73
Good	1109	29.05
Very good	1600	41.91
Excellent	756	19.8

Table 1. Demographics, lifestyle, socio-economical class, D-ISCO-categories as well as baseline safety climate, mental and physical work ability. SD=Standard Deviation, D-ISCO=Danish version of International Standard Classification of Occupations

	Physical work ability						Mental work ability					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
Number of safety climate	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
1 vs 0	1.22	1.05-1.41	1.19	1.02-1.39	1.23	0.96-1.32	1.21	1.04-1.40	1.18	1.01-1.37	1.16	0.99-1.36
2 vs 0	1.32	1.06-1.64	1.29	1.03-1.61	1.31	1.04-1.66	1.32	1.06-1.64	1.29	1.03-1.61	1.29	1.03-1.63
≥3 vs 0	1.55	1.29-1.87	1.52	1.27-1.84	1.53	1.25-1.86	1.50	1.25-1.80	1.43	1.19-1.72	1.51	1.24-1.83

Table 2. Number of safety climate problems related to physical and mental work ability. CI=Confidence Interval. Adjustments: Model 1. Gender and age. Model 2. Gender, age, socioeconomic class, occupational group, lifestyle (smoking habits and body mass index), mental and physical work ability in 2012 and previous accident in 2012. Model 3: Sensitivity analysis of model 2, excluding those with previous accidents at baseline.

	Physical work ability		Mental work ability	
Question	Odds ratio	CI	Odds ratio	CI
1. Management ensures that everyone receives the necessary information on safety.	1.53	1.27-1.85	1.32	1.09-1.59
2. Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight.	1.39	1.18-1.63	1.28	1.09-1.51
3. Management involves employees in decisions regarding safety	1.26	1.08-1.47	1.26	1.08-1.47
4. We who work here help each other to work safely	1.38	1.14-1.68	1.32	1.09-1.60
5. We who work here consider minor accidents as a normal part of our daily work (negated or reversed item)	1.05	0.90-1.22	1.19	1.02-1.38

Table 3. Physical and mental work ability related to each single safety climate problem in 2012. Adjustments: Gender, age, socioeconomic class, D-ISCO-group (Danish version of international standard classification of occupations), lifestyle (smoking habits and body mass index).

Discussion

The results of the present study shows a prospectively dose response association between the number of safety climate problems and decreased physical and mental work ability after two years (from 2012 to 2014). Furthermore, the results suggest that safety climate problems are generally important, since all questions in the safety climate questionnaire; 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with*

safety rules – even when the work schedule is tight", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease mental work ability after two years. For physical work ability all questions except 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease after two years.

The data in the present study are analysed using three models. Model 1 is adjusted to age and gender, while model 2 further is adjusted to socioeconomic class, D-ISCO-group (Danish version of international standard classification of occupations), lifestyle (smoking habits and body mass index), and previous accident in 2012 (Table 2). This step-wise adjustment for potential confounders did not change the odds-estimates to any significant extent. It can be argued that those with previous accidents at baseline may be more prone to lose further work ability with time. Thus, adjusting for previous accidents may not be sufficient (Model 2 of Table 2). Consequently, we also performed a sensitivity analyses where we excluded those with previous accidents at baseline (Model 3 of Table 2). These results were largely similar, although the lowest category became non-significant. Thus, the results presented seem quite robust. Thus, it appears, that job group, lifestyle and socioeconomic class does not have a large impact on the relationship between safety climate problems and future work ability. The consequence of safety climate problems on work ability, therefore, seem to be present across occupation and health behaviour (i.e. lifestyle). Primary and secondary prevention of safety climate problems at the workplace should be highly prioritised among all blue collar workers.

The present study shows a clear dose-response association between the number of safety climate problems and reduced physical and mental work ability. Work ability is typically assessed by self-report. Self-assessed work ability is a strong predictor of future disability pension [31]. Even experiencing one

safety climate problem increases this risk significantly (table 2). In other words, the more safety climate problems experienced, the higher the risk of reporting reduced physical and mental work ability after two years. The data for the five single safety climate questions (table 3), shows an increased risk of experiencing a reduced work ability from all questions, and all except question 5 for mental and physical work ability, respectively. Together the data from the present study suggests that it is not enough to bring focus to one safety climate problem if the companies should have success in reducing the risk of affecting the physical and mental work ability of the workers. Rather, it is important to address each of the safety climate-related issues.

Measurements of safety climate instead of injury claims distinguish by the ability to predict the risks of injury and react before they actually occur, and thereby help workplaces with safety climate problems to target their initiatives before they lead to injury [32]. Safety climate problems have previously been associated with increased risk of accidents among blue-collar workers [5] and in the general working population [33]. Therefore, it is important for companies to prioritise safety climate, since it is associated with not only an increased risk of accidents but also lower physical and mental work ability.

Safety climate problems have previously been associated with occupational accidents [5]. The present study elaborates on this finding by showing that safety climate problems predict risk of decreased work ability. Thus, it could be speculated that our measure of safety climate is a proxy measure for perceived overall working environment among blue-collar workers. Furthermore, measuring safety climate instead of actual accidents provides the advantage for the companies to focus on preventive measures by improving different aspects of the safety climate before an accident occurs [32] and thereby further impacting work ability. This suggests that companies should bring safety climate into focus and implement initiatives that reduce the safety climate problems.

Strengths and limitations

The present study has both strengths and limitations. A strength is the prospective design that enables implications of the relationship between reported safety climate problems in 2012 and physical and mental work ability in 2014. Nevertheless, a limitation of the present study is that it is based on self-reported questionnaire data rather than measurements that are more objective. The results could, therefore, have been affected by recall bias. The present study was a questionnaire survey with volunteer participation, therefore there might have been selection bias. Another limitation is the response rate since 3822 of the 6249 participants that were invited to fill in the questionnaire in both 2012 and 2014 replied. Therefore, it is possible that some of the workers did not reply due to long term sickness absence which could be related to physical and mental work ability, which might have resulted in more conservative estimates. Furthermore, a limitation is that we did not take information regarding changes from 2012 to 2014 into account in e.g. job changes, changes in job position or company, safety training received, changes in the management personnel, or witnessing work-related injuries, therefore, these variables could have influenced perceptions of safety climate. This present study is based on the five safety climate questions included in the DWECS. The DWECS is a survey with the purpose of continuously obtain knowledge about the physical and mental work environment of employees in Denmark and follow the development in their health over time. Since the DWECS is a large questionnaire survey which covers many factors within the working environment, it was - due to practical reasons - not possible to include all safety acclimate scales from the NOSAQ-50. This is a clear limitation since the NOSAQ-50 survey contains 50 items about safety climate. Future studies should evaluate if the safety climate can be evaluated by using the five single items used in the present study. However, as the present study evaluate whether safety climate problems can be predictive of future physical and mental work ability among blue-collar workers, we believe that these five single questions provide knowledge about the safety climate and contributes good knowledge to practitioners on the workplaces. Importantly, the 5 single item questionnaires has previously been used as a proxy for safety climate [5]. Another limitation is that the five safety climate items in the present study

combine organizational-level and group-level safety climate problems without differentiating between these two levels. However, the five single item has been used in previous studies to show the association between safety climate and future accidents [5] and the two single items from the work ability has been used to d evaluate the dose-response association between leisure time physical activity and work ability [29] and association of multimorbidity and work ability with risk of long-term sickness absence [15]. In the present study we used a 4-point agree/disagree scale, as we were interested in knowing whether the participants agreed or disagreed this scale was dichotomized to "agree" and "disagree". Other potential scales could have been used, but we doubt that this would have changed the results as a 5-point likert scale correlates strongly with a 4-point agree/disagree scale. Furthermore, we have previously validated (predictive validity) this scale [5].

Conclusion

This study shows a prospectively dose response association between the number of safety climate problems and future decrease in physical and mental work ability. Furthermore, the study shows that all safety climate problems are important, since all questions in the safety climate questionnaire 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease mental work ability after two years. For physical work ability all questions except 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease after two years. Therefore, safety climate problems should be highly prioritized in blue-collar companies, since safety climate can predict physical and mental work ability.

Author contributions

Mikkel Brandt, Jeppe ZN Ajslev and Lars L. Andersen designed the study. Lars L. Andersen performed the statistical analysis. Mikkel Brandt and Jeppe Ajslev wrote the initial draft for the article. Emil Sundstrup and Ninna Maria Wilstrup contributed with valuable feedback and sparring on the interpretation of data. All authors provided feedback on the manuscript, before approving the final version.

Literature

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1. p. 8-9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8 & 10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8 & 10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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Safety climate as a predictor of work ability problems in blue-collar workers: Prospective cohort study

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Abstract

Objectives

To evaluate whether safety climate items would be predictive of future physical and mental work ability among blue-collar workers.*Methods*

Blue-collar workers (n=3822) from the Danish Work Environment and Health study replied to questions on safety climate, physical and mental work ability, and health in 2012 and 2014. Using multivariate logistic regression, we estimated the association of number of safety climate items (0-5) in 2012 with physical and mental work ability in 2014. Potential confounders included sex, age, socioeconomic class, occupational group, lifestyle (smoking habits and body mass index), and previous accidents.

Results

Compared to workers free from safety climate items , workers reporting two and three or more safety climate items, respectively, had higher risk for reporting reduced physical work ability in 2014 (OR 1.29, CI 95% 1.03–1.61 and 1.52, CI 95% 1.27–1.84, respectively). Similar findings were observed with mental work ability as outcome. Using number of safety climate items as a continuous variable, a dose-response association existed both for physical and mental work ability (trend-test P<0.0001).

Conclusion

A dose-response association between the number of safety climate items at baseline and lower physical and mental work ability was detected after two years. Safety climate items should be highly prioritized in blue-collar companies.

Key terms: Occupational health and safety; occupational injury; safety culture; accident; mental health; physical health; mental work ability; physical work ability

Strengths and limitations of this study

- The prospective design that enables implications of the relationship between reported safety climate items in 2012 and physical and mental work ability in 2014.

- The study is based on self-reported questionnaire data rather than measurements that are more objective.
- The present study was a questionnaire survey with volunteer participation, therefore there might have been selection bias.
- The response rate since 3822 of the 6249 participants that were invited to fill in the questionnaire in both 2012 and 2014 replied, and it is possible that some of the workers did not reply due to long term sickness absence which could be related to physical and mental work ability, which might have resulted in more conservative estimates.
- We did not take job changes from 2012 to 2014 into account, therefore some of the blue-collar workers could have changed jobs during the period.

Funding

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Introduction

Blue-collar workers as a group are exposed to manual physical work and experience problems related to increased risk of accidents, poor work ability and poor safety climate [1].

Safety climate measurements have in recent years developed into a widely recognized predictor for accidents both at local organizational level [2,3] and in the general working population [4,5]. Originally developed by Israeli social scientist Dov Zohar [6] safety climate as a concept now has almost 40 years of tenure to its name. Whereas the focus for safety climate investigations has been on evaluating the construct's capability to foresee the risk for accidents in work, the construct addresses a number of organizational issues, which may, in fact, have a wider impact on health and safety outcomes, which in turn are important for how the workers are able to perform their job.

For instance, a number of questions related to manager's and worker's orientations and practices regarding safety may in fact also be indicators of their orientations and practices concerning other aspects of health

and safety, such as physically exerting work and low job control which over the long term can lead to loss of mental and physical work ability [7].

Work ability is a measure of the workers capacity in relation to the physical and mental work demands [8,9]. Poor work ability has been associated with long term sickness absence, chronic disease, loss of productivity, all-cause mortality and early retirement [10–14]. Whereas good work ability has been shown to bolster against the negative effects of chronic diseases on long term sickness absence [15].

That the safety climate concept may be important for maintaining a good physical and mental work ability seems even further reasonable as earlier qualitative research has indicated that a number of cultural characteristics tied to safety culture within work [16] are much the same as those tied to physical risk factor prevention [17]. For example, managerial attention to as well as priority and support of preventive activities and practices are highly important in all areas of occupational health and safety [18,19]. Thus, a good safety climate may be an important part of primary prevention to maintain a good work ability. If it is, in fact, the case, that safety climate questionnaire items are capable of predicting work ability outcomes of physical and mental character, this may provide an easily accessible indication of the potential benefits to work ability from improving the safety climate. This may be highly beneficial to both researchers, occupational health and safety professionals, organizations, and society.

Hence, in this study, we evaluate whether safety climate items would be predictive of future physical and mental work ability among blue-collar workers.

Methods

Study design

This prospective cohort study uses questionnaire data on single item safety climate and physical and mental work ability from the Danish Work Environment and Health study [20,21]. The present analyses is part of a larger project, the Danish Work Environment & Health study, of which some articles have already been published, e.g. [5,15]. To secure consistency and transparency the reporting of this study follows the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE guideline) [22] and follows the STROBE Statement checklist for Cohort studies [23]

Ethics

The study was notified to and registered by the Danish Data Protection Agency (Datatilsynet; journal number 2015-57-0074). According to Danish law, questionnaire and register-based studies need neither approval by ethical and scientific committee nor informed consent. All data were processed and analysed anonymously.

Patient and Public Involvement

No patients involved

Participants

Baseline characteristics are shown in table 1. The population for the study consisted of blue-collar workers who participated in both the 2012 and the 2014 wave of the DWECS [20,21], which served as baseline and follow up, respectively. A random sample of 6249 blue-collar workers aged 18-64 years was invited to participate in the DWECS in both 2012 and 2014 i.e. the same participants were followed our time. In total 3822 blue-collar workers participated in both 2012 and 2014 and serves as the study sample. A data

manager of the research institute performed the data management and cleaning of data according to basic and standardized procedures.

Questionnaire variables

Safety climate

Five single items were selected from the Nordic Occupational Safety Climate Questionnaire (NOSACQ-50) and provided a short version of vital aspects of the safety climate concept [6,24–27]. NOSACQ-50 is a reliable tool for measuring safety climate and valid for predicting safety motivation, perceived safety level, and self-related safety behaviour [24]. In this study five items were selected to be particularly indicative of the safety climate, as they address the main themes concerned in the literature: managerial (question 1-3) and employee commitment, participation and engagement (question 4-5) [6,24,27]. The original NOSAQ-50 survey contains 50 items, but, only five items were included in the DWECS survey: 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item).. Each question was asked with four options on a 4-point scale of "strongly agree", "agree", "disagree", or "strongly disagree". Safety climate items are defined as a negative answer on the questions i.e. all responses of "disagree" or "strongly disagree" were interpreted as a safety climate item, except for question 5 (negated wording), where "agree" or "strongly agree" were interpreted as a safety climate item. For further analyses, a variable containing information on the number of safety climate items was generated ranging from 0 to ≥3 problems.

Work ability

Two single-item questions from the Work Ability Index questionnaire [28] were used to evaluate work ability in regard to the physical and mental demands of the job: (i) "How do you rate your current work

ability with respect to the physical demands of your work?" (ii) "How do you rate your current work ability with respect to the mental demands of your work?" [15,29]. For each question, respondents replied on a 5-point Likert scale: "excellent", "very good", "good", "fair" or "poor". Sub-sequently, these responses were dichotomized into good (excellent, very good and good) and poor (fair and poor) work ability to obtain more statistical power [15].

Control variables

In the analyses we adjusted for; age (continuous), gender (male, female), socioeconomic class, occupational group, lifestyle and previous accidents in 2012. Furthermore, mental and physical work ability also served as a control variable Based on registers from Statistics Denmark, the respondents were classified into two socioeconomic groups according to employment grade, job title, and education [30] (Borg V, Kristensen TS, Burr H. Work environment and changes in self-rated health: A five year follow-up study. Stress Medicine 2000; 16(1):37-47.). White collar workers included managers, academics, people with 3—4 years of vocational education and other salaried workers. Blue collar workers comprised skilled, semiskilled or unskilled workers. In the present study, we included only blue-collar workers. Occupational group was coded and categorized (1–9) according to the 1988 revision of the Danish version of the International Standard Classification of Occupations register (D-ISCO 08): 1) management work, 2) work requiring knowledge at the highest level within the area concerned, 3) work that requires medium level knowledge, 4) regular office and customer service, 5) service and sales work, 6) work in agriculture, forestry and fishing (excluding assisting), 7) craftsmanship, 8) operator and assembly work as well as transport work, and 9) other manual work.

Lifestyle factors i.e. smoking (never, ex-smoker, yes) and body mass index (BMI (kg/m2)), which was determined from respondents' self-reported height and weight

Statistical analysis

Using general models (Proc Genmod) of SAS version 9.4., multivariate logistic regression was used to model the association between number of safety climate items in 2012 and work ability in 2014. Work ability was the dependent variable and number of safety climate items the independent variable. The first model was controlled for age and sex, and the second model was controlled for all the previously mentioned confounders. Estimates are reported as odds ratios (OR) and 95% confidence intervals (95% CI). Furthermore, to test the dose-response association, the number of safety climate items was introduced as a continuous variable in a separate trend test. Finally, we tested the association between each of the five single item question about safety climate and work ability using the same models as above.

Results

Table 1 shows the demographics, lifestyle, socio-economical class, D-ISCO-categories as well as baseline safety climate, mental and physical work ability. In both 2012 and 2014 6249, participants were invited to participate in the DWECS. Of these participants, 3822 answered the questions regarding physical work ability in both 2012 and 2014, therefore the response rate was 3822/6249*100 = 61.2%.

Table 2 shows the number of safety climate items related to physical and mental work ability. Compared to participants with no safety climate items in 2012, participants reporting two safety problems in 2012 had a higher risk for reporting reduced physical work ability in 2014 (OR 1.29, CI 95% 1.03–1.61) and the risk was even higher for participants reporting three or more safety problems in 2012 (OR 1.52, CI 95% 1.27–1.84). The same picture was observed in the analyses with mental work ability as outcome measure. Using number of safety climate items as a continuous variable, a dose-response association existed both for physical and mental work ability (trend-test P<0.0001).

Of the five single safety climate questions all were significant increased odds ratio for reduced mental work ability and all, except one; We who work here consider minor accidents as a normal part of our daily work (negated or reversed item) with an odds ratio of 1.05 (CI 0.90-1.22) (table 3).

	N	Mean	SD	%
Gender	3822			
Men	1917			50.16
Women	1905			49.84
Age	3822	46.45	10.31	
Body mass index (kg/m²)	3777	26.17	4.42	
Smoking habits	3800			
Smoker	928			24.42
Ex-smoker	1122			29.53
Non-smoker	1750			46.05
Socioeconomic class	3822			
Work that requires basic skills	3215			82.12
Other employees	607			15.88
Occupational group	3822			
Without category	41			1.07
Management work	12			0.31
Work requiring knowledge at the highest level within the area concerned	17			0.44
Work that requires medium level knowledge	42			1.1
Regular office and customer service	761			19.91
Service and sales work	1257			32.89
Work in agriculture, forestry and fishing (excluding assisting)	29			0.76
Craftsmanship	621			16.25
Operator and assembly work as well as transport work	433			11.33
Other manual work	609			15.93
≥1 accident leading to ≥1 day of sickness absence in the 12 months prior to completing the survey in 2012	3808			
No	3511			92.2
Yes	297			7.8
Safety climate items (% disagreeing)	3557			

Management ensures that everyone receives the necessary information on safety	584	17.19
Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight	814	23.83
Management involves employees in decisions regarding safety	993	28.98
We who work here help each other to work safely	534	15.7
We who work here consider minor accidents as a normal part of our daily work (negated or reversed item)	1016	31.73
Accumulated safety climate items	3575	
0	1585	44.34
1	1019	28.5
2	355	9.93
≥3	616	17.23
Physical work ability	3822	
Poor	36	0.94
Fair	327	8.56
Good	1178	30.82
Very good	1470	38.46
Excellent	811	21.22
Mental work ability	3818	
Poor	58	1.52
Fair	295	7.73
Good	1109	29.05
Very good	1600	41.91
Excellent	756	19.8

Table 1. Demographics, lifestyle, socio-economical class, D-ISCO-categories as well as baseline safety climate, mental and physical work ability. SD=Standard Deviation, D-ISCO=Danish version of International Standard Classification of Occupations

	Physical work ability						Mental work ability					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
Number of safety climate items	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI

1 vs 0	1.22	1.05-1.41	1.19	1.02-1.39	1.23	0.96-1.32	1.21	1.04-1.40	1.18	1.01-1.37	1.16	0.99-1.36
2 vs 0	1.32	1.06-1.64	1.29	1.03-1.61	1.31	1.04-1.66	1.32	1.06-1.64	1.29	1.03-1.61	1.29	1.03-1.63
≥3 vs 0	1.55	1.29-1.87	1.52	1.27-1.84	1.53	1.25-1.86	1.50	1.25-1.80	1.43	1.19-1.72	1.51	1.24-1.83

Table 2. Number of safety climate items related to physical and mental work ability. CI=Confidence Interval. Adjustments: Model 1. Gender and age. Model 2. Gender, age, socioeconomic class, occupational group, lifestyle (smoking habits and body mass index), mental and physical work ability in 2012 and previous accident in 2012. Model 3: Sensitivity analysis of model 2, excluding those with previous accidents at baseline.

	Physical work ability		Mental work ability	
Question	Odds ratio	CI	Odds ratio	CI
1. Management ensures that everyone receives the necessary information on safety.	1.53	1.27-1.85	1.32	1.09-1.59
2. Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight.	1.39	1.18-1.63	1.28	1.09-1.51
3. Management involves employees in decisions regarding safety	1.26	1.08-1.47	1.26	1.08-1.47
4. We who work here help each other to work safely	1.38	1.14-1.68	1.32	1.09-1.60
5. We who work here consider minor accidents as a normal part of our daily work (negated or reversed item)	1.05	0.90-1.22	1.19	1.02-1.38

Table 3. Physical and mental work ability related to each single safety climate item in 2012.

Adjustments: Gender, age, socioeconomic class, D-ISCO-group (Danish version of international standard classification of occupations), lifestyle (smoking habits and body mass index).

Discussion

The results of the present study shows a prospectively dose response association between the number of safety climate items and decreased physical and mental work ability after two years (from 2012 to 2014). Furthermore, the results suggest that safety climate items are generally important, since all questions in the safety climate questionnaire; 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease mental work ability after two years. For physical work ability all questions except 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease after two years.

The data in the present study are analysed using three models. Model 1 is adjusted to age and gender, while model 2 further is adjusted to socioeconomic class, D-ISCO-group (Danish version of international standard classification of occupations), lifestyle (smoking habits and body mass index), and previous accident in 2012 (Table 2). This step-wise adjustment for potential confounders did not change the odds-estimates to any significant extent. It can be argued that those with previous accidents at baseline may be more prone to lose further work ability with time. Thus, adjusting for previous accidents may not be sufficient (Model 2 of Table 2). Consequently, we also performed a sensitivity analyses where we excluded those with previous accidents at baseline (Model 3 of Table 2). These results were largely similar, although the lowest category became non-significant. Thus, the results presented seem quite robust. Thus, it appears, that job group, lifestyle and socioeconomic class does not have a large impact on the relationship between safety climate items and future work ability. The consequence of safety climate items on work ability, therefore, seem to be present across occupation and health behaviour (i.e. lifestyle). Primary and

secondary prevention of safety climate items at the workplace should be highly prioritised among all blue collar workers.

The present study shows a clear dose-response association between the number of safety climate items and reduced physical and mental work ability. Work ability is typically assessed by self-report. Self-assessed work ability is a strong predictor of future disability pension [31]. Even experiencing one safety climate item increases this risk significantly (table 2). In other words, the more safety climate items experienced, the higher the risk of reporting reduced physical and mental work ability after two years. The data for the five single safety climate questions (table 3), shows an increased risk of experiencing a reduced work ability from all questions, and all except question 5 for mental and physical work ability, respectively. Together the data from the present study suggests that it is not enough to bring focus to one safety climate item if the companies should have success in reducing the risk of affecting the physical and mental work ability of the workers. Rather, it is important to address each of the safety climate-related issues.
Measurements of safety climate instead of injury claims distinguish by the ability to predict the risks of injury and react before they actually occur, and thereby help workplaces with safety climate items to target their initiatives before they lead to injury [32]. Safety climate items have previously been associated with increased risk of accidents among blue-collar workers [5] and in the general working population [33]. Therefore, it is important for companies to prioritise safety climate, since it is associated with not only an increased risk of accidents but also lower physical and mental work ability.

Safety climate items have previously been associated with occupational accidents [5]. The present study elaborates on this finding by showing that safety climate items predict risk of decreased work ability. Thus, it could be speculated that our measure of safety climate is a proxy measure for perceived overall working environment among blue-collar workers. Furthermore, measuring safety climate instead of actual accidents provides the advantage for the companies to focus on preventive measures by improving different aspects

of the safety climate before an accident occurs [32] and thereby further impacting work ability. This suggests that companies should bring safety climate into focus and implement initiatives that reduce the safety climate items.

Strengths and limitations

The present study has both strengths and limitations. A strength is the prospective design that enables implications of the relationship between reported safety climate items in 2012 and physical and mental work ability in 2014. Nevertheless, a limitation of the present study is that it is based on self-reported questionnaire data rather than measurements that are more objective. The results could, therefore, have been affected by recall bias. The present study was a questionnaire survey with volunteer participation, therefore there might have been selection bias. Another limitation is the response rate since 3822 of the 6249 participants that were invited to fill in the questionnaire in both 2012 and 2014 replied. Therefore, it is possible that some of the workers did not reply due to long term sickness absence which could be related to physical and mental work ability, which might have resulted in more conservative estimates. Furthermore, a limitation is that we did not take information regarding changes from 2012 to 2014 into account in e.g. job changes, changes in job position or company, safety training received, changes in the management personnel, or witnessing work-related injuries, therefore, these variables could have influenced perceptions of safety climate. This present study is based on the five safety climate questions included in the DWECS. The DWECS is a survey with the purpose of continuously obtain knowledge about the physical and mental work environment of employees in Denmark and follow the development in their health over time. Since the DWECS is a large questionnaire survey which covers many factors within the working environment, it was - due to practical reasons - not possible to include all safety acclimate scales from the NOSAQ-50. This is a clear limitation since the NOSAQ-50 survey contains 50 items about safety climate. Future studies should evaluate if the safety climate can be evaluated by using the five single items used in the present study. However, as the present study evaluate whether safety climate items can be

predictive of future physical and mental work ability among blue-collar workers, we believe that these five single questions provide knowledge about the safety climate and contributes good knowledge to practitioners on the workplaces. Importantly, the 5 single item questionnaires has previously been used as a proxy for safety climate [5]. Another limitation is that the five safety climate items in the present study combine organizational-level and group-level safety climate items without differentiating between these two levels. However, the five single item has been used in previous studies to show the association between safety climate and future accidents [5] and the two single items from the work ability has been used to d evaluate the dose-response association between leisure time physical activity and work ability [29] and association of multimorbidity and work ability with risk of long-term sickness absence [15]. In the present study we used a 4-point agree/disagree scale, as we were interested in knowing whether the participants agreed or disagreed this scale was dichotomized to "agree" and "disagree". Other potential scales could have been used, but we doubt that this would have changed the results as a 5-point likert scale correlates strongly with a 4-point agree/disagree scale. Furthermore, we have previously validated (predictive validity) this scale [5].

Conclusion

This study shows a prospectively dose response association between the number of safety climate items and future decrease in physical and mental work ability. Furthermore, the study shows that all safety climate items are important, since all questions in the safety climate questionnaire 1) "*Management ensures that everyone receives the necessary information on safety*", 2) "*Management encourages employees here to work in accordance with safety rules – even when the work schedule is tight*", 3) "*Management involves employees in decisions regarding safety*", 4) "*We who work here help each other to work safely*" and 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease mental work ability after two years. For physical work ability all questions except 5) "*We who work here consider minor accidents as a normal part of our daily work"* (negated or reversed item) were related to a decrease after two years. Therefore, safety

climate items should be highly prioritized in blue-collar companies, since safety climate can predict physical and mental work ability.

Statements

a. Contributorship statement

Mikkel Brandt, Jeppe ZN Ajslev and Lars L. Andersen designed the study. Lars L. Andersen performed the statistical analysis. Mikkel Brandt and Jeppe Ajslev wrote the initial draft for the article. Emil Sundstrup and Ninna Maria Wilstrup contributed with valuable feedback and sparring on the interpretation of data. All authors provided feedback on the manuscript, before approving the final version.

b. Competing interests

The authors declare no competing interests

c. Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

d. Data sharing statement

Data can be shared upon request

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1. p. 8-9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	8 & 10
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8 & 10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.