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# Do different job demands interact as predictors of long-term sickness absence? A register-based follow-up on 55 467 Danish workers

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**ABSTRACT**

**Objectives** To assess interactions between combinations of quantitative demands, emotional demands, unclear and contradictory demands, and violence/threats of violence in the prospective association with risk of long-term sickness absence (LTSA).

**Methods** We included 55 467 employees from the 2012, 2014 and 2016 waves of the Work Environment and Health in Denmark (WEHD) survey. We measured the four independent variables in the WEHD survey and assessed risk of LTSA in a national register during 12 months of follow-up. Using Cox proportional hazards models, adjusted for age, sex, educational attainment and job group, we estimated risk of LTSA and assessed deviation from additivity using relative excess risk due to interaction (RERI).

**Results** For combinations of high emotional demands and high quantitative demands (HR 1.50; 95% CI 1.33 to 1.70; RERI 0.06; 95% CI -0.15 to 0.26) and high emotional demands and violence/threats of violence (HR 1.76; 95% CI 1.53 to 2.02; RERI 0.12; 95% CI -0.43 to 0.66) we found no indications of deviations from additive effects in predicting LTSA. For combinations of violence/threats of violence and high quantitative demands (HR 1.90; 95% CI 1.64 to 2.20; RERI 0.36; 95% CI 0.01 to 0.71) and unclear and contradictory demands and high quantitative demands (HR 1.46; 95% CI 1.31 to 1.62; RERI 0.23; 95% CI 0.04 to 0.42) the results indicated an excess risk of LTSA above additivity (ie, superadditivity).

**Conclusions** Participants reporting high quantitative demands combined with either violence/threats of violence or unclear and contradictory demands showed a higher risk of LTSA than expected, indicating superadditivity. Results have implications for preventing negative health effects related to adverse psychosocial working conditions.

**INTRODUCTION**

Much research on psychosocial working conditions has focused on associations between individual indicators of psychosocial working conditions and health-related outcomes, such as risk of depression or long-term sickness absence (LTSA). This research posits that self-reported exposure to high quantitative demands,<sup>1-4</sup> high emotional demands,<sup>5, 6</sup> and threats and violence<sup>7-9</sup> predict adverse health-related outcomes.

**WHAT IS ALREADY KNOWN ON THIS TOPIC**

- ⇒ Much research on psychosocial working conditions has focused on associations between individual indicators of job demands and health-related outcomes, and has thus not addressed the complexity of a work environment where multiple job demands occur simultaneously in the psychosocial work environment.
- ⇒ Accordingly, previous research tells us little about the health-related consequences of the simultaneous presence of different types of job demands in the psychosocial work environment.

However, by studying indicators of psychosocial working conditions in isolation or by mutually adjusting for other indicators, this research fails to grasp the complexity of a work environment where several exposures occur simultaneously. Only few studies have examined the consequences of the simultaneous exposure to adverse working conditions<sup>10-13</sup> and, accordingly, extant research tells us little about the health effects of the simultaneous presence of more than one job demand or negative act in the psychosocial work environment.

Previous studies have investigated the potential buffering effects of job resources<sup>14</sup> on associations between (1) job demands or negative acts and (2) health-related outcomes,<sup>15-20</sup> and these studies highlight the relevance of studying the combined effects of simultaneous exposures in the psychosocial work environment.

Little is known, however, about the consequences of the simultaneous exposure to different job demands in the psychosocial work environment. In one cross-sectional study, Geisler *et al*<sup>10</sup> found a negative association between emotional demands and 'quality of work' for workers with high levels of quantitative demands, work pace and role conflict, while they found a positive association for workers reporting low levels of quantitative demands, work pace and role conflict. Moreover, Jimmieson *et al*<sup>11</sup> found that the negative cross-sectional association between emotional demands and job satisfaction was exacerbated when other job demands (time demands and cognitive demands) also were high. Finally, in a prospective study with a 2-month follow-up, van Woerkom *et al*<sup>12</sup> found a statistically



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**WHAT THIS STUDY ADDS**

- ⇒ In this study, we investigate potential interaction between different job demands in predicting risk of long-term sickness absence (LTSA) in a prospective analysis in a large study population.
- ⇒ The study shows that workers reporting simultaneous exposure to two job demands are at increased risk of LTSA compared with workers reporting high levels of only one of the relevant job demands.
- ⇒ Furthermore, for two combinations of job demands (high quantitative demands and high emotional demands and high emotional demands and violence/threats of violence), we found additive effects in predicting LTSA. For another two combinations (high quantitative demands and violence/threats of violence and high quantitative demands and unclear and contradictory demands) we observed a positive deviation from additivity (ie, superadditivity) in predicting LTSA, which implies that, for the two latter combinations, the association with LTSA is significantly stronger than the sum of the risk estimates of the individual factors.

**HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY**

- ⇒ The results of the study are important for future practices in assessing and preventing occupational hazards in the psychosocial work environment.
- ⇒ The results are particularly relevant for work environment authorities, managers, human resource professionals, and occupational health and safety professionals to promote worker health and well-being.

significant interaction effect between workload and emotional demands in predicting workplace-registered sickness absence in 832 Dutch healthcare workers. Accordingly, these studies suggest that the simultaneous presence of high levels of different job demands may be associated with an increased risk of adverse work-related outcomes as compared with a work environment where workers report exposure to high levels of no or only one job demand.

The cited studies<sup>10–12</sup> contain several limitations that limit the possibilities for drawing inference from the results. First, the cited studies are based on small study populations that are not representative of the working population as a whole. Second, two of the studies<sup>10,11</sup> are characterised by further limitations as they (1) are based on cross-sectional survey data, which limits the possibilities for causal inference due to a lack of temporal separation of independent and dependent variables, (2) do not have a specific focus on health-related outcomes and (3) measure exposures and outcomes in questionnaires, which implies a risk of common methods biases inflating the observed associations.<sup>21</sup>

Previous studies show that self-reported exposure to job demands and negative acts is associated with adverse outcomes.<sup>1–9</sup> It may thus be expected that the presence of high levels of one type of job demand may limit the ability of workers to cope successfully with additional job demands or negative acts in the psychosocial work environment.<sup>12</sup> Accordingly, the presence of high levels of two or more job demands may imply a mutually reinforcing negative effect on worker health and well-being.

The Danish Working Environment Authority (DWEA) is a governmental agency that is responsible for upholding safe and healthy working conditions in Danish workplaces. When inspecting psychosocial working conditions, the DWEA is

obliged to pay particular attention to the following factors in the psychosocial work environment: quantitative demands, emotional demands, unclear and contradictory demands, and violence/threats of violence (in the following, we refer to these four factors as job demands). This study is part of a project commissioned by the DWEA and the aim of the study is to explore prospective associations between the following combinations of job demands and risk of LTSA.

- ▶ High emotional demands and high quantitative demands.
- ▶ High emotional demands and violence/threats of violence
- ▶ High quantitative demands and violence/threats of violence
- ▶ High quantitative demands and unclear and contradictory demands.

We conducted the analyses as prospective analyses in a large study population (>55 000 persons) using a register-based measure of LTSA as the endpoint. Accordingly, the analysis has been designed to avoid the limitations of the studies cited above.

**METHODS**

This study is based on data from the 2012, 2014 and 2016 waves of the Work Environment and Health in Denmark study (WEHD). The WEHD is a biennial survey on working conditions and health in Danish wage earners.<sup>22</sup>

WEHD consists of a stratified workplace survey conducted in 2012 and 2016, and a nationwide survey conducted in 2012, 2014 and 2016. In 2012, the nationwide survey roughly constituted two-thirds of the study population and the workplace survey, that was stratified by type of industry and workplace size, constituted about one-third of the study population.<sup>22</sup> The design of WEHD is described in further detail elsewhere.<sup>22</sup>

The average response rate from the 2012, 2014 and 2016 waves was 50%. The study population included 67 402 individual respondents and the first response from the participants in either 2012, 2014 or 2016 constituted the baseline of the study. An analysis of non-response in the 2012 round of the WEHD showed that participation rates increased with female gender, age, income, higher education, cohabitation and Danish origin.<sup>22</sup> We excluded respondents who reported not being employed at baseline (5116), respondents with LTSA or other reasons for censoring (retirement due to age or disability, emigration or death) during the 2 years before baseline (6153), and 666 respondents with missing data on covariates, which gives a final sample of 55 467 participants.

**Dependent variable: LTSA**

We collected data on LTSA from the Danish Register for Evaluation of Marginalisation (DREAM).<sup>23</sup> DREAM contains weekly information on all social transfer payments in Denmark since 1991, and on retirement, maternity leave, emigration, death and all compensation granted for sickness absence since 1996.

We defined LTSA as any sickness absence spell lasting six consecutive weeks or more for each participant during 12 months (52 weeks) of follow-up after baseline. The reason for this cut-off point was that of January 2012 only sickness absence spells of 30 calendar days or more were reimbursed by the municipality and subsequently registered in DREAM. We used a lower cut point of 6 weeks to ensure that all cases of LTSA were of 30 calendar days or more. We linked data from the baseline survey (WEHD) to the DREAM-register using the respondents' unique civil registration number.

### Independent variables: psychosocial working conditions

We collected data on the following measures in the study questionnaire.

Emotional demands were measured with a two-item scale. Sample item: 'How often are you emotionally affected by your work?' We observed the following Pearson's  $r$  correlations in 2012, 2014 and 2016, respectively: 0.42, 0.39 and 0.40.

Quantitative demands were measured with a four-item scale. Sample item: 'How often do you find that you do not have enough time for all your work tasks?' We observed the following Cronbach's  $\alpha$ -values in 2012, 2014 and 2016, respectively: 0.79, 0.79 and 0.80.

Unclear and contradictory demands were measured with a two-item scale. Sample item: 'How often are opposing demands made on you in your work?' We observed the following Pearson's  $r$  correlations in 2012, 2014 and 2016, respectively: 0.22, 0.24 and 0.23.

Response on the items of these three multi-item scales was scored on five-point Likert scales. Items were added into scales with higher scale values indicating higher levels of the measured dimension. We coded the upper median on these three scales as being *exposed* to high emotional demands, high quantitative demands, and unclear and contradictory demands.

Violence/threats of violence was measured with two items: (1) 'Have you been exposed to physical violence in your workplace within the last 12 months?' and (2) 'Have you been exposed to threats of violence in your workplace within the last 12 months?'

Response options on these two items were: (1) yes, daily, (2) yes, weekly, (3) yes, monthly, (4) yes, now and then, and (5) no, never. These response options were collapsed into two categories: (1) exposed (daily, weekly, monthly and now and then) and (2) not exposed (never), and we further coded respondents reporting exposure to either violence or threats of violence as exposed to violence or threats of violence.

### Covariates

All analyses were adjusted for age, sex, educational attainment and job group. All covariates were measured in national registers in Statistics Denmark.

### Statistical analysis

We followed participants from baseline (ie, the week where they answered the WEHD questionnaire) until first onset of LTSA or censoring due to migration, retirement, death or end of follow-up (52 weeks/12 months after baseline). Using Cox regression models, we calculated HRs and 95% CIs for the association between combinations of job demands and risk of LTSA during the follow-up with calendar time in weeks as underlying time axis. Estimates were adjusted for age, sex, educational attainment and job group. Age was analysed as a continuous variable and the remaining three covariates were analysed as categorical variables. We found that the proportional hazard assumption was satisfied through visual inspection the negative log of the estimated survival curve across each of the four independent variable divided into quartiles.

Following the approach described by Andersson *et al*,<sup>24</sup> we analysed the interaction between two independent variables by investigating deviation from additivity from the risk estimates of the two independent variables. Specifically, we estimated the HR for the following four combinations of exposure levels of two different job demands, say job demand A and job demand B: (1) Both job demands A and B at low level (reference,  $HR_{00}=1$ ), (2) Job demand A at high level and job demand B at

low level ( $HR_{10}$ ), (3) Job demand A at low level, and job demand B at high level ( $HR_{01}$ ) and (4) Both job demands A and B at high level ( $HR_{11}$ ). Under the assumption of additivity of the risk (ie, no interaction between demands A and B) the predicted value of the latter risk is  $HR_{11}=HR_{10}+HR_{01}-1$ . We tested if the estimate of  $HR_{11}$  deviated significantly from additivity by calculating the relative excess risk due to interaction (RERI). CIs were calculated with the Hosmer and Lemeshow method.<sup>25</sup> RERI values that are significantly different from 0 indicates deviation from additivity.<sup>24</sup>

All analyses were done using the PHREG procedure in SAS V.9.4 (SAS Institute).

### RESULTS

Table 1 shows descriptive statistics for background variables. The mean age was 45.2 years and 51.7% of the population were women.

Table 2 shows that participants reporting exposure to high quantitative demands (HR 1.25; 95% CI 1.15 to 1.36), high emotional demands (HR 1.25; 95% CI 1.14 to 1.37), unclear and contradictory demands (HR 1.28; 95% CI 1.18 to 1.39) and violence/threats of violence (HR 1.59; 95% CI 1.34 to 1.88) have an increased risk of LTSA.

#### Combination of emotional demands and quantitative demands

Table 3 shows that respondents reporting exposure to high emotional demands and low quantitative demands (HR 1.22; 95% CI 1.07 to 1.39) and high quantitative demands and low emotional demands (HR 1.22; 95% CI 1.06 to 1.40) have an increased risk of LTSA, when compared with the unexposed reference group. Respondents reporting exposure to a combination of high emotional demands *and* high quantitative demands have a higher risk of LTSA (HR 1.50; 95% CI 1.33 to 1.70), than respondents reporting exposure to one of the two exposures. The combined effect of the two exposures does not depart from of additivity as the RERI-coefficient is not statistically significant (RERI 0.06; 95% CI -0.15 to 0.26) (figure 1).

#### Combination of emotional demands and violence/threats of violence

Table 3 shows that respondents reporting exposure to high emotional demands and no exposure to violence/threats of violence (HR 1.19; 95% CI 1.08 to 1.31) and exposure to violence/threats of violence and low emotional demands (HR 1.46; 95% CI 1.02 to 2.08) have an increased risk of LTSA, when compared with the unexposed reference group. Respondents reporting exposure to a combination of high emotional demands and violence/threats of violence have a higher risk of LTSA (HR 1.76; 95% CI 1.53 to 2.02), than respondents only reporting exposure to one of the two exposures. The combined effect of the two exposures does not depart from of additivity as the RERI-coefficient is not statistically significant (RERI 0.12; 95% CI -0.43 to 0.66) (figure 1).

#### Combination of quantitative demands and violence/threats of violence

In table 3, we find that respondents reporting exposure to violence/threats of violence and low quantitative demands (HR 1.34; 95% CI 1.10 to 1.64) and high quantitative demands and no exposure to violence/threats of violence (HR 1.20; 95% CI 1.09 to 1.31) have an increased risk of LTSA, when compared with the unexposed reference group. Respondents reporting

**Table 1** Descriptive statistics for background variables

	n	%	Mean	SD
Age	55 467		45.2	11.4
Sex				
Men	26 768	48.3		
Women	28 699	51.7		
Educational level				
Low (basic schooling)	8 239	14.9		
Middle-low (upper secondary school and vocational education)	24 180	43.6		
Middle-high (short and intermediate higher education)	16 061	29.0		
High (long higher education)	6 987	12.6		
Job group				
Managers	2 915	5.3		
Professionals	17 452	31.5		
Technicians and associate professionals	7 543	13.6		
General office clerks	5 029	9.1		
Personal services workers	8 191	14.8		
Skilled agricultural, forestry and fishery workers	349	0.6		
Building and related trades workers	4 532	8.2		
Plant and machine operators and assemblers	3 131	5.6		
Elementary occupations and unknown job group	6 325	11.4		
Wave of the Work Environment and Health in Denmark-study				
2012	21 069	38.0		
2014	14 780	26.6		
2016	19 618	35.4		

exposure to violence/threats of violence and high quantitative demands have a higher risk of LTSA (HR: 1.90; 95% CI 1.64 to 2.20), than respondents reporting exposure to one of the two exposures. The combined effect of the two exposures is markedly larger than the expected additive effect of the risk estimates of the two exposures, and the statistically significant RERI-coefficient indicates that the combined effect departs from of additivity (RERI 0.36; 95% CI 0.01 to 0.71) (figure 1).

### Combination of quantitative demands and unclear and contradictory demands

Finally, table 3 shows that respondents reporting exposure to unclear and contradictory demands and low quantitative

demands (HR 1.12; 95% CI 0.98 to 1.28) and high quantitative demands and no unclear and contradictory demands (HR 1.11; 95% CI 0.98 to 1.24) have an increased although statistically non-significant risk of LTSA when compared with the unexposed reference group. Respondents reporting exposure to a combination of unclear and contradictory demands and high quantitative demands have a higher risk of LTSA (HR 1.46; 95% CI 1.31 to 1.62), than respondents reporting exposure to one of the two exposures. The combined effect of the two exposures is substantially larger than the expected additive effect of the risk estimates of the two individual exposures and the statistically significant RERI-coefficient indicates that the combined effect departs from of additivity (RERI 0.23; 95% CI 0.04 to 0.42) (figure 1).

**Table 2** Risk of long-term sickness absence during follow-up for participants reporting exposure to high quantitative demands, high emotional demands, high unclear and contradictory demands, and violence/threats of violence

	N	Cases N (%)	HR	95% CI
High quantitative demands				
Exposed	28 879	1313 (4.6)	1.25	1.15 to 1.36
Unexposed	25 106	981 (3.9)	1	Ref
High emotional demands				
Exposed	31 103	1488 (4.8)	1.25	1.14 to 1.37
Unexposed	23 227	824 (3.6)	1	Ref
High unclear and contradictory demands				
Exposed	24 884	1155 (4.6)	1.28	1.18 to 1.39
Unexposed	29 461	1157 (3.9)	1	Ref
Violence/threats of violence				
Exposed	5 669	375 (6.6)	1.59	1.34 to 1.88
Unexposed	48 016	1 897 (4.0)	1	Ref

Note: All analyses are adjusted for sex, age, educational attainment and job group.

## DISCUSSION

In this prospective study of 55 467 workers, we found that workers reporting exposure to combinations of different types of job demands had a higher risk of LTSA than workers reporting exposure to one or none of the exposures under study.

For the combinations of high emotional demands and high quantitative demands and high emotional demands and violence/threats of violence, we found no indications of a deviation from additivity in predicting LTSA. For the combinations violence/threats of violence and high quantitative demands and unclear and contradictory demands and high quantitative demands, the results showed a positive deviation from additivity (ie, superadditivity) in predicting LTSA. Accordingly, the findings of this study are in line with previous findings suggesting that workers reporting simultaneous exposure to two or more job demands are faced with an increased risk of adverse work-related outcomes, such as lower levels of 'quality of work'<sup>10</sup> and job satisfaction<sup>11</sup> and increased risk of sickness absence<sup>12</sup> than workers reporting exposure to high levels of one or none of the investigated job demands. Similar results were reported in other studies analysing

**Table 3** Risk of long-term sickness absence during follow-up for four combinations of job demands

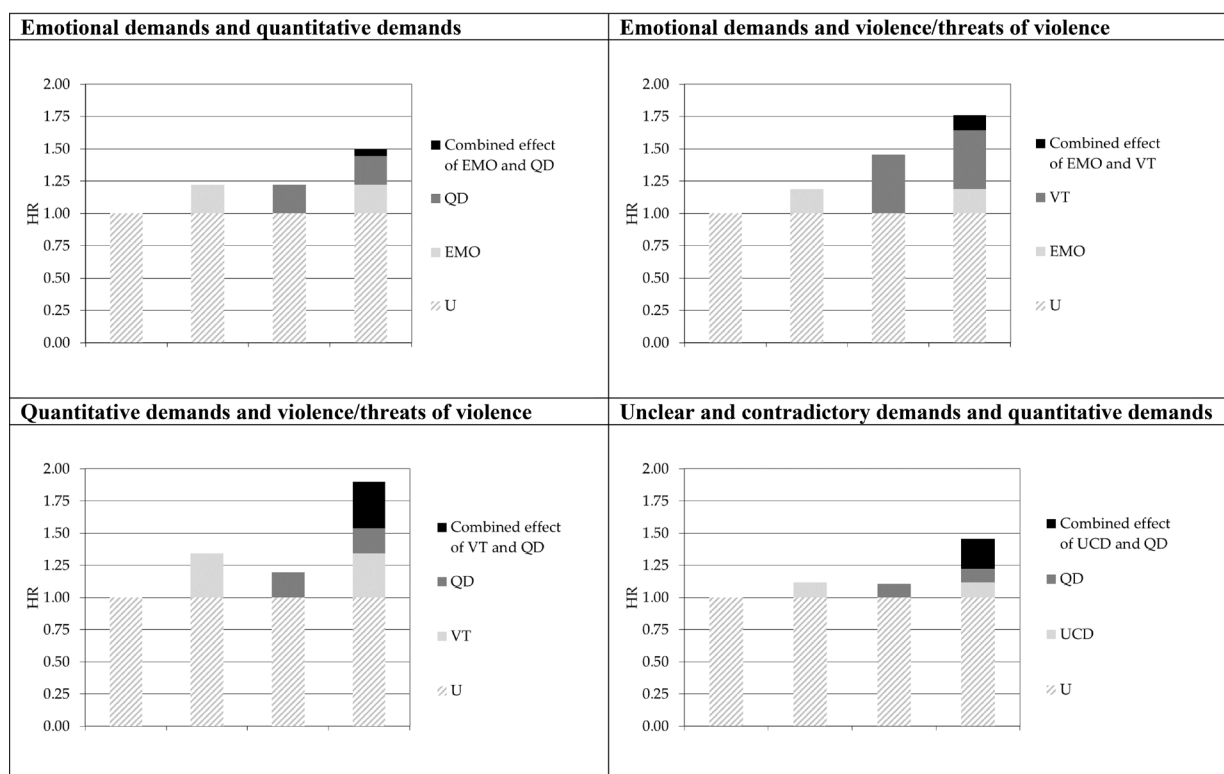
	At risk N	Cases N (%)	HR	95% CI	RERI	95% CI
Combination: emotional demands and quantitative demands (Pearson's $r=0.11$ )						
Low emotional demands and low quantitative demands	12 160	410 (3.4)	1	Ref	0.06	-0.15 to 0.26
High emotional demands and low quantitative demands	12 846	568 (4.4)	1.22	1.07 to 1.39		
High quantitative demands and low emotional demands	10 845	402 (3.7)	1.22	1.06 to 1.40		
High emotional demands and high quantitative demands	17 964	910 (5.1)	1.5	1.33 to 1.70		
Combination: emotional demands and violence/threats of violence (Pearson's $r=0.22$ )						
Low emotional demands and no exposure to violence/threats of violence	22 261	776 (3.5)	1	Ref	0.12	-0.43 to 0.66
High emotional demands and no exposure to violence/threats of violence	25 600	1118 (4.4)	1.19	1.08 to 1.31		
Exposure to violence/threats of violence and low emotional demands	622	32 (5.1)	1.46	1.02 to 2.08		
High emotional demands and exposure to violence/threats of violence	5034	342 (6.8)	1.76	1.53 to 2.02		
Combination: quantitative demands and violence/threats of violence (Pearson's $r=0.06$ )						
Low quantitative demands and no exposure to violence/threats of violence	22 776	853 (3.7)	1	Ref	0.36	0.01 to 0.71
High quantitative demands and no exposure to violence/threats of violence	25 147	1040 (4.1)	1.34	1.10 to 1.64		
Exposure to violence/threats of violence and low quantitative demands	2131	113 (5.3)	1.2	1.09 to 1.31		
Exposure to violence/threats of violence and high quantitative demands	3525	260 (7.4)	1.9	1.64 to 2.20		
Combination: unclear and contradictory demands and quantitative demands (Pearson's $r=0.22$ )						
Low unclear and contradictory demands and low quantitative demands	16 544	639 (3.9)	1	Ref	0.23	0.04 to 0.42
High unclear and contradictory demands and low quantitative demands	12 664	507 (4.0)	1.12	0.98 to 1.28		
High quantitative demands and low unclear and contradictory demands	8473	340 (4.0)	1.11	0.98 to 1.24		
High unclear and contradictory demands and high quantitative demands	16 143	804 (5.0)	1.46	1.31 to 1.62		

RERI was calculated using the following formula:  $RERI = H_{R1} - H_{R1} - H_{R0} - H_{R01} + 1$ . All analyses are adjusted for sex, age, educational attainment and job group. RERI, relative excess risk due to interaction.

the combined effects of self-reported exposures in the work environment.<sup>13 26–28</sup>

The results of this study suggest that the simultaneous presence of two job demands are associated with increased risk of LTSA, and this increased risk either manifests itself through additive or superadditive effects. Previous studies have found that high

levels of job demands and negative acts may increase the risk of burn-out<sup>14 29 30</sup> and other adverse health-related outcomes,<sup>31–34</sup> which again may increase the risk of sickness absence. Following the conservation of resources (COR) theory,<sup>35</sup> workers invest their resources to deal with job demands in the work situation. A work environment, where workers have to deal with



**Figure 1** Plots of associations between four combinations of job demands and risk of long-term sickness absence. EMO, emotional demands; QD, quantitative demands; UCD, unclear and contradictory demands; U, common reference category; VT, violence/threats of violence.

high levels of job demands may contribute towards depleting psychological and/or physiological resources in workers, which is likely to reduce their ability to deal successfully with additional job demands or negative acts in the work environment. In COR-theory such dynamics are labelled ‘loss spirals’<sup>12 35</sup> and the concept of loss spirals may contribute to our understanding of the dynamics at play when analysing how combinations of job demands are associated with risk of LTSA through additive or superadditive effects.

This study provides new knowledge on the consequences of combinations of job demands in the psychosocial work environment. By pointing towards the consequences of combinations of job demands, the findings are of importance to the prevention of negative health-related consequences from adverse psychosocial working conditions. Moreover, results not shown in the present paper show that the investigated combinations are most prevalent among human service professions. Accordingly, to prevent cases of LTSA and enhance worker retention, it may be relevant for work environment authorities, managers and human resource-professionals to pay particular attention to the presence of combinations of job demands in the psychosocial work environment. Another possible avenue for the prevention of LTSA may be to ensure the presence of job resources<sup>14 36</sup>—for example, job control and social support in the psychosocial work environment. This is particularly relevant in case of job demands—for example, high emotional demands and violence and threats—that may prove difficult to prevent in specific types of work. Although previous studies indicated that job resources might contribute to alleviating the adverse consequences of job demands or negative acts<sup>18–20</sup> it cannot be taken for granted, however, that the availability of job resources may offset the entire risk of LTSA associated with combinations of job demands that we investigated in this study.

### Limitations and strengths

It may be a limitation of the study that we used median split to operationalise high levels of quantitative demands, emotional demands and unclear and contradictory demands, thereby considerably reducing the complexity of the predictor variables. The median split, however, is a requirement in the selected method for analysing additive interaction. Another limitation may be that we have no information on the types of diagnoses the observed cases of LTSA are based on. It could be expected that self-reported exposure to combinations of job demands was associated with absence related to mental health disorders, but it is not possible to test this hypothesis. It is also a limitation that one of the two items used to measure emotional demands was changed from the 2012 wave of the WEHD to the subsequent waves. It must be noted, however, that the interitem correlations were similar in all three waves, which leads us to conclude that the two different measures of emotional demands offer comparable measures of the same underlying construct. The correlation between the two items used to assess unclear and contradictory demands is low. This may be considered a limitation of the study. Moreover, we excluded participants with LTSA for more than six consecutive weeks during the 2 years prior to baseline. It was not possible to exclude participants with shorter absence periods. This may constitute a source of reporting bias. Additionally, the response rate was 50%, which implies a risk of selection bias in the study population. These potential sources of bias must be taken into account in the interpretation of the results. Another limitation may be that we measured the four job demands at the same point in time and, accordingly, it was not possible to

test possible mediating relationships between exposure variables. This may be examined in future studies. Finally, it can be debated whether it is appropriate to label violence/threats of violence as a job demand. However, following the Job-Demands-Resources model,<sup>14</sup> job demands are defined as ‘physical, psychological, social or organizational aspects of the job that require sustained [...] effort and are therefore associated with certain physiological and/or psychological costs’ (p296), and in this perspective, it does not seem unreasonable to label violence/threats of violence as a job demand.

These limitations, however, must be balanced against several strengths. This study adds to the literature by providing prospective evidence from a large study population (>55 000 participants) on the potential interaction between job demands in predicting adverse health-related outcomes. Moreover, the outcome is measured using a register-based measure, which reduces reporting biases and the loss of participants during follow-up. Therefore, this study design allows for inference on the direction of the observed associations and reduces potential biases associated with common methods variance.<sup>21</sup>

### CONCLUSIONS

This study found that combinations of job demands in the psychosocial work environment were associated with an increased risk of LTSA. For the combinations of high emotional demands and high quantitative demands and high emotional demands and violence/threats of violence this study found indications of additive effects. For the combinations of violence/threats of violence and high quantitative demands and unclear and contradictory demands and high quantitative demands we found an excess risk of LTSA above additivity (ie, superadditivity).

The results are important for work-related prevention of adverse health-related outcomes and provide new knowledge by attempting to grasp the complexity of the psychosocial work environment.

**Contributors** All authors contributed to the design of the study. JKS, LD and TC performed the data analysis. TC wrote the first draft of the manuscript. All authors contributed significantly to the preparation of the manuscript and all authors approved the final version of the manuscript. TC is responsible for the overall content of the study as guarantor.

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**Patient consent for publication** Not applicable.

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**Data availability statement** Data are available on reasonable request. The data that this study is based upon may be shared on reasonable request to the corresponding author.

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