






# BMJ Open Prediction of violence or threat of violence among employees in social work, healthcare and education: the Finnish Public Sector cohort study

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## ABSTRACT

**Objectives** To develop a risk prediction algorithm for identifying work units with increased risk of violence in the workplace.

**Design** Prospective cohort study.

**Setting** Public sector employees in Finland.

**Participants** 18 540 nurses, social and youth workers, and teachers from 4276 work units who completed a survey on work characteristics, including prevalence and frequency of workplace violence/threat of violence at baseline in 2018–2019 and at follow-up in 2020–2021. Those who reported daily or weekly exposure to violence or threat of violence daily at baseline were excluded.

**Exposures** Mean scores of responses to 87 survey items at baseline were calculated for each work unit, and those scores were then assigned to each employee within that work unit. The scores measured sociodemographic characteristics and work characteristics of the work unit.

**Primary outcome measure** Increase in workplace violence between baseline and follow-up (0=no increase, 1=increase).

**Results** A total of 7% (323/4487) of the registered nurses, 15% (457/3109) of the practical nurses, 5% of the social and youth workers (162/3442) and 5% of the teachers (360/7502) reported more frequent violence/threat of violence at follow-up than at baseline. The area under the curve values estimating the prediction accuracy of the prediction models were 0.72 for social and youth workers, 0.67 for nurses, and 0.63 for teachers. The risk prediction model for registered nurses included five work unit characteristics associated with more frequent violence at follow-up. The model for practical nurses included six characteristics, the model for social and youth workers seven characteristics and the model for teachers included four characteristics statistically significantly associated with higher likelihood of increased violence.

**Conclusions** The generated risk prediction models identified employees working in work units with high likelihood of future workplace violence with reasonable accuracy. These survey-based algorithms can be used to target interventions to prevent workplace violence.

## INTRODUCTION

Workplace violence encompasses a wide range of offensive behaviours. According to the

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ We had data on nurses, social and youth workers, and teachers allowing us to create prediction models that consider the unique work unit characteristics of each occupation.
- ⇒ Bootstrapped-enhanced least-absolute-shrinkage-and-selection-operator regression allowed us to identify the most robust work unit-level predictors of increased workplace violence.
- ⇒ Using work unit-level predictors had the upside of being able to identify employees working in units where the risk of workplace violence is likely to rise in the future, but at the same time, these predictors overlook individual characteristics that could contribute to this increased risk.

International Labour Organization (ILO), it includes ‘any action, incident or behaviour that departs from reasonable conduct, resulting in the assault, threat, harm or injury of a person in the course of, or as a direct consequence of, their work’.<sup>1 2</sup> Violence in the workplace can take the form of physical or mental abuse, which may involve verbal threats, throwing objects, hitting, kicking or the use or threat of a weapon. The ILO emphasises that the perpetrator could be an unrelated criminal, a current or former colleague, supervisor, manager or an individual with a personal relationship to an employee but no workplace affiliation. However, the most prevalent form of workplace violence typically involves individuals associated with the organisation’s services, such as customers, clients, patients, students or others.

Exposure to workplace violence is associated with various adverse outcomes, including turnover intentions,<sup>3</sup> sleep problems,<sup>4</sup> mental distress,<sup>5</sup> mental disorders<sup>6–8</sup> and even suicide.<sup>9</sup> In the public sector, violence or threats from patients, pupils, clients or customers have been reported more often

by women, younger employees, nurses and teachers.<sup>10</sup> High job demands in nurses and teachers<sup>11–13</sup> and organisational injustice in teachers<sup>4</sup> have also been linked to an increased likelihood of workplace violence in these occupations. However, to date, no previous studies have employed data-driven approaches to examine the interaction of multiple predictors with likelihood of increased violence.

Our objective was to assess the extent to which work unit characteristics can predict the increase in violence or threat of violence in occupations prone to such incidents, including nurses, social and youth workers, and teachers.<sup>10</sup> Work unit data were obtained by aggregating employee responses from standard workplace surveys. To comprehensively capture multiple predictors, we examined a wide range of potential predictors at the work unit level. These included sociodemographic characteristics such as age and sex distribution, and work characteristics, including psychosocial work environment, and turnover and retirement intentions. Since predictors of workplace violence may vary across occupations, we developed separate predictive models for each occupation.

## METHODS

### Study design and participants

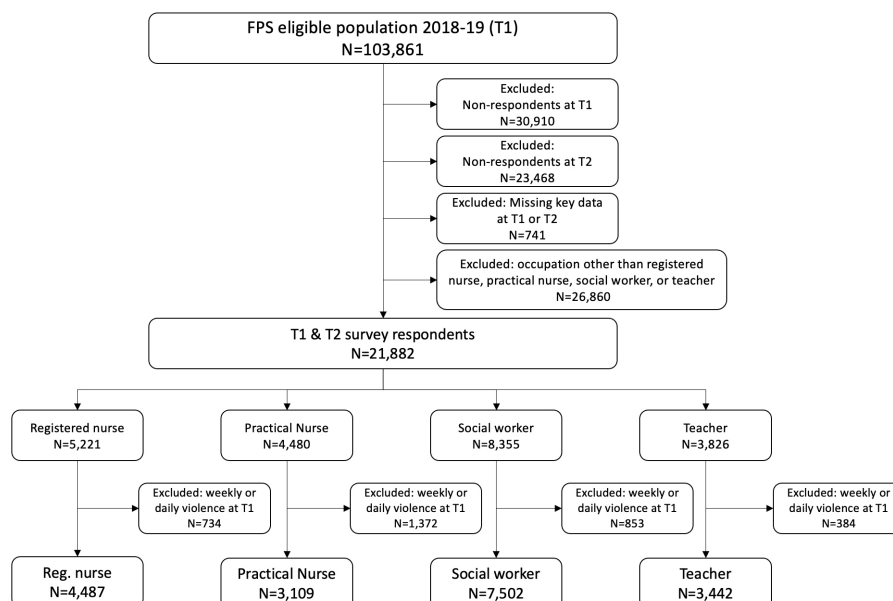
This observational prospective multiwave cohort study is based on the Finnish Public Sector (FPS) study including personnel of 11 cities and 5 public sector health and social care organisations.<sup>14</sup> We used data from two survey waves of the FPS, the first conducted in 2018–2019 (T1) and the second in 2020–2021 (T2). The response rate was 71% in both T1 and T2. Responding to the survey was voluntary.

The sample selection is described in figure 1. We focused on occupational groups in which violence is common, that is, registered nurses (n=4487), practical

nurses working either in healthcare, elderly care or childcare (n=3109), social workers and youth counselors (n=3442), and teachers (n=7502). We excluded participants who reported frequent exposure (ie, daily or weekly) to workplace violence already at T1 and those with missing data on workplace violence at T2. The included participants were those who responded to a workplace survey at T1, reported encountering violence or threat of violence at workplace monthly, less often or not at all at T1, and responded to questions on frequency of workplace violence (daily, weekly, monthly, less often, not at all) at T1 and T2. The total number of included participants was 18 540 from 4276 work units. We computed mean scores of their responses to workplace survey items at baseline for each work unit and assigned those mean scores to each participant within that respective work unit. We used these aggregated survey responses at T1 to predict the increase in workplace violence at T2.

### Measures

Violence/threat of violence at work was measured with self-reports at T1 and T2 using the following question: ‘Have any of the following violent or threatening confrontations involving clients happened to you over the past 12 months?’ (yes/no): (1) throwing or breaking things; (2) mental abuse (eg, verbal threats); (3) physical violence (eg, hitting, kicking); (4) threatening with a weapon (firearm, edged weapon, striking weapon). ‘yes’ to any kind of violence was coded as 1, and ‘no’ to all was coded as 0. If the respondent replies ‘yes’, we asked how often confrontations had happened using the following response format: ‘daily’, ‘weekly’, ‘monthly’, ‘less frequently’ and ‘no violence/threat of violence’. Our outcome was dichotomous: increase in workplace violence versus no increase in workplace violence. As we only included in study participants who reported



**Figure 1** Flow chart of the sample selection. FPS, Finnish Public Sector.

encountering violence or threat of violence at workplace monthly, less often or not at all at T1, increase in workplace violence was indicated if the participant reported violence or threat of violence at workplace on weekly or daily basis at T2. Those participants who reported workplace violence or threat of workplace violence monthly, less often or not at all at T2 belonged to the group of 'no increase in workplace violence'.

The predictor variables were individual survey responses aggregated to work unit level (87 variables). In addition, organisational records on employee turnover and number of employees were aggregated to work unit level resulting in a total of 89 predictor variables on sociodemographic characteristics, work characteristics, psychosocial work environment factors, leadership, turnover and retirement intentions in each work unit. Detailed description is provided in online supplemental appendix 1, but a bullet-point list of the predictors follows:

- ▶ Sociodemographic characteristics of the work unit
  - Mean age.
  - Proportion of women.
  - Proportion of full-time and part-time employees.
  - Proportion of temporary employees.
  - Proportion of managers and specialists (ie, employees with high occupation-based socioeconomic status).
  - Proportion of manual workers (ie, employees with low occupation-based socioeconomic status).
  - Proportion of day workers.
  - Proportion of shift workers.
  - Mean length of employment.
  - Years in shift work.
  - Turnover.
  - Work unit size.
- ▶ Work characteristics
  - Five items on job demands.<sup>15 16</sup>
  - Nine items on job control.<sup>15 16</sup>
  - One item on effort at work.<sup>17</sup>
  - Three items on work rewards.<sup>17</sup>
  - Seven items on worktime control.<sup>18 19</sup>
  - Five items on job insecurities.<sup>20 21</sup>
  - Two items on changes at work.
  - Seven items on procedural justice.<sup>22</sup>
  - Six items on relational justice.<sup>22</sup>
  - Four items on supervisor support.
  - Four items on support from the work unit to supervisor.
  - Two items on performance appraisals/career development discussions: having had such a discussion within the last 12 months, and whether the discussion was perceived useful.<sup>23</sup>
  - Fourteen items on team climate on four dimensions: safety, support for innovation, vision and task orientation.<sup>24 25</sup>
  - One item on discrimination at work: Is there discrimination due to age, gender, education, opinion, status, origins, language, religion, believes/convictions, political activity, trade union activity,

health, disability, sexual orientation, or gender identity/gender expression?<sup>26</sup>

- Five items on job satisfaction.
- One item on retirement intentions.
- one item on turnover intentions.

The response format in most of the items in the survey was a five-point scale from 1=strongly agree to 5=strongly disagree. For ease of interpretability, we reverse-coded the items so that more was more, that is, a higher score always indicated a stronger agreement. The survey form, which includes all the items that are based on previous research, is also provided in online supplemental appendix 2.

### Statistical analysis

We generated risk prediction models separately for four occupational groups: registered nurses, practical nurses, social and youth workers, and teacher. For each occupational group, we split our data into training and test datasets with a 75/25 split, stratifying for the outcome. The training dataset was used to develop the prediction model and the test dataset was used to test the predictive validity of the model in an independent dataset.<sup>27</sup> These dataset were stratified by the outcome to ensure that the proportion of those reporting violence or threat of violence at T2 was the same in both datasets. We used bootstrap-enhanced least-absolute-shrinkage-and-selection-operator (LASSO) with logistic regression to create our prediction model. In selecting our final predictors, we used 10-fold cross-validation and determined the optimal lambda value.<sup>27</sup> With the optimal lambda value, we can find a sparse model that balances between simplicity, that is a model with a small number of predictors, and precision, a model with good predictive performance.

We standardised all predictors for LASSO, and the final predictors selected by regular LASSO may vary based on the sample and how strongly the predictors are correlated. However, with bootstrap-enhanced lasso, the final predictors are selected based on a set proportion of the bootstrap replications. For our study, we used 100 bootstrap replications and set the threshold for predictor selection to 95%.

We then used the predictors retained from the bootstrap-enhanced LASSO model to fit a model to the training dataset, which was used to predict the outcome in the test data. It is important to note that the variables retained by LASSO are a result of optimising for the number of variables in the model and overfitting, so not all variables may be statistically significant in the final model. To evaluate the performance of our models, we compared our predictions against the observed cases of increased violence, plotted an receiver operating characteristic (ROC) curve, and computed the area under the curve (AUC). We also plotted the predicted probabilities for increased violence cases for ease of risk comparison between those who reported encountering violence more often and those who did not.

As a sensitivity analysis, we recreated prediction models using backward stepwise regression. We set a limit on

**Table 1** Characteristics of the study participants at baseline (T1) by occupational group

	Registered nurses (n=4487)	Practical nurses (n=3109)	Social and youth workers (n=3442)	Teachers (n=7502)	P for difference between groups
Work unit size, mean (SD)	27.2 (30.9)	23.4 (24.7)	25.7 (42.0)	33.2 (25.2)	<0.001
Sex, %					
Men	8.2	11.8	17.0	25.5	<0.001
Women	91.8	88.2	83.0	74.5	
Age, mean (SD)	44.3 (3.7)	44.3 (4.0)	45.0 (4.2)	46.0 (3.2)	<0.001
Working time, %					
Full time	91.8	91.3	95.9	95.8	<0.001
Part time	8.2	8.7	6.1	4.2	
Type of work, %					
Day work	53.7	28.8	72.4	96.7	<0.001
Shift work*	46.3	71.2	18.6	3.3	<0.001
Increased violence from T1 to T2, %	7.2	14.7	4.7	4.8	<0.001

\*Shift work and other irregular working times.

the number of predictors to match those selected by the LASSO models. We tested the performance of these models using the same methods as the LASSO models. All data analyses were performed using R (V.4.1.2), RStudio (V.2021.09.2), and packages bolasso (V.0.1.0) and glmnet (V.4.1-4). The study was conducted according to the Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) guideline.

### Patients and public involvement

No patients or members of the public were involved in the design, conduct or reporting of this research.

### RESULTS

The descriptive characteristics of the study population (ie, those who had encountered violence monthly, less often or not at all at T1) are shown in table 1. A total of 7% (323/4487) of the registered nurses, 15% (457/3109) of the practical nurses and 5% of the social and youth workers (162/3442) and teachers (360/7502) reported increased workplace violence.

### Selection of variables to prediction of increased risk of workplace violence

Variable selection was performed separately for each occupational group. Five variables were statistically significantly associated with increased violence at work among registered nurses. Working in a unit where employees reported that their work required strenuous effort (OR 1.62, 95% CI 1.16 to 2.26) and having influence over shift arrangements (OR 2.53, 95% CI 1.82 to 3.52) were associated with higher odds of increased violence. A higher percentage of temporary employees (OR 1.16, 95% CI 1.04 to 1.30) and higher percentage of manual workers in the work unit (OR 1.13, 95% CI 1.08 to 1.19) were also associated with higher odds of increased violence. Receiving rewards from work through personal satisfaction was associated with lower odds of increased violence

(OR 0.33, 95% CI 0.20 to 0.54) (table 2). The sensitivity analysis using backwards stepwise regression analysis was largely like the main model. ‘Threat of redundancy’ was the only additional variable statistically significantly associated with increased risk of violence (online supplemental appendix 3, table A).

Eleven variables were selected for practical nurses including eight variables statistically significantly ( $p < 0.05$ ) associated with increased violence at work in a multivariable analysis. Working in a unit where employees actively provide their supervisor with information about work-related matters (OR 2.62, 95% CI 1.66 to 4.14), where work required learning new skills (OR 2.22, 95% CI 1.29 to 3.81) but also included many similar, repetitive tasks (OR 1.77, 95% CI 1.17 to 2.69) were associated with higher odds of increased violence. Protective factors (ie, variables that were associated with lower odds of increased violence) were working in a unit with high task variety (OR 0.37, 95% CI 0.23 to 0.58), where everyone felt understood and accepted (OR 0.53, 95% CI 0.37 to 0.77), having enough time to get work done (OR 0.70, 95% CI 0.56 to 0.87), working in a unit with day work (OR 0.82, 95% CI 0.77 to 0.88) and in units with a higher turnover rate (OR 0.90, 95% CI 0.83 to 0.98) (table 2). The sensitivity analysis produced a set of variables corresponding to the main model but including additionally threat of redundancy, higher decision latitude and higher work-time control associating with increased risk of violence (online supplemental appendix 3, table B).

The predictors selected for social workers included seven variables, all reaching statistical significance ( $p < 0.05$ ). Work units with varying tasks (OR 3.17, 95% CI 1.47 to 6.82), higher percentage of discrimination at the work unit (OR 1.21, 95% CI 1.01 to 1.45) and more years shift work (OR 1.11, 95% CI 1.07 to 1.15) were associated with higher odds of increased violence. Protective factors against increasing violence were working in a unit where there were possibilities to take breaks (OR 0.29, 95% CI

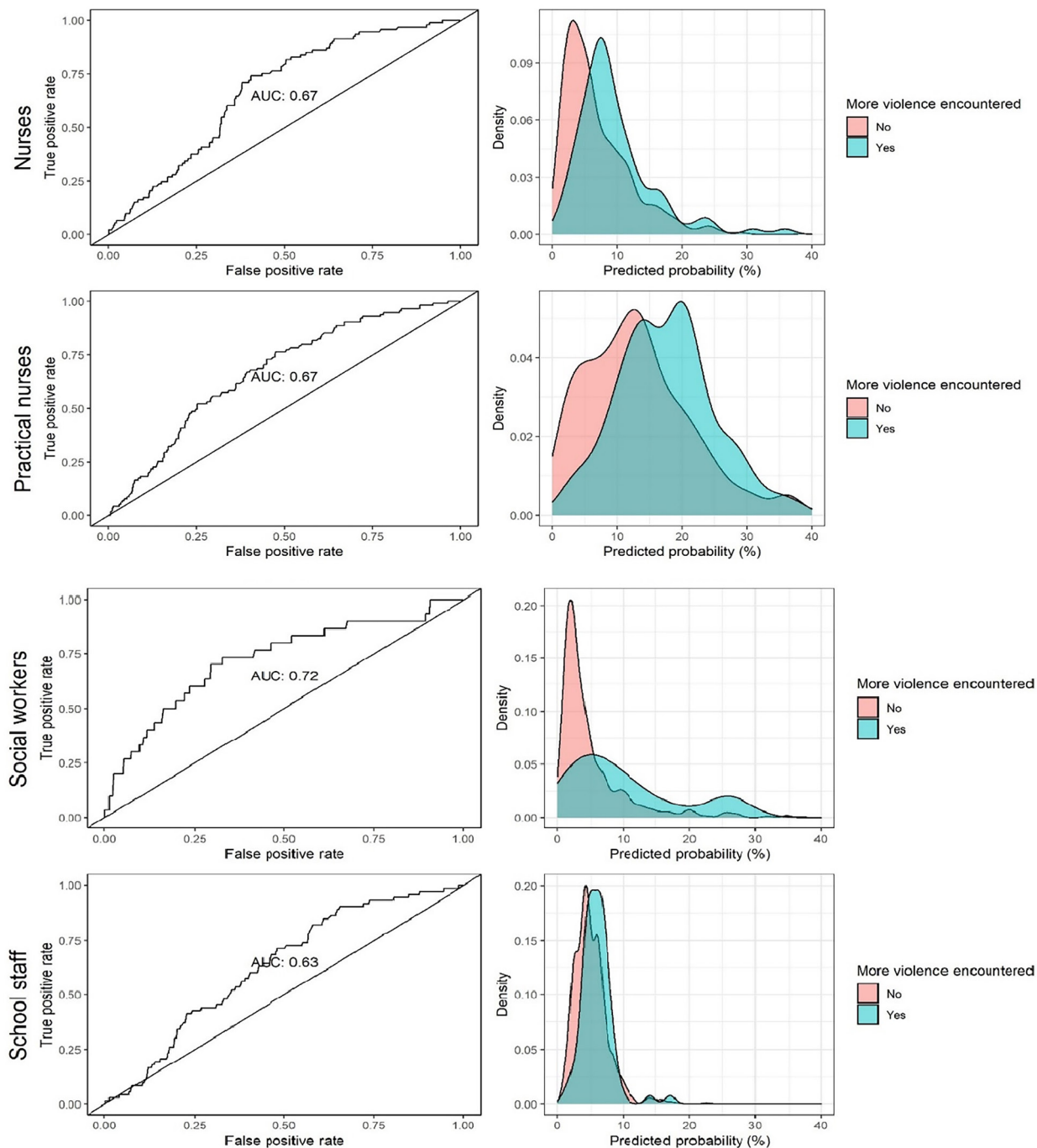
**Table 2** Work unit level predictors for increased violence among different occupational groups

Measure	Predictor variable (item)	OR	95% CI
Nurses (N=4487)			
Sociodemographics	%, temporary employees (per 10% increase)	1.16	1.04 to 1.30
Sociodemographics	%, manual workers (per 10% increase)	1.13	1.08 to 1.19
Job demands	Work requires very strenuous effort	1.62	1.16 to 2.26
Rewards from work	Rewards through personal satisfaction	0.33	0.20 to 0.54
Work time control	Influence over shift arrangements	2.53	1.82 to 3.52
Work time control	Influence over timing of vacations	0.92	0.59 to 1.43
Practical nurses (N=3109)			
Sociodemographics	%, manual workers (per 10% increase)	1.00	0.95 to 1.06
Sociodemographics	%, turnover (per 10% increase)	0.90	0.83 to 0.98
Sociodemographics	%, day work (per 10% increase)	0.82	0.77 to 0.88
Job demands	Enough time to get the work done	0.70	0.56 to 0.87
Job control (skill discretion)	Work requires learning new skills	2.22	1.29 to 3.81
Job control (skill discretion)	Work includes many similar, repetitive tasks	1.77	1.17 to 2.69
Job control (skill discretion)	Work includes different tasks (task variety)	0.37	0.23 to 0.58
Work time control	Influence over taking leave	0.87	0.66 to 1.15
Job insecurity	Threat of involuntary transfer to other work tasks	0.87	0.69 to 1.09
Team climate (safety)	Everyone feels understood and accepted in work unit	0.53	0.37 to 0.77
Support to supervisor	Employees actively provide the supervisor with information about work-related matters	2.62	1.66 to 4.14
Social workers (N=3442)			
Sociodemographics	Mean age (per 10-year increase)	0.55	0.36 to 0.86
Sociodemographics	%, manual workers (per 10% increase)	0.86	0.78 to 0.94
Sociodemographics	Years in shift work (per 1-year increase)	1.11	1.07 to 1.15
Job control (skill discretion)	Work requires creativity	0.41	0.23 to 0.74
Job control (skill discretion)	Work includes different tasks (task variety)	3.17	1.47 to 6.82
Work time control	Possibility to take breaks during the workday	0.29	0.21 to 0.40
Team climate (safety)	Discrimination at work unit (per 10% increase)	1.21	1.01 to 1.45
Teachers (N=7502)			
Sociodemographics	%, temporary employees (per 10% increase)	1.01	0.92 to 1.12
Sociodemographics	%, turnover per (10% increase)	1.31	1.13 to 1.51
Job control (decision latitude)	A lot of independent decisions in work	0.34	0.20 to 0.57
Job control (skill discretion)	Work requires creativity	2.74	1.15 to 6.55
Job control (skill discretion)	Work includes different tasks (task variety)	4.41	1.91 to 10.2
Support to supervisor	Work unit supports their supervisor	0.94	0.65 to 1.37
Team climate (goal clarity)	Members of the work unit understand their goals	0.91	0.54 to 1.53

Statistically significant associations are coloured.

0.21 to 0.40), where the work required creativity (OR 0.41, 95% CI 0.23 to 0.74), with higher mean age (OR 0.55, 95% CI 0.36 to 0.86) and more employees in manual occupations (OR 0.86, 95% CI 0.78 to 0.94) (table 2). The sensitivity analysis produced a set of variables corresponding to that in the main model but including contradicting associations of supervisory behaviours with increased risk of violence (online supplemental appendix 3, table C).

The set of predictors for teachers included seven variables, four reaching statistical significance ( $p < 0.05$ ). Variables associated with higher odds of increased violence were working in a school with high task variety (OR 4.41, 95% CI 1.91 to 10.2), high creativity (OR 2.74, 95% CI 1.15 to 6.55) and higher turnover rate (OR 1.31, 95% CI 1.13 to 1.51). In turn, working in a school with higher decision latitude among the teachers (OR 0.34, 95% CI



**Figure 2** Model performance by occupation. Left side: Receiver operating characteristic curve for work unit-level prediction for encountering more violence ( $\lambda = \min + 1$  standard error). Right side: Density plot for encountering more violence at T2 by predicted probability (logistic regression, work unit-level predictor variables). AUC, area under the curve.

0.20 to 0.57) was associated with lower odds for increased violence (table 2). The sensitivity analysis produced a set of predictors largely corresponding to that in the main model but included unexpected associations of beneficial goals and low threat of discontinuation of assignments with increased risk of violence (online supplemental appendix 3, table D).

### Model performance

The ROC curves and density plots for the models constructed using the LASSO-selected variables are

shown in figure 2. The curves of those encountering more violence and those not, were largely overlapping. The AUC scores were between 0.63 and 0.72, the best model performance achieved by the model in social and youth workers (AUC=0.72) and the poorest performance in the model on teachers (AUC=0.63). The model performance of sensitivity analysis was like main models and shown in online supplemental appendix 3, figure A.

Table 3 shows detection rate, false positive rate and ratio of true to false positive for the two models using various

**Table 3** Detection rate (%), false positive rate (%) and ratio of true to false positive for predictive probability using various risk thresholds

	Predictive probability of increased violence for cut-off of a positive test result						
	5%	10%	15%	20%	25%	30%	35%
<b>Nurses</b>							
Detection rate	83.9	34.4	15.1	6.5	2.2	2.2	1.1
False positive rate	55.0	21.8	8.4	2.7	0.87	0.10	0.10
Ratio true to false positive	1/7	1/7	1/6	1/5	1/5	½	1/1
<b>Practical nurses</b>							
Detection rate	94.8	85.2	61.7	35.7	18.3	8.7	6.1
False positive rate	82.5	63.5	37.0	19.9	9.7	5.9	3.8
Ratio true to false positive	1/5	1/4	1/4	1/3	1/3	1/4	¼
<b>Social and youth workers</b>							
Detection rate	70.0	40.0	26.7	20.0	20.0	3.3	3.3
False positive rate	29.6	12.8	6.3	3.5	2.5	0.96	0.36
Ratio true to false positive	1/12	1/12	1/9	1/7	1/5	1/4	1/3
<b>Teachers</b>							
Detection rate	64.4	2.7	1.4	–	–	–	–
False positive rate	44.1	3.8	0.89	–	–	–	–
Ratio true to false positive	1/17	1/35	1/16	–	–	–	–

risk thresholds for test positive result. For a 5% cut-off for positive test results (ie, increased violence in follow-up), the detection rate was 64% for teachers, 70% for social and youth workers, 84% for registered and public health nurses, and 95% for practical nurses. The corresponding true to false ratios for positive test result were 1 to 5–17. That is, while many cases were detected, this came at a price of many false positives, that is, cases where violence did not increase despite our prediction. With 15% cut-off as the threshold, detection rate decreased, but false positive rate did not improve markedly. The detection and false positive rates and ratios of true to false positives of the sensitivity analysis are shown in online supplemental appendix 3, table E.

## DISCUSSION

This cohort study of 18 540 nurses, social and youth workers, and teachers identified several independent predictors of increased violence including sociodemographic characteristics of the work unit, demands of the job (haste and lack of time) and job control (skill discretion, decision latitude and work time control) and safety of the team climate at the work unit. Occupational group-specific risk prediction algorithms generated using those variables showed reasonable predictive power for social and youth workers and for nurses, but rather low predictive power for teachers.

We are not aware of previous studies on prediction algorithms for workplace violence, but the predictors, including sociodemographic factors, observed in this study agree with pre-existing evidence on correlates of violence at work. High influence over work shifts in registered

nurses, low percentage of employees in day work in practical nurses and longer work history in shift work in social and youth workers marked higher likelihood of increased violence. All these items are indicators of working in shifts. Shift work has also previously been linked with risk of violence.<sup>28 29</sup> For other work unit characteristics, the direction of the association varied by occupation. High turnover rate at the work unit was a risk predictor (ie, associated with a higher likelihood of increased violence) among teachers, but it was associated with a slightly lower likelihood of increased violence among practical nurses. A previous study found an association between turnover intentions and workplace violence among nurses.<sup>8</sup> In our study, a higher turnover rate in work units where the practical nurses worked probably co-occurred with other characteristics related to lower violence risk. For example, higher turnover rate could characterise working in a unit in which violence is less common. Other inconsistencies in predictors between occupational groups involved the proportion of manual workers in the work unit. A larger proportion was associated with increased risk of violence in nurses, but reduced risk in social and youth workers. These inconsistencies warrant further investigation.

In addition to work unit-level sociodemographic characteristics, individual items of job demands and job control scales were most strongly associated with risk of increased violence. High job demands, such as high work pace and insufficient time to get the work done at the work unit, were associated with increased risk of violence among nurses. Among social and youth workers, possibilities to take breaks were associated with lower likelihood of increased violence. Supporting these findings, the review



articles have listed workload as one of the risk predictors for workplace violence in physicians,<sup>28</sup> and in nurses.<sup>29</sup> However, the evidence is inconclusive as there are major gaps in previous research: several studies were based on qualitative data, most quantitative studies are limited to cross-sectional data, and in some studies, the design was not reported.<sup>28 29</sup> Longitudinal evidence is largely lacking.

The relationship with items of job control and increased violence was complex. In the job demands-job control, (ie, JDJC model) on work stress,<sup>15 16</sup> job control is divided into skill discretion and decision latitude. Skill discretion includes task variety, and requirements for creativity and learning. High task variety at the work unit was a protective factor among practical nurses, but a risk predictor among teachers and social and youth workers. High creativity at the work unit was a protective factor for social and youth workers, but a risk predictor for teachers. High requirements for learning new things were a risk predictor for practical nurses. High decision latitude at the work unit (school) was a protective factor in teachers. As noted also previously, the associations of the dimensions of the JDJC-model on health and well-being may vary by occupation.<sup>30–32</sup>

The safety of the team climate (non-discrimination and acceptance) was shown to be associated with a lower likelihood of increased violence in practical nurses and social and youth workers. This would imply that horizontal psychosocial resources, as identified in previous research,<sup>33</sup> might be able to buffers against increase in violence. In turn, vertical resources, such and organisational justice or indicators of leadership quality,<sup>33</sup> did not predict increased risk of violence among the selected occupational groups.

### Strengths and limitations

The strengths of this study include a large baseline population of public sector employees from which we could select subgroups of occupational groups with a high risk of workplace violence. The survey data included several questions (89 item) from various themes including sociodemographic characteristics, work characteristics, workplace psychosocial stressors and resources, and job satisfaction, including retirement intentions. To test the robustness of our prediction models, we built them twice, first with LASSO and then with backward stepwise regression, both producing roughly similar risk prediction models. To increase the validity and practical useability of our results, we aggregated the predictor variables to represent work unit level situation. Use of work unit-aggregated variables decreases the role of response style and self-reporting bias. Second, identification of work units rather than individuals at high risk of increasing violence, is more useful for subsequent interventions.

This study has several limitations. First, as data only included four high-risk public sector occupational groups, generalising the findings to other groups is not possible. Additionally, relying on a self-reported measure of violence or threat of violence may lead to subjectivity

bias, possibly underestimating or overestimating violence prevalence. Furthermore, the predominantly female composition of the occupational groups in our study limits generalisability to other demographics. Using single items instead of full scales in our study may also be considered a limitation. However, we identified individual items with strong predictive ability and, by minimising survey items, increased tool usability. Future research should develop risk prediction models for other high-risk occupations like police and security guards. Exploring violence predictors in low-risk occupations, such as library workers, is also important. Unlike high-risk occupations with preventive tools and training, low-risk workers may lack resources to handle violent situations. Finally, the use of single items instead of full scales on questionnaire measures may be considered as a weakness of our study. However, as we aimed to develop a tool for employers with maximum useability, we needed to identify the individual items within the scales (ie, measures of latent constructs) that would provide the best predictive ability with minimum number of survey items.

### CONCLUSIONS

In the current study, we set out to develop risk prediction models at work unit-level for workplace violence using data collected from comprehensive workplace surveys. We achieved a satisfactory level of prediction accuracy, particularly for social and youth workers and nurses. The developed models may offer tools for employers to identify work units that are at higher risk of experiencing increased violence in the workplace. We found some shared factors among nurses and social and youth workers that predicted increased violence, such as shift work and high work demands, including a fast work pace, inadequate time and insufficient breaks. In addition, we observed that a supportive team climate may act as a protective factor against the escalation of violence.

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