Risk Management and Healthcare Policy

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

A Tool for Predicting Disability Pension Applications in the Finnish Public Sector: Sickness Absences as Early Indicators of Declining Work Ability

Petra Sohlman [1,2]

[1]Faculty of Management and Business Studies, Tampere University, Tampere, Finland; [2]Unit of Finance and Financial Planning, Keva, Helsinki, Finland

Correspondence: Petra Sohlman, Unit of Finance and financial planning, Unioninkatu 43, Keva, FI-00087, Finland, Email petra.sohlman@keva.fi

Purpose: Identifying employees at the greatest risk of work disability is critical to preventing early exit from the labor market. Understanding how different factors influence work disability risk in the years leading to a pension is important in preventing early exits. Our aim in this study is to model the risk factors for an employee applying for a disability pension by using a novel and extensive register dataset and to evaluate the predicted risk for different occupations in the workforce.

Methods: We use a logistic model to assess the risk of filing a first-time disability pension application using rich register data. We evaluate the performance of the model and finally present the evaluated risk distribution among current employees. Data are also included for short-term sickness absences, usually not available for register studies. A pension application is used as a follow-up to include employees whose application is rejected but who nonetheless carry a physician's note of diminished work ability, also a new approach to modeling work disability risk. The data cover all public sector occupations in Finland and their diverse disability risk profiles.

Results: The constructed risk model accurately and transparently predicts the disability pension application risk in different employee groups. Age, occupation, cumulative sickness days, and number of sickness spells of all lengths, including short ones, were positively associated with the risk; proximity of retirement age and high earnings were negatively associated. Validation measures allow for using the model in providing employers with risk profiles of their employees.

Conclusion: The developed model can be used as a tool for predicting the risk status of employee groups and for assessing the economic effects of sickness absences and disability pension risk. The modeling results reported here are already in practical use by public sector employers in Finland, eg, for early intervention.

Keywords: early intervention, health impact assessment and monitoring, working life, aging, short term sickness absences

Introduction

In the Nordic countries, the share of the working-age population receiving disability benefits is above the OECD average of 6%. Figures for Finland show that annual disability pension (DP) expenditure relative to GDP also exceeds the OECD average.[1] As the workforce continues to age, the economic dependency ratio is increasing across most of Europe, and the need to prolong working lives is widely recognized.[2,3] All these trends highlight the need for policies aimed at reducing social expenditure, extending working lives, and preventing pensioner income poverty. In the Finnish context, where a key focus is to prevent early exit from the labor market, the years leading to a disability pension present an important window of opportunity for extending working lives. It is critical to identify those employee groups that are at greatest risk of permanently losing their work ability.

In recent studies, it has been widely recognized that data driven occupational wellbeing management, early interventions that incorporate customized solutions to different work ability challenges, and comprehensive cost management that enables the evaluation of all aspects of work disability risk as well as commitment to a sustained benchmarking and networking process with healthcare, insurance providers, and other stakeholders are the key success factors in diminishing work disability costs as well as lengthening healthy working lives.[4–6] There is a need for managerial tools that are able to distill the essential,

https://doi.org/10.2147/RMHP.S585895
Received: 17 December 2025
Accepted: 5 April 2026
Published: 3 June 2026

up-to-date information on employees' diverse work ability challenges, translate these into comparable numbers, and aid in translating effects of disability risk into monetary terms.

Factors of Work Disability Risk

There is a considerable body of research on the sociodemographic risk factors of disability in the Nordic countries. This work has shown that long-term sickness absences (SA), age, gender, and occupational group, and income status are important factors in explaining individual-level risks, both in Finland and elsewhere.[7–18] A recent Finnish study found that the risk of disability retirement increased with increasing SAs in all occupations, and that especially long-term SAs are a strong indicator of disability risk.[7] The data in that study only included SAs of 10 days or longer. Another Finnish study suggested that long-term absence spells and the total number of annual sick days are predictors of a disability pension before age 55, but short spells (1–3 days) only when combined with other factors.[8]

The associations of long-term SAs with disability retirement differ between diagnostic groups, and the strength of these associations also depends on occupation and gender.[9] SAs have been found to be early markers of disability pension risk among Danish, Swedish, and Finnish employees. In Norwegian studies, age, underlying illness, long absences, earnings, and education emerged as predictors of disability risk.[10–15] Other Finnish studies have also reported increased SA rates for disability pensioners in the years preceding retirement.[16–18] Another Finnish study analyzed survey data of annual SAs preceding a DP and found associations between different SA trajectories and 10-year DP risk, using diagnosis, gender, and age as covariates.[19]

In Finland, the risk of applying for a disability pension has also been studied separately from the risk of being awarded a DP.[20] The findings showed that occupational class, age, and diagnosis influenced both risks: a white-collar occupation with a better employment history reduced the risk of applying but increased the odds for a pension being granted, while age increased both odds. Research into the risk factors of DP that uses large sociodemographic date-specific register data is scarce in Europe, and most of the existing work uses survey data to explore psychosocial workplace factors, which are outside the scope of this study.

Tools for Risk Evaluation

For practical purposes, the assessment of the combined effect of multiple risk factors requires a multifactorial model. Previous work largely entails evaluating the relationships, causal or descriptive, between pension risk and different predictors. For the task of building a useful risk evaluation tool, the predictors should be easily constructed in different contexts, allow for repeated measurement, and offer opportunity to varied interpretation. Recently, a prediction model was developed based on self-reported Finnish data where age, self-rated health, number of sickness absences in previous year, socioeconomic class, and several health and work-related factors are used to identify high-risk employees.[21,22] Another Finnish study suggested preventing several stressors from accumulating to enhance work ability.[23] A recent German study used administrative data to assess the risk of permanent work disability by developing a risk score to identify employees with unmet rehabilitation needs.[24] Data on occupation or short sickness absences were, however, not included in this analysis.

These models, however, rely on self-reported data or include no data on short SAs, occupation, and are able to target the risk when a pension has already been awarded.

Overall, a sustainable tool for repeated risk evaluation must be based on readily available and continuously updated register-based data that incorporates different risk factors comprehensively. Our previous work combined demographic and SA data to model new disability pensions.[25] However, we wanted to use pension applications as the risk outcome for a more proactive intervention tool, build a more parsimonious model for easier interpretation of risk factors in a practical management tool, and also include additional predictors in the model.

Therefore, a separate prediction model is needed for the public sector that is based on up-to-date register data, that includes all sickness absences of different lengths, and that can recognize earliest possible signs of work disability. Furthermore, the model needs to differentiate between age and occupational groups so that differences in how SAs and other factors are associated with the predicted risk of disability can be identified. It is generally assumed that the risks of work disability and SA patterns are different for younger and older employees, and that accumulating SA days may have very different consequences for those risks. The study is intended for the domain of predictive modeling rather than to show causal connections between disability risk and its constituents.

The SA data used in developing our model include all sickness-related absences from work, including short spells of less than 10 days, which in most cases are excluded from register-based research studies, although they represent roughly 85% of all SA days.[26] Furthermore in our study, a disability pension application (DPA) is used as a follow-up instead of a marker of passage into retirement, which means we can also include those employees whose applications are eventually rejected but who still carry a physician's diagnosis of diminished work ability. Rejected applications comprise approximately a third of all applications.[26] Considerations following from including also rejective decisions in the risk target are presented in Discussion. Our panel data cover a wide range of occupational classes and employees of different ages.

Our purpose in this study is to see how the DPA risk of Finnish public sector employees can be described using readily available register data. In the next chapters, we describe a logistic model for DPA risk, and the predictors used in the analysis. Next, we show how our model for predicting disability applications performs when compared to observed applications: the estimated risk for different employee groups is compared with the observed risk to evaluate the group-level performance of the model. We also show how risk profiles differ in age groups 45 and over in different occupations. Finally, we offer some closing remarks.

Sickness Absence and Disability Pension Rules in Finland

Under current pension rules in Finland, a disability pension may be granted to an individual whose ability to work has been reduced for at least 1 year because of illness, injury, or disability. The decision is always based on a medical assessment of the degree to which the employee's work ability is diminished, either permanently or long term. A DP may be granted either for a fixed term or until further notice. A fixed-term DP is called a cash rehabilitation benefit. Both types of pension may be payable as partial pensions, meaning that less rigorous criteria are applied to the degree of disability, that the amount of benefit paid out is reduced by one half, and that it is assumed the individual will continue to work part-time while receiving the benefit. Partial pensions can be upgraded into full pensions and cash benefits into permanent pensions if the disability persists or the individual's work ability diminishes further. A disability pension and cash rehabilitation benefit are usually preceded by a period of sickness allowance. Sickness allowance is payable for a maximum of 300 working days, and an application for DP is usually submitted before this limit is reached.[27]

Pension providers' statistics show that the transition from sickness allowance to full and permanent DP typically occurs via cash rehabilitation benefits and partial pensions. New disability pensions are mainly in the form of cash rehabilitation benefits, but most disability pensions are paid out as permanent, full-time disability pensions.[28] Therefore, it is reasonable to consider first DP applications as the first marker of a person's physician-evaluated diminished work ability.

In 2023, about 37% of all first-time applications for an earnings-related disability pension were rejected. In the public sector, the figure was slightly lower, 31%.[29] The most common reason for a negative pension decision is insufficient proof of a persistent and irreversible deterioration of work ability. Earlier research has found that 43% of these applicants are granted a DP in the four following years, and most spend at least part of their time outside employment.[29] The odds of applying for a disability pension rise sharply with age: 72% of applicants are 45 years or over, 52% are 55 or over when applying. The general minimum old-age pension limit in Finland is currently 65 years with incentives to lengthen the working life.[30]

This study is limited to disability pensions granted under the earnings-related pension system. Customers of the Social Insurance Institution with insufficient work history are not included.

Data and Methods

The data for this study were gathered from the administrative registers of the Finnish public sector pensions provider Keva. They consist of 222,321 municipal sector employees under the age of 65 with no previous history of disability pension applications. The data include date-specific records on employment spells, sickness spells, occupations, wages, as well as pension applications and pension payments in 2016–2021. The explanatory variables used in the analysis are described in Table 1. The data on sickness absences are reported by employers, with dates included for the beginning and end of each absence spell. Thus, absences of all lengths are included, also those shorter than 10 days, which usually are excluded in these studies. Employment and wage information consist of working spells, occupations, and pension-insured earnings, as recorded in the national incomes register. The data for this study comprised about 40% of municipal employees and came mainly from large and medium-sized municipalities as well as from large joint municipal authorities. Missing data was negligible, as we

Table 1 Description of the Explanatory Variables Used in Analysis

Explanatory Variable	All				No DP Application				DP Application			
	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max
Age, years	43.0	11.7	17.1	65.0	42.7	11.7	17.1	65.0	50.7	9.5	18.0	63.9
Gender: female	0.8	0.4	0.0	1.0	0.8	0.4	0.0	1.0	0.8	0.4	0.0	1.0
Proximity of old age pension limit	0.0	0.2	0.0	1.0	0.0	0.2	0.0	1.0	0.0	0.1	0.0	1.0
Annual wage earnings, thousand euros	29.0	19.0	0.0	371.0	29.0	19.2	0.0	371.0	28.6	14.0	0.0	178.0
Occupational risk group	5.2	1.7	2.0	10.0	5.2	1.7	2.0	10.0	5.9	1.6	2.0	10.0
Year	2.0	0.8	1.0	3.0	2.0	0.8	1.0	3.0	1.9	0.8	1.0	3.0
Cumul. annual SA days, previous year	10.2	23.4	0.0	365.0	8.7	18.6	0.0	365.0	41.5	62.4	0.0	365.0
N of SA spells previous year (1–5 days)	1.7	2.3	0.0	55.0	1.6	2.2	0.0	41.0	2.6	2.9	0.0	55.0
N of SA spells previous year (6–10 days)	0.2	0.5	0.0	7.0	0.1	0.4	0.0	7.0	0.4	0.7	0.0	6.0
N of SA spells previous year (11–15 days)	0.1	0.3	0.0	7.0	0.1	0.3	0.0	4.0	0.2	0.5	0.0	7.0
N of SA spells previous year (16–20 days)	0.0	0.2	0.0	4.0	0.0	0.2	0.0	3.0	0.1	0.3	0.0	4.0
N of SA spells previous year (21–25 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.2	0.0	3.0
N of SA spells previous year (26–30 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	2.0	0.0	0.2	0.0	3.0
N of SA spells previous year (31–45 days)	0.0	0.2	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.3	0.0	3.0
N of SA spells previous year (46–60 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.3	0.0	3.0
N of SA spells last year (over 60 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.4	0.0	3.0
Cumulative annual SA days, 2 yrs ago	9.0	20.0	0.0	365.0	8.1	17.5	0.0	365.0	27.9	45.2	0.0	365.0
N of SA spells 2 yrs ago (1–5 days)	1.6	2.2	0.0	40.0	1.5	2.1	0.0	36.0	2.6	2.8	0.0	40.0
N of SA spells 2 yrs ago (6–10 days)	0.1	0.4	0.0	8.0	0.1	0.4	0.0	8.0	0.4	0.7	0.0	7.0
N of SA spells 2 yrs ago (11–15 days)	0.1	0.3	0.0	7.0	0.1	0.2	0.0	4.0	0.2	0.5	0.0	7.0
N of SA spells 2 yrs ago (16–20 days)	0.0	0.2	0.0	4.0	0.0	0.2	0.0	3.0	0.1	0.3	0.0	4.0
N of SA spells 2 yrs ago (21–25 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.2	0.0	3.0
N of SA spells 2 yrs ago (26–30 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	2.0	0.0	0.2	0.0	3.0
N of SA spells 2 yrs ago (31–45 days)	0.0	0.1	0.0	4.0	0.0	0.1	0.0	3.0	0.1	0.3	0.0	4.0
N of SA spells 2 yrs ago (46–60 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.2	0.0	3.0
N of SA spells 2 yrs ago (over 60 days)	0.0	0.1	0.0	3.0	0.0	0.1	0.0	3.0	0.1	0.3	0.0	3.0

Abbreviations: DP, disability pension; SA, sickness absence.

were working with administrative records, where the data is comprehensive and complete. All data accessed complied with relevant data protection and privacy regulations as required for highly sensitive data.

To build the logistic model, the data is split into two parts. The first 3 years (2016–2018) of sickness and work data are first used for assessing the predictors. For the risk target, we consider a three-year follow-up (2019–2021), where a total of 2,969 employees (1.3%) filed an application for a disability pension. From these data, a random 10% sample was further separated aside for testing the model performance later. All pension types (full, partial, fixed-term, until further notice) were considered as homogeneous outcomes in the analysis: any new DP application filed during the follow-up was considered a positive outcome for the prediction model. Because our aim is to create a model that gives a snapshot evaluation of the overall disability risk using recent sickness absences, the follow-up begins immediately upon the end of the sickness absence data, ie., SAs that translate into a disability pension are included in the data. Workplace accidents (a specific benefit) were excluded from the SA data. Data selection is described in Figure 1.

Model for DP Application Risk

Previous research literature, institutional knowledge about early signals of disability, and the practical needs for applying the model in different environments guided the selection of variables. Also in practice, only predictors that are routinely available in administrative registers and can be updated regularly were considered.

We set out to build an individual-level model for the risk of filing a DPA during a three-year follow-up period by constructing the risk factor candidates. The annual number of SAs of different durations, annual accrued sickness days,

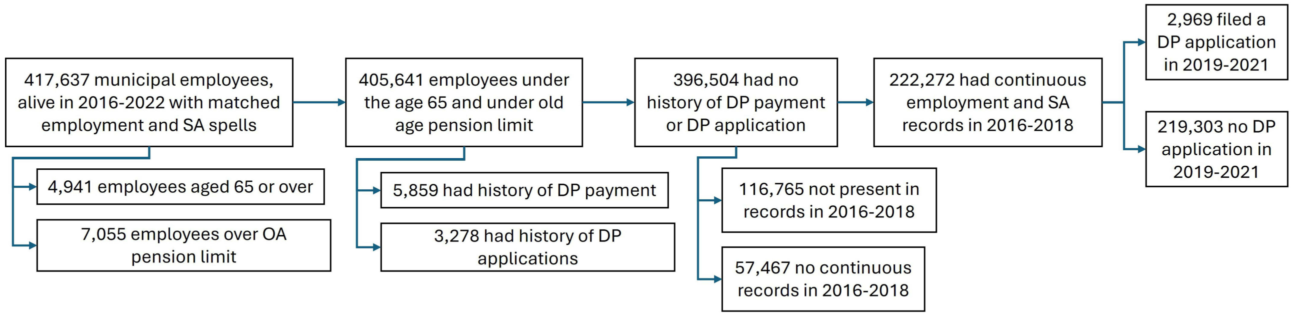

Figure 1 Data selection flow of the study population.

annual earnings, occupation, gender, proximity of old-age retirement, age, and interactions between these factors was all identified as candidates for risk factors.

SAs were reported as calendar days, and consecutive absences, where the end date of a previous spell is back-to-back with the start date of the next spell, were merged. In addition, the follow-up year was added as a variable to evaluate the significance of accrued follow-up time.

Occupation was included in the model by rating occupational groups according to their relative susceptibility to DPA. The variable "Occupational risk group" was constructed to measure differences in the ex-ante disability risk across occupations. First, all public sector occupations were aggregated to the ISCO-08 classification, and the relative DPA count for each class was measured during the latest 5 years before the follow-up period. Each occupational class was then ordered according to this ex-ante risk into 10 groups or bins. The resulting variable takes the values 1–10 and may be added to the risk model as a numerical variable. See also (25).

Proximity of old-age retirement was included as a variable 1/x, where $x \in \{1,2,3\}$ denotes the number of years to reaching retirement age.

Although prediction is the goal, interactions were not preferred in the model, because the practical use of the results for employers requires interpreting the individual predictors with odds values. In addition, AUC analyses suggested that interactions did not improve predictive performance, and thus focusing on the main effects was reasonable.

To assess overfitting, we considered the number of outcome events relative to the effective degrees of freedom in the model (EPV), which was 108. Although the traditional rule for EPV > 10 yields a useful reference, we primarily addressed overfitting through model parsimony, and evaluation of predictive performance in an independent validation dataset.

We assessed multicollinearity using variance inflation factors and condition indices. This analysis shows some collinearity between the total number of SA days and the numbers of SA spells of different lengths. Any remarkable correlation was only found between the total number of SA days and the number of SA spells over 60 days. With VIF values of 5.3 and 4.2, translating to tolerances of 0.19 and 0.23, respectively, it can be argued that the total days could in principle be clustered with at least the "over 60 days" category for better predictor stability, but in this case, we wanted to include both measures in the model for practical applications. These are also measures that Finnish employers use in their day-to-day work.

Logistic regression was used to model the risk of applying for a disability pension during a three-year follow-up. Three years of SA history was available for all employees. The analyses were performed using SAS 9.4.

Results

The odds ratios for the predictors in the final model (AUC: 0.8269) and corresponding 95% confidence intervals are presented in Figure 2.

The calibration plot in Figure 3 shows the overall good performance of the model estimates compared to observations. For the highest risk deciles, the estimates are slightly too high compared to outcomes. The Brier score for the whole population was 0.036, which is very close to zero. Despite a minor overestimation of risk at the upper end of the

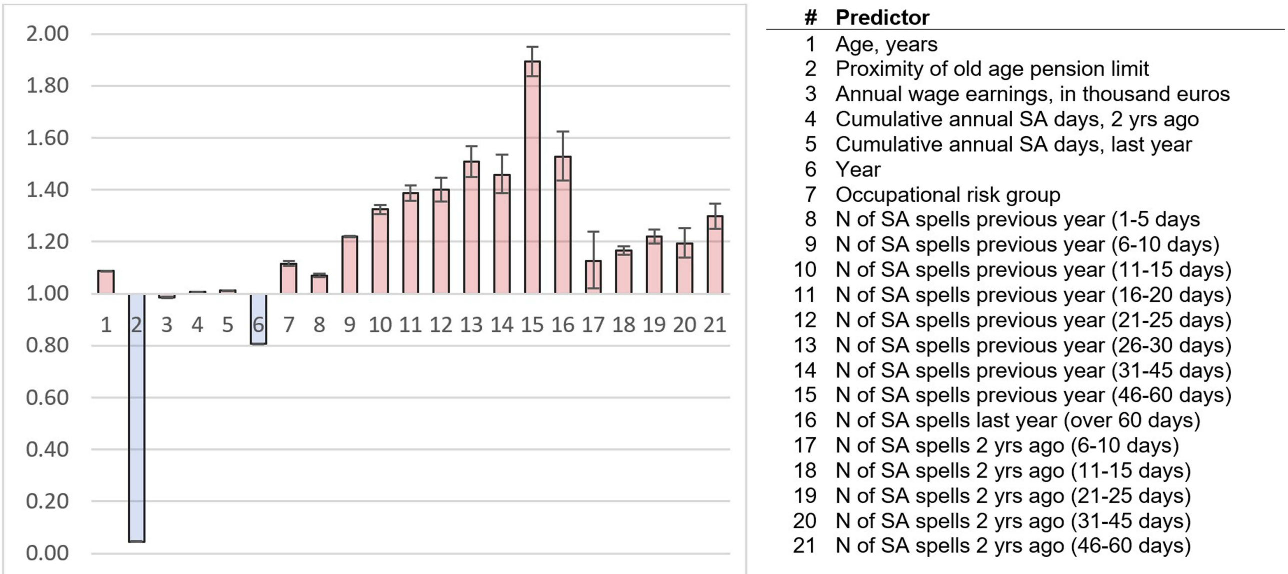

Figure 2 Odds ratios with 95% confidence intervals for significant factors in the model with two years of sickness absence and earnings history.

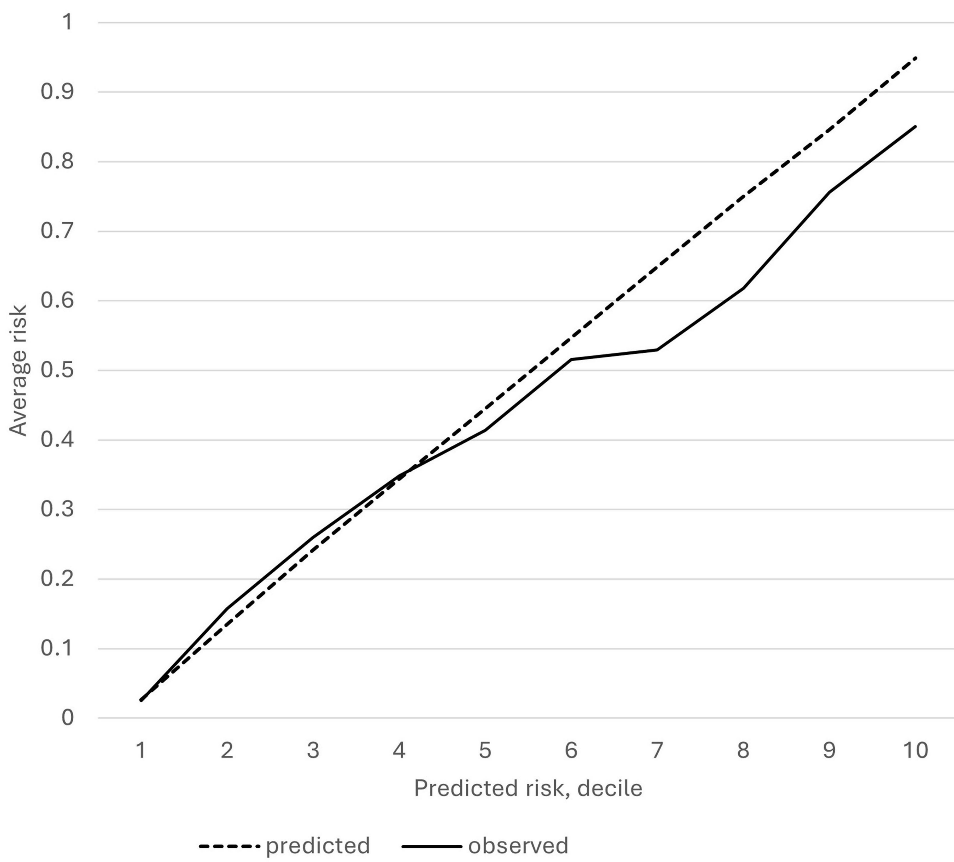

Figure 3 Calibration curve for the model.

prediction scale, the model showed good discrimination (AUC) and overall accuracy (Brier score), supporting satisfactory model performance.

To assess practical validity, a decision curve analysis was performed as well. The results in Figure 4 show that the model developed should be preferred to both strategies of treating all or treating none with all threshold probabilities. Thus, we can say that the model is useful in decision-making.

Predictor values are given in Table 2. Age, risk class of occupation, cumulative days of SAs in the preceding 2 years, number of SA spells of all lengths in the previous year, and SA spells of most lengths in the penultimate year were found to have a positive association with DP risk. Proximity of old-age retirement age, annual earnings, and number of years observed were associated with a lower the risk of applying for a DP. For example, the odd ratio given for age, 1.088, means that for every additional year of age, the risk of DPA increases by 8.8%, other factors staying the same.

Comparing the positive association of SA spells of different lengths with the risk estimate, we can see that the association generally gets stronger with increasing length of the SA spell. The range of 46–60 SA days is most strongly correlated with the overall risk: each spell is associated with an increase in the risk by 89%, with 95% CIs of 80–98%. A SA spell of 30–45 days is associated with a 46% rise in the overall risk (CI: 40%, 52%) and a spell of 26–30 days by 50% (CI: 41%, 58%). Sickness absences shorter than or equal to 10 days are associated with a less profound increase in the risk: 1–5 days' SA spells with 7.0% (CI: 6.6%, 7.7%) and 6–10 days' spells 22% (CI: 20%, 24%). It is worth noting that short SA spells are associated with a higher risk other factors staying the same although the association is weaker.

Proximity of retirement age has the greatest negative association with the DPA risk. From 3 years before reaching retirement age, each year of age is associated with a decrease in overall risk by 95.5% (CI: 95.1%, 95.9%). Annual earnings are associated with a 1.48% (CI: 1.41%, 1.55%) decrease in risk for every increase of one thousand euros. Annual cumulative SA days in the previous year are associated with a 1.18% (CI: 1.12%, 1.24%) increase in the risk for every sickness day, and SAs in the penultimate year with a 0.73% (CI: 0.70%, 0.76%) increase. Not all lengths of SA spells accumulated in the penultimate year had a significant association with the risk, nor did gender. Female gender had a negative association of 0.7% (CI: –1.5%, 2.7%), not significant in this data. There were no significant interactions between risk factors.

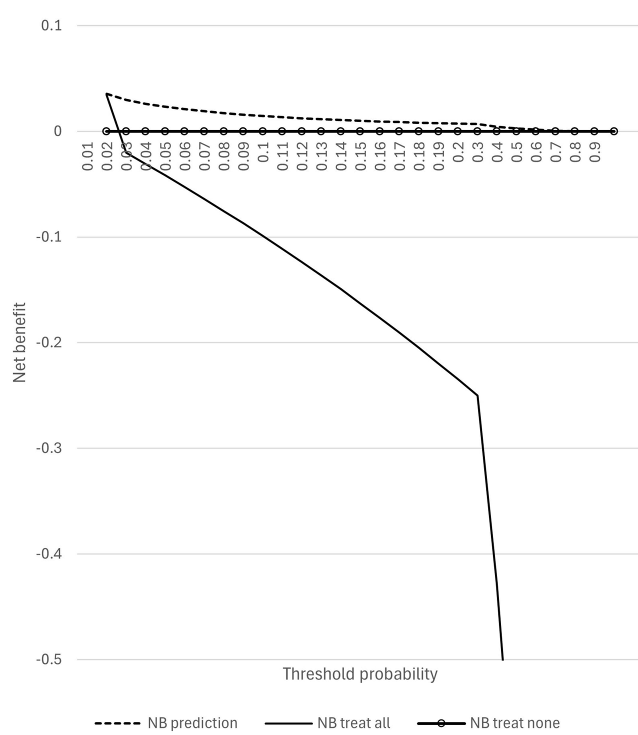

Figure 4 Decision curve for the model.
Abbreviation: NB, net benefit.

Table 2 Estimates for Parameters of the Final Model with Odds Ratios and Limits of 95% Confidence Intervals

#	Predictor		Estimate	OR	CLL	CLU
0	Intercept	***	−7.402	0.001	0.001	0.001
1	Age, years	***	0.084	1.088	1.086	1.089
2	Proximity of old age pension limit	***	−3.102	0.045	0.041	0.049
3	Annual wage earnings, in thousand euros	***	−0.015	0.985	0.985	0.986
4	Cumulative annual SA days, 2 yrs ago	***	0.007	1.007	1.007	1.008
5	Cumulative annual SA days, last year	***	0.012	1.012	1.011	1.012
6	Year	***	−0.215	0.806	0.798	0.815
7	Occupational risk group	***	0.110	1.116	1.110	1.122
8	N of SA spells previous year (1–5 days)	***	0.067	1.070	1.066	1.073
9	N of SA spells previous year (6–10 days)	***	0.199	1.220	1.203	1.238
10	N of SA spells previous year (11–15 days)	***	0.281	1.325	1.296	1.355
11	N of SA spells previous year (16–20 days)	***	0.327	1.386	1.341	1.434
12	N of SA spells previous year (21–25 days)	***	0.336	1.399	1.341	1.460
13	N of SA spells previous year (26–30 days)	***	0.411	1.508	1.435	1.584
14	N of SA spells previous year (31–45 days)	***	0.377	1.458	1.402	1.517
15	N of SA spells previous year (46–60 days)	***	0.638	1.893	1.801	1.990
16	N of SA spells last year (over 60 days)	***	0.424	1.528	1.422	1.642
17	N of SA spells 2 yrs ago (6–10 days)	***	0.118	1.126	1.109	1.142
18	N of SA spells 2 yrs ago (11–15 days)	***	0.153	1.166	1.139	1.193
19	N of SA spells 2 yrs ago (21–25 days)	***	0.199	1.220	1.166	1.278
20	N of SA spells 2 yrs ago (31–45 days)	***	0.177	1.194	1.146	1.244
21	N of SA spells 2 yrs ago (46–60 days)	***	0.261	1.298	1.234	1.365

Notes: ***Significant with 99.9% confidence level.

Model Validation

The performance of the risk model can be assessed by comparing the model predictions for 2019–2021 with true outcomes in years 2019–2021 using the validation data (10% of original sample). We do this by summarizing the employee-level DPA risk estimate across age, gender, and occupation groups, and by then averaging the risk across the number of employees in those groups. We also present and compare the Brier scores in each group.

The average observed number of applications per employee compared to the average estimated risk of applications indicates that the model provides relatively accurate estimates of the total DP application risk by employee age and gender. The model slightly overestimates the risk for employees aged 40–54 and for those over age 60 and underestimates the risk for those aged under 40 and those aged 55–59. The Brier scores increase with age until age 59, and they also show slightly larger inaccuracy for age group 55–59. The predictive performance of the model varies slightly between men and women of all ages, inaccuracy for women being slightly higher. These results are presented in Table 3.

The risk of DPA increases with age but decreases after the age of 60. Women's overall estimated application risk is 32% higher than men's.

Similarly, the total estimated risk per employee in different occupations can be compared with the observed number of DP applications. This is illustrated in Table 4. Estimated risk per employee varies greatly between occupational groups: it is lowest for teachers and physicians and highest for secretaries, kitchen aids, and hospital care assistants. In general, it seems that our model underestimates the risk for nursing occupations, general practitioners, other healthcare workers, and construction workers. On the other hand, the risk per employee predicted for secretaries, social workers, firefighters, kitchen workers, and experts in administration, among others, was lower than the share of observed DPAs. The Brier scores are low but increase slightly with increased predicted risk, pointing at slightly higher inaccuracy. In general, the model is able to differentiate rather well between age groups and occupations.

Table 3 Model Performance: Estimated and Observed Number of Disability Pension Applications per Employee and Brier Scores According to Age and Gender

	Women			Men			All		
	Observed %	**Predicted %**	**Brier Score**	**Observed %**	**Predicted %**	**Brier Score**	**Observed %**	**Predicted %**	**Brier Score**
Age group									
−24	1.06%	0.69%	0.010	1.01%	0.52%	0.010	1.05%	0.65%	0.010
25-29	1.54%	1.01%	0.014	0.99%	0.77%	0.010	1.40%	0.95%	0.013
30-34	1.94%	1.55%	0.018	0.80%	1.05%	0.007	1.65%	1.43%	0.016
35-39	2.64%	2.32%	0.024	1.48%	1.60%	0.014	2.35%	2.14%	0.021
40-44	3.10%	3.60%	0.027	1.82%	2.51%	0.016	2.79%	3.34%	0.024
45-49	4.72%	5.49%	0.040	2.89%	4.07%	0.025	4.29%	5.15%	0.036
50-54	7.07%	7.92%	0.057	4.88%	5.52%	0.041	6.55%	7.35%	0.053
55-59	13.68%	11.01%	0.100	9.42%	7.70%	0.073	12.73%	10.28%	0.094
60-	4.63%	6.16%	0.038	3.44%	4.21%	0.034	4.36%	5.72%	0.037
All	4.85%	4.70%	0.039	3.06%	3.20%	0.026	4.42%	4.34%	0.036

Table 4 Model Performance: Estimated and Observed Number of Disability Applications per Employee and Brier Scores by Occupation (ISCO-08 Like Groups)

Occupation	**Observed %**	**Predicted %**	**Brier Score**
Customer service	5.5%	6.2%	0.045
Experts in economics, law, administration	1.0%	2.2%	0.015
Directors	1.3%	2.6%	0.020
Nursing	5.7%	5.0%	0.046
Janitorial work	4.2%	5.0%	0.044
Library, museum, and archives	5.3%	5.1%	0.040
School assistants	5.7%	5.7%	0.042
Culture, art, sports	1.4%	2.3%	0.017
Physicians	2.2%	1.6%	0.020
Drivers	6.4%	7.3%	0.045
Specialists in science and technology	3.5%	3.3%	0.025
Teachers	2.3%	2.2%	0.020
Firefighters	2.0%	2.6%	0.023
Builders	6.1%	5.1%	0.045
Hospital care assistants	7.7%	7.8%	0.061
Secretaries	5.8%	7.6%	0.048
Cleaning and kitchen work	8.2%	8.0%	0.065
Social workers	3.0%	3.7%	0.033
Social sector nurses	3.6%	3.8%	0.033
Specialists in administration	4.2%	4.6%	0.033
Other healthcare specialists	5.6%	4.5%	0.037
Primary school teachers	5.2%	5.3%	0.042
All	**4.4%**	**4.3%**	**0.037**

Additionally, an analysis was performed modeling both rejected and accepted applications separately against not filing an application, using the same predictors as used in the main analysis. The results, not presented here, revealed no significant differences between the coefficients for accepted and for rejected applications.

Disability Risk for Ages Over 45: Occupational Differences

Next, we present some results about the current disability pension application risk in the Finnish public sector, focusing on ages over 45 years and using the model outlined in the sections above.

Applying the model to data for employees at year-end 2021 yields the risk estimates presented for each five-year age group in Table 5 (CLs omitted for clarity). The table also includes some descriptive statistics for SAs in the most recent year: annual cumulative SA days, number of SA spells of 1–10 days, and number of SA spells of over 30 says, averaged across occupational groups. These measures are commonly used to assess the number of SAs indicating an elevated disability pension risk and to optimize the timing of intervention.

The role of age is highlighted in the risk estimate: in all occupations, the DPA risk increases with age and is greatest for employees aged 55–59 and decreases among those over 60. In addition, as expected, the number of short spells generally decreases with age and the number of long spells increases with age. Differences between occupational groups are clear in all age groups, and large numbers of all SAs occur in those occupations with the greatest predicted risk.

The effect of occupational stress and other non-SA related risk factors emerges clearly when comparing occupations with similar SA measures. For example, physicians and specialists in science and technology have similar SA measures, but the risk estimate for the latter group is much higher. On the other hand, physicians and directors have similar predicted levels of disability risk, but directors' SA measures are much lower. Another comparison between firefighters and customer service workers shows that the former have much lower levels of predicted risk even though the SA measures are similar. These examples highlight the complexity of estimating disability risk using SAs alone in a diverse range of employees.

Discussion

In this study, we presented a statistical model for the risk of filing a first-time application for a disability pension and identifying the factors affecting disability risk. Including sickness absences of different lengths in our analysis, we also described the associations of different socioeconomic predictors with the outcome, ie., the probability of a DP application. To include the earliest indications of risk in the analysis, the data comprise all sickness-related absences from work, including short spells of less than 10 days, and the disability pension application is used as a follow-up measure rather than marking passage into retirement.

We constructed and evaluated a prediction model for the three-year risk of filing an application. The risk factors in the model include age, annual earnings, occupational stress, and SAs of different durations in the last 2 years. The proposed model adequately predicts the risk of applying for a disability pension in different employee groups. Age, occupation, cumulative sickness absence days preceding the application, and the number of sickness absence spells of all lengths have a positive association with the disability pension application risk. High earnings are negatively associated with the disability risk, as is the proximity of retirement age. While lengthened SA spells have a stronger correlation with the risk, short spells do prove to add value to the model. Finally, we presented some estimates for the work disability risk using the model for public sector occupations and age groups.

Contrary to expectations, we found that the applicant's gender had no association with the disability pension risk in this data. This may be due to the highly gendered occupational structure of municipal employees: in fact, the gender effect could be captured by the occupational risk factor. While gender as a predictor turned out to be insignificant in this model, it does not imply gender equality in disability risk.

Comparison of the associations of these factors confirms the results of many previous studies but also adds to the existing body of knowledge. It is well established that the longer the SA, the greater its associations with the risk of DP pension (7–8, 11, 13), which was also one of our results; but in our analysis, even short absences did have a positive association with the risk. This adds to the results presented in (8), where short SAs were concluded to have an effect only combined to other factors, while with our data and model, we were able to find an independent association of short absences and DP risk. The odds ratio for a short (0–5 days) SA spell is 1.070 (CI: 1.066, 1.073) in the final risk model, and increases rapidly with the length of the spell, until a 46–60 days' spell has an OR of 1.893 (CI: 1.801, 1.990). This emphasized the importance of early intervention.

Table 5 Sickness Absences and Predicted Risk for Public Sector Occupations at the End of 2021

DPA Risk for 2021 Employees	**Age**															
	Mean SA days				**1–10 days' SA spells, avg**				**Over 30 days' SA spells, avg**				**Predicted DP Application Risk**			
Occupation	45-49	50-54	55-59	60-	45-49	50-54	55-59	60-	45-49	50-54	55-59	60-	45-49	50-54	55-59	60-
Customer service	12.4	9.9	13.5	6.5	1.26	1.24	1.81	1.03	0.09	0.07	0.07	0.03	2.90%	4.01%	7.47%	3.39%
Experts in economics, law, administration	4.8	5.4	5.8	7.0	0.56	0.51	0.49	0.48	0.04	0.04	0.05	0.06	0.96%	1.53%	2.37%	1.59%
Directors	2.1	3.6	3.4	5.7	0.40	0.34	0.33	0.37	0.00	0.03	0.03	0.05	0.73%	1.13%	1.59%	1.33%
Nursing	14.7	16.1	16.1	16.0	2.46	2.34	2.11	1.98	0.07	0.09	0.10	0.10	3.03%	4.60%	6.40%	4.19%
Janitorial work	10.9	9.3	12.1	9.8	1.21	1.16	0.98	0.87	0.07	0.07	0.08	0.08	2.46%	3.26%	5.40%	3.13%
Library, museum, and archives	9.9	11.3	9.7	10.4	1.70	1.62	1.32	1.41	0.06	0.07	0.08	0.05	2.25%	3.68%	4.80%	3.79%
School assistants	15.9	16.3	16.5	13.3	2.34	2.59	2.28	2.08	0.10	0.07	0.10	0.09	3.43%	4.92%	6.46%	4.55%
Culture, art, sports	3.7	3.9	4.6	5.7	0.37	0.41	0.41	0.46	0.02	0.02	0.03	0.05	1.22%	1.99%	2.83%	2.04%
Physicians	5.7	6.4	7.5	7.4	0.89	0.83	0.72	0.71	0.04	0.04	0.06	0.06	0.74%	1.07%	1.67%	1.36%
Drivers	10.6	11.0	11.1	12.5	1.63	1.51	1.33	1.00	0.07	0.06	0.07	0.07	2.66%	4.05%	5.86%	3.94%
Specialists in science and technology	6.3	6.0	8.5	7.6	0.91	0.74	0.70	0.59	0.04	0.04	0.07	0.07	1.12%	1.90%	2.94%	1.83%
Teachers	6.2	7.0	7.4	8.6	1.24	1.13	1.08	0.92	0.03	0.04	0.05	0.06	1.10%	1.79%	2.56%	2.13%
Firefighters	8.7	10.6	13.0	13.2	0.97	1.12	1.18	1.03	0.07	0.08	0.10	0.08	1.72%	2.52%	3.94%	2.35%
Builders	9.3	7.6	8.4	8.1	1.28	1.08	0.96	0.81	0.05	0.05	0.04	0.05	2.14%	2.60%	4.17%	2.63%
Hospital care assistants	13.0	15.1	14.6	17.4	2.01	1.82	1.51	1.45	0.07	0.08	0.09	0.11	3.37%	5.40%	7.33%	5.09%
Secretaries	10.0	10.8	12.5	10.2	1.61	1.40	1.32	1.16	0.06	0.07	0.09	0.07	2.93%	4.10%	6.14%	3.81%
Cleaning and kitchen work	11.1	10.8	12.7	13.1	1.44	1.29	1.09	0.95	0.05	0.07	0.09	0.10	3.18%	4.53%	6.88%	4.67%
Social workers	9.8	9.8	10.0	8.3	1.32	1.23	1.03	1.14	0.07	0.07	0.07	0.06	1.86%	2.80%	4.05%	2.67%
Social sector nurses	10.9	11.7	11.4	15.5	1.69	1.69	1.80	1.59	0.08	0.07	0.06	0.08	2.18%	3.14%	4.71%	4.18%
Specialists in administration	5.0	7.7	6.1	9.6	0.72	0.67	0.76	0.56	0.04	0.06	0.04	0.07	1.24%	2.36%	3.06%	2.35%
Other healthcare specialists	10.9	13.3	12.7	12.1	1.74	1.54	1.39	1.65	0.07	0.10	0.09	0.06	2.15%	3.78%	5.18%	3.35%
Primary school teachers	16.2	15.6	15.9	16.4	2.87	2.55	2.50	2.19	0.07	0.08	0.09	0.09	3.18%	4.27%	6.10%	4.45%
All	**10.4**	**11.3**	**11.7**	**12.0**	**1.72**	**1.62**	**1.50**	**1.36**	**0.06**	**0.07**	**0.07**	**0.08**	**2.17%**	**3.32%**	**4.85%**	**3.40%**

Abbreviations: DPA, disability Pension Application; DP, disability Pension.

https://doi.org/10.2147/RMHP.S585895

It is also known that there are clear differences in the estimated risk between age groups and occupations (7,9), which we were able to address at a level of detailed occupational groups when previous studies used a cruder division, and also make comparisons on the level of the whole Finnish public sector. For example, the estimated three-year DPA risk for a 55–59-year-old (10.3%) is on average threefold compared to a 25–29-year-old (1.0%) and threefold compared to a 40–44-year-old (3.3%). The average three-year DPA risk for a teacher (2.2%) is half of the public sector average (4.3%), while for a kitchen worker (8.0%) it is almost double the average.

The model developed here is an advancement to existing register-based risk modeling. For example in (22), a recent survey data based self-screening tool developed for Finnish workers, lower income, older age, and all sickness benefits were associated with higher DP risk. While the intended use of the tool in (22) and our modeling results are very different (internet self-survey vs. employer risk management) and our register data does not include health measurements outside SA patterns, our results partially confirm these survey-based results, presenting odds ratios for factors based on large administrative registers, as well as additionally including occupational stress into the model on an ex ante risk-based scale.

Compared to the model developed in (25), where new pensions were used as a target, while including different sets of predictors, we can see that estimates for predictors show similar associations. Thus, targeting new applications rather than new pensions is a valid modeling choice as similar mechanisms in data seem to govern both phenomena, while having DPA as risk target widens the population at risk, offering an earlier point of view onto DP risk. We were also able to include earnings into our model. Female gender did not have any significant association with DPA in our analysis, compared to (25) where female gender was associated positively with a new pension. This might also mean that earnings, compared with occupational risk, account for the variance otherwise associated with gender. We were also able to assess our model in terms of predicting performance and point out that especially modeling high-risk cases might benefit from additional predictors.

In addition, we presented a risk estimate for public sector employees over the age of 45 at the end of 2021 to highlight the differences between occupations in both SAs and risk estimates: although higher SA levels lead to a higher level of estimated risk, there are occupation-specific differences in the level of predicted risk, which we were able to present at the level of occupational group.

The key results of this study suggest that sickness absences of all lengths, also short ones, have a significant positive association with the three-year DPA risk, and that the strength of this association varies significantly according to age and occupation. Register-based data on employment, earnings, and SA spells combined with demographic factors are very useful in describing the disability pension application risk in different public sector employee groups. However, when the prediction model's estimates are compared with observed pension applications, some disparities emerge which suggest that the model could benefit from additional employee-level information, such as health behavior, motivation, psycho-social work environment, and other stressors that cannot be measured by SA, or data on underlying SA illness (diagnosis). For example, personal motivation of an employee could have a large effect on how well a return to work is feasible,[31,32] something that currently cannot be measured with the existing data. On the other hand, underlying illnesses may dictate how SAs reflect the diminishing work ability.

The risk target, filing an application for a disability pension, reflects the risk signal, which in practice is the medical professional's certification of diminished work ability. Thus, even in the case of a rejective decision, the applicants have indeed already received a physician's certificate of a perceived disability risk. These employees will all need preventive support from the employer and occupational healthcare, and therefore they should be included in the group considered being at risk. While it is reasonable to argue that including both positive and rejective decisions in the target might introduce administrative and social heterogeneity, in this case, misclassification based on this choice is not expected to play any major role. Thus, using this model is reasonable given the goal of recognizing disability risk at the earliest possible time.

During the COVID-19 pandemic, there were population level fluctuations in SA patterns.[33,34] In some occupations, working from home became more popular.[35,36] Our model measured SA patterns before the start of the pandemic and using SA numbers measured during the pandemic might result in biased results. The key is to update the model at appropriate intervals to best reflect the situation at each timeframe of prediction.

The model and the risk estimates are meant to be used at group level for risk-based stratification of employees, aimed at allocating limited support measures. In practice, the results are already provided for the employers as a tool for determining the disability risk in their employees at an appropriate group level for allocating limited resources of interventional action. In early intervention, the goal is to recognize employees who would most benefit from eg. occupational rehabilitation. These results give the employer tools to estimate the average cost of future disability at group levels, highlighting the cost–benefit ratio of intervention. The results should always be presented over appropriately sized employee groups so that no single employee may be recognized. In addition to organization-level governance of a model before utilization, it is essential to ensure that statistical models can handle uncertainties resulting from outside events, and it is important that they are regularly updated.

Transferability of the results beyond the Finnish context is an important issue. By using predictors that can be similarly constructed elsewhere and adding multiple levels of SA measurement, we ensured that the model in principle is suited for use in different environments. In the Nordic countries, the sickness and disability systems and the labor markets are reasonably similar, but since workplace and pension practices as well as other labor market policies elsewhere may differ substantially, the practical aspects of using the model should be considered case by case.

Conclusions

In this study, a novel approach for incorporating corporate data from person-level sickness absences to pension insurance provider's registers of employment and earnings, disability pension applications, occupations, and other socioeconomic factors were combined to build insight into how they affect the risk of work disability. Information on the patterns of sickness absences from work is of special interest, as researchers rarely get to incorporate detailed information about short absences into their studies. We were also able to use the disability pension applications as risk indicators to include those employees who end up receiving a rejective decision to their application while still carrying a physician's certificate of diminished work ability, allowing for an earlier view into the process of work disability.

The model presented for the risk of applying for a disability pension illustrates the potential benefits of predicting the three-year application risk for municipal employees. Using a straightforward regression method, the associations of factors of risk can be easily compared and different explainable scenarios built. This provides a basis for developing register-based tools for professionals in human resources, risk management, and occupational healthcare, allowing them to visualize the disability risk, highlight the differences between occupational and age groups, and help allocate scarce resources for risk management and early intervention. The associations of SAs of varying lengths with the overall risk can thus be assessed in concrete terms of the impact on the immediate costs of sickness absences or on employers' future pension contributions, for example. Several risk assessment tools in the form of regularly updated, interactive reports are already available for most Finnish municipal sector employers based on the work.

To incorporate differences between illnesses behind declining work ability into risk assessment, future studies will need to examine how DP risk factors differ between major diagnostic groups. Also, it would be interesting to know whether the analysis presented here would benefit from the inclusion of register-based, health, and motivation-related factors. Our findings on the impact of short SAs on the short-term disability risk are particularly interesting, and further studying of this role would probably also benefit from the inclusion of additional risk factors in the model, such as data on medical diagnosis.

Data Sharing Statement

The data that support the findings of this study are available from Keva and the municipal employers who participated in the study via bilateral research permits with Keva, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Ethics Approval and Informed Consent

Ethical approval for this study was waived by The Academic Ethics Committee of Tampere Region, Finland, because this research does not require ethical review. Research is based purely on public and published data, registry and documentary data, or archive data.

Consent for Publication

We confirm that the details of any images etc. can be published, and that the person providing consent has been shown the article contents to be published.

Acknowledgments

The author wishes to thank Dr. Janne Salonen and Prof. Lasse Koskinen for their insightful comments and practical advice during the research and writing process.

Funding

No funding was received for this study.

Disclosure

The author reports no conflicts of interest in this work.

References

1. OECD. Sickness, disability and work: breaking the barriers: a synthesis of findings across OECD countries. Report, OECD Publishing; 2009.
2. European Commission, Directorate-General for Economic and Financial Affairs. The 2024 ageing report: underlying assumptions and projection methodologies. Institutional Paper 257; 2023.
3. European Commission. An Agenda for adequate, safe and sustainable pensions. 2012; White Paper.
4. Shiri R, Bergbom B. Work ability and well-being management and its barriers and facilitators in multinational organizations: a scoping review. *Healthcare*. 2023;11(7):978. doi:10.3390/healthcare11070978
5. Dannheim I, Ludwig-Walz H, Buyken A, et al. Effectiveness of health-oriented leadership interventions for improving health and wellbeing of employees: a systematic review. *J Public Health*. 2022;30:2777–2789. doi:10.1007/s10389-021-01664-1
6. Saarela K. *Prediction of Work Disability Risk Using Machine Learning (Dissertation)*. Helsinki: Helsinki University; 2025.
7. Salonen L, Blomgren J, Laaksonen M, Niemelä M. Sickness absence as a predictor of disability retirement in different occupational classes: a register-based study of a working-age cohort in Finland in 2007–2014. *BMJ Open*. 2018;8:e020491.
8. Kivimäki M, Forma P, Wikström J, et al. Sickness absence as a risk marker of future disability pension: the 10-town study:Table 1. *J Epidemiol Commun Health*. 2004;58(8):710–711. doi:10.1136/jech.2003.015842
9. Salonen L, Blomgren J, Laaksonen M. From long-term sickness absence to disability retirement: diagnostic and occupational class differences within the working-age Finnish population. *BMC Public Health*. 2020;20(1):1078. doi:10.1186/s12889-020-09158-7
10. Lund T, Kivimäki M, Labriola M, Villadsen E, Bang Christensen K. Using administrative sickness absence data as a marker of future disability pension: the prospective DREAM study of Danish private sector employees. *Occup Environ Med*. 2008;65(1):28–31. doi:10.1136/oem.2006.031393
11. Karlsson N, Carstensen J, Gjesdal S, Alexanderson K. Risk factors for disability pension in a population-based cohort of men and women on long-term sick leave in Sweden. *Eur J Public Health*. 2008;18(3):224–231. doi:10.1093/eurpub/ckm128
12. Kivimäki M, Ferrie J, Hagberg J, et al. Diagnosis-specific sick leave as a risk marker for disability pension in a Swedish population. *J Epidemiol Commun Health*. 2007;61(10):915–920. doi:10.1136/jech.2006.055426
13. Virtanen M, Kivimäki M, Vahtera J, et al. Sickness absence as a risk factor for job termination, unemployment, and disability pension among temporary and permanent employees. *Occup Environ Med*. 2006;63(3):212–217. doi:10.1136/oem.2005.020297
14. Gjesdal S. Predictors of disability pension in long-term sickness absence: results from a population-based and prospective study in Norway 1994-1999. *Eur J Public Health*. 2004;14(4):398–405. doi:10.1093/eurpub/14.4.398
15. Gjesdal S, Bratberg E. Diagnosis and duration of sickness absence as predictors for disability pension: results from a three-year, multi-register based* and prospective study. *Scand J Public Health*. 2003;31(4):246–254. doi:10.1080/14034940210165154
16. Perhoniemi R, Blomgren J, Laaksonen M. Determinants of disability pension applications and awarded disability pensions in Finland, 2009 and 2014. *Scand J Public Health*. 2020;48(2):172–180. doi:10.1177/1403494819843778
17. Laaksonen M, Blomgren J, Gould R. Sickness allowance trajectories preceding disability retirement: a register-based retrospective study. *Eur J Public Health*. 2016;26:1050–1055. doi:10.1093/eurpub/ckw081
18. Klein J, Reini K, Saarela J. Sickness absence and disability pension in the very long term: a Finnish register-based study with 20 years follow-Up. *Front Public Health*. 2021;9:556648. doi:10.3389/fpubh.2021.556648
19. Leino-Arjas P, Seitsamo J, Nygård C, K.c P, Neupane S. Process of work disability: from determinants of sickness absence trajectories to disability retirement in a long-term follow-up of municipal employees. *Int J Environ Res Public Health*. 2021;18(5):2614. doi:10.3390/ijerph18052614
20. Laaksonen M, Blomgren J, Gould R. Sickness absence history before disability retirement: a register based case-control study. *Eur J Public Health*. 2023;23(supplement 1).
21. Airaksinen J, Jokela M, Virtanen M, Oksanen T, Pentti J, Vahtera J. Development and validation of a risk prediction model for work disability: multicohort study. *Nat Sci Rep*. 2017;7(1):13578. doi:10.1038/s41598-017-13892-1
22. Nyberg S, Airaksinen J, Pentti J, et al. Predicting work disability among people with chronic conditions: a prospective cohort study. *Nat Sci Rep*. 2023;13(1):6334. doi:10.1038/s41598-023-33120-3
23. Selander K, Nikunlaakso R, Laitinen J. Association between work ability and work stressors: cross-sectional survey of elderly services and health and social care service employees. *Arch Public Health*. 2022;80(1):83. doi:10.1186/s13690-022-00841-2
24. Bethge M, Spanier K, Streibelt M. Using administrative data to assess the risk of permanent work disability: a cohort study. *J Occupat Rehab*. 2021;31(2):376–382. doi:10.1007/s10926-020-09926-7
25. Sohlman P, Louhi R, Salonen J. Predicting disability pension risk among public-sector employees in Finland: a new evaluation tool for employers. *Int Soci Security Rev*. 2025;78(4):99–120. doi:10.1111/issr.70013
26. Keva, Helsinki, Finland. Statistics and research. 2026. Available from: https://www.keva.fi/uutishuone/tutkimukset-tilastot-ja-ennusteet/. Accessed April 23, 2026.

27. Finnish Centre for Pensions, Helsinki, Finland. Earnings-related disability pension. 2026. Available from: https://www.etk.fi/en/finnish-pension-system/pensions/earnings-related-pension-benefits/disability-pension/. Accessed March 5, 2026.
28. Finnish Centre for Pensions, Helsinki, Finland. Earnings-related pension recipients in Finland. Available from: https://www.etk.fi/en/research-statistics-and-projections/statistics/earnings-related-pension-recipients/. Accessed November 12, 2025.
29. Finnish Centre for Pensions, Helsinki, Finland. Statistics of pension applications. Available from: www.etk.fi. Accessed March 5, 2026.
30. Perhoniemi R, Blomgren J, Laaksonen M. Mitä hylkäävän työkyvyttömyyseläkepäätöksen jälkeen? Työttömyys-, sairauspäiväraha- ja kuntoutusrahaetuudet sekä uudet eläkepäätökset neljän vuoden seurannassa. [What next after a rejected disability pension application? Unemployment, sickness and rehabilitation benefits and new disability pension decisions in a four-year follow-up]. *Yhteiskuntapolitiikka*. 2018;83(2):117–131.
31. Vanovenberghe C, Du Bois M, Lauwerier E, Van den Broeck A. Does motivation predict return to work? A longitudinal analysis. *J Occup Health*. 2021;63(1):e12284. doi:10.1002/1348-9585.12284
32. Dahle UR, Petersen FC. Long term sickness absence: motivation rather than ability to work may be key. *BMJ*. 2005;330(7499):1087. doi:10.1136/bmj.330.7499.1087-b
33. Cybulski L, Pettersson E, Alexanderson K, Farrants K. Associations between prior and subsequent sickness absence before and during the COVID-19 pandemic: a Swedish prospective cohort study of 306 933 blue-collar workers in the retail and wholesale industry. *BMJ Open*. 2025;15(10):e096764. doi:10.1136/bmjopen-2024-096764
34. McTaggart E, Megiddo I, Bowers J, Kleczkowski A, Kamrujjaman M. Sickness absence rates in NHS England staff during the COVID-19 pandemic: insights from multivariate regression and time series modelling. *PLoS One*. 2025;20(7):e0323035. doi:10.1371/journal.pone.0323035
35. Bick A, Blandin A, Mertens K. Work from home before and after the COVID-19 outbreak. *Am Econ J Macroecon*. 2023;15(4):1–39. doi:10.1257/mac.20210061
36. Barrero JM, Bloom N, Davis SJ. Why working from home will stick. *Natl Bur Econ Res* Working Paper 2021;28731.