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Work Participation Following Vocational Rehabilitation in Occupational Disease Patients: A Propensity Score-Matched Analysis Using Finnish Nationwide Registry Data

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Abstract

Purpose Occupational diseases (ODs) often disrupt careers and threaten long-term employment. Vocational rehabilitation (VR) is intended to restore work ability, yet evidence on its effectiveness for OD patients is scarce. This study uses nationwide registry data to evaluate the impact of VR on sustained work participation.

Methods We analyzed linked data from multiple Finnish registers, including all individuals aged 18–55 who received VR through workers' compensation insurance for an OD recognized between 2005 and 2018. Rehabilitees were propensity score–matched to OD patients without VR. Subgroup analyses distinguished rehabilitees who received formal education during VR from those who did not. Follow-up time averaged 5.1 years and extended up to 8 years post-VR.

Results A total of 1377 matched pairs were formed. Work participation at one year post-VR was lower among rehabilitees than controls (74.1% vs 84.0%), reflecting severe baseline impairment. However, the gap narrowed over time, with near parity at four years (79.1% vs 81.6%). Neither group regained pre-OD levels (> 90%). Recovery was faster among those receiving education: Parity was achieved within two years (82.0% vs 82.7%), and the employment rate continued to improve throughout the 8-year follow-up (84.8% vs 84.4%).

Conclusions As required by legislation, VR is implemented when other interventions are insufficient to ensure sustainable employability. The results show that VR recipients achieved a level of work participation comparable to that of the control group, although the two groups were not fully comparable due to statutory entitlement. This study suggests that VR effectively promotes labor market integration.

Keywords Vocational rehabilitation · Occupational disease · Work participation · Long-term follow-up · Employment outcomes · Registry data

Introduction

Occupational diseases (ODs) can lead to substantial career disruption, often necessitating a change in job tasks or even a complete career shift to maintain employment. Previous studies have shown that many occupational diseases have negative socioeconomic consequences for patients, and the need for a change of job appears common, for example, in occupational asthma [1], occupational rhinitis [2], and occupational dermatitis [3, 4].

Vocational rehabilitation (VR) has been used to promote OD patients' ability to work after an OD diagnosis, especially among patients with allergic ODs [5, 6]. Although VR has an established role in the management of ODs, little is known about the effectiveness of VR in ODs. For example, the unemployment rate after occupational asthma has varied between countries, and the lowest rates have been recorded in countries with retraining systems for OD patients [1], possibly indicating the effectiveness of VR through education. The effectiveness of VR in the workers' compensation context has been examined in the State of Washington. The study included both ODs and occupational injuries. Approximately 60 percent of VR recipients had job earnings two years after completing their rehabilitation, suggesting

MS Office (Excel and Word) and Inkscape were used to create graphics. MS Word files available upon request.

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successful employment. However, the study did not include a control group without VR, so the findings were mainly descriptive [7].

To our knowledge, no studies have examined the effectiveness of VR in ODs specifically. The effectiveness of VR has most often been assessed with a focus on specific health conditions or targeted interventions. While these studies provide important insights, they offer only a partial picture of the broader impact of VR. In contrast, large-scale registry-based studies that could capture the effectiveness across diverse conditions and populations remain scarce. A meta-analysis from the Netherlands found evidence for a moderate effect of VR interventions on work participation among patients with various chronic physical conditions [8]. A Finnish study about the effectiveness of VR administered by an earnings-related pension scheme among patients with mental or musculoskeletal work disability found a modest effectiveness on work participation [9]. A Swedish study found VR programs to be ineffective, especially VR containing education [10]. A register study on the Canada Pension Plan Disability program's VR participants found greater effectiveness among women than men [11]. German register-based cohort data showed that vocational retraining completion was associated with improved long-term employment among individuals with disabilities [12]. OD patients are typically firmly integrated into the workforce prior to the diagnosis, and their work disability may be highly specific to their current work and avoidable in other professions; therefore, previous research does not fully capture the overall role of VR in ODs.

According to Finland's Workers' Compensation Act, the recognition of an OD requires that the illness is likely to be primarily caused by a physical, chemical, or biological factor related to work [13]. Employers are required to insure their employees against occupational accidents and diseases. Insurance is mandatory for farmers but voluntary for other self-employed individuals. Once the OD is recognized, the insurance company is required to assess the need for VR without a separate application from the patient. A recommendation for VR may be provided by healthcare professionals alongside the OD diagnosis. VR for ODs typically consists of job tryouts, job coaching, and/or education. Education provided as part of VR typically consists of a vocational qualification or degrees from university of applied sciences. We have described the details of the Finnish VR setting in a previous publication [5].

The aim of this study was to evaluate the effectiveness of VR based on work participation by comparing VR recipients and their matched controls among OD patients. We present the results on differences in work participation across OD diagnoses and assess the effectiveness of education in comparison to other types of VR.

Methods

The study was a retrospective cohort study based on combined registry data from Finland. Data on ODs were obtained from the finnish register of occupational diseases (FROD), a nationwide register maintained by the Finnish Institute of Occupational Health that covers all suspected and recognized cases of occupational diseases. The FROD data were obtained for the years 2005 to 2018 for analysis, and the variables selected for analysis were diagnosis and year of OD recognition.

The information about use of VR was derived from the insurance compensation data gathered from the Finnish Workers' Compensation Center and the Farmers' Social Insurance Institution Mela for the years 2005–2020. The datasets contain the annual records of VR expenses and rehabilitation allowances, from which rehabilitants and the initiation and termination of their VR were identified. These datasets do not include a more detailed description of the nature of VR actions. To identify retirement associated with OD, data on workers' compensation pension expenses were obtained from insurance records.

Sociodemographic data covering each individual year from 2005 to 2020 were retrieved from Statistics Finland. The dataset includes the variable 'main type of activity', which describes the nature of a person's economic activity at the end of the calendar year [14]. Work participation was derived from this variable. In addition to employed, the variable also includes classifications for unemployed persons, pensioners, students, and those categorized as "other outside the workforce", providing a comprehensive overview of economic activity. The dataset includes variables of educational level and year of degree completion for each calendar year, enabling the identification of educational changes related to VR. It also contains variables used for matching purposes, as detailed in Supplementary Table S1. Additionally, the subjects' yearly income data together with workers' compensation pension payments were analyzed to determine retirements attributable to workers' compensation pensions.

The data on sickness allowance days were obtained from the Social Insurance Institute of Finland. The earnings period data were obtained from the Earnings and Accrual Register (Finnish Centre for Pensions). The FROD data, sickness allowance data and earnings period data were obtained from the Finnish Social and Health Data Permit Authority (Findata; data permit THL/3512/14.02.00/2021).

Data Management

All datasets were received pseudonymized and the data were stored and handled in the data-secure environment provided by Statistics Finland. The pseudonymized identity codes were used to combine datasets. The FROD cases were paired with insurance data using case-specific accident numbers or by comparing the diagnoses and recognition dates in both datasets.

Subjects were divided into the intervention and control pools. The intervention pool consisted of individuals with a recognized OD diagnosis and recorded VR-related expenses and/or rehabilitation allowances in the insurance data (VR recipients). The control pool comprised individuals with a recognized OD diagnosis but no recorded provision of VR services in the insurance data. The recognition date was used to set the index year for each subject. Subjects with inadequate data for baseline characteristics were excluded. No imputations were performed for missing data.

In terms of the inclusion criteria for the analyses, subjects aged 18–55 years in the index year were included to allow adequate time for rehabilitation and follow-up before old age pension. Subjects with workers' compensation pension expenses amounting to at least 60% of their annual taxable income at the end of the observation period or in the year preceding old-age retirement were excluded. In these cases, VR-related actions likely reflected eligibility assessment rather than implementation, potentially biasing effectiveness estimates. For subjects with more than one FROD case, the primary case was determined by identifying the case with VR compensation. For the control pool, the recognized OD with the most severe diagnosis was chosen as the primary case. Diagnosis severity was determined by expert judgment, ranking conditions such as asthma above rhinitis and rhinitis above contact urticaria.

Data on economic activity were gathered for two years preceding the index year to evaluate work participation before OD diagnosis. For the VR recipients, the follow-up of work participation was initiated in the last year of VR. For the controls, the follow-up began the third year after the index year, the gap set according to the median duration of the VR. Follow-up was continued for up to eight years, until 2020 (end of data), end of individual data, or start of registered old age pension, depending on which of these conditions was first met.

Education as a VR intervention was identified from changes in Statistics Finland's education data. Subjects with a change in educational level or degree completion year during VR or the subsequent year were identified and labeled as having received education through VR.

Career interruptions among controls were assessed during the year of occupational disease recognition and the subsequent two years using registered earnings periods, which reflect active employment contracts.

Propensity Score Matching

An exact match of the primary OD diagnosis was required. Work-related adherence and ability to change profession differs between farmers and other professionals, thus dichotomized socioeconomic class (farmer or non-farmer) was exactly matched. The index year was exactly matched to allow a similar follow-up time for both individuals in the matched pair. During follow-up, matched pairs were included in the analysis only for years in which data on the economic activity were available for both subjects and both remained eligible.

Multiple variables were included in the propensity score modeling, focusing on possible confounders of the work participation outcome. The variables included age, sex, socio-economic group, and level of education from the index year, as well as non-changing characteristics such as first language and country of birth. Income data, number of sickness absence days, and work adherence were assessed for the year preceding the recognition of OD in order to avoid potential bias introduced by disruptions during the diagnostic phase. For subjects with OD recognition in 2005, data from the year of OD recognition were used instead. Family related data and area of residence were recorded at the beginning of follow-up, as these factors may influence an individual's ability to seek employment. Recommendations from systematic reviews were followed in variable selection [15, 16]. Variables used in matching are listed in Table 1, with selected categories collapsed for brevity. Full details are provided in Supplementary Table S1.

Matching was performed by assigning individual controls to VR recipients, resulting in matched pairs in the intervention and control groups. Logistic regression propensity scores were calculated. The nearest neighbor matching method was used, and the control units were paired without replacement. Matching was done with a 1:1 ratio. To evaluate the effect of education, it was necessary to perform two distinct matching procedures following the same methodology.

The study was conducted and reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement [17].

Statistical Analysis

The annual percentage of working subjects and 95% confidence intervals were calculated for the intervention and control groups. The statistical significance of difference between intervention and control groups was determined using Fisher's exact test. Due to the multiple comparisons, *p*-values

Table 1 Covariate balance and standardized mean differences (SMDs) after propensity score matching among vocational rehabilitation (VR) recipients and controls

	VR recipients		Controls		
	N (%)	Mean (SD)	N (%)	Mean (SD)	SMD
Number of subjects	1377		1377		
Age [a]		36.1 (9.6)		36.8 (10.2)	−0.067
Sex (male)	654 (47.5)		630 (45.8)		0.033
Occupational disease					
Occupational asthma	401 (29.1)		401 (29.1)		0.000
Occupational rhinitis	370 (26.9)		370 (26.9)		0.000
Protein contact dermatitis or contact urticaria	196 (14.2)		196 (14.2)		0.000
Allergic contact dermatitis	119 (8.6)		119 (8.6)		0.000
Irritant contact dermatitis	113 (8.2)		113 (8.2)		0.000
Other [d]	178 (12.9)		178 (12.9)		0.000
Country of birth (Finland)	1285 (93.3)		1308 (95.0)		−0.066
First language					
Finnish	1273 (92.4)		1292 (93.8)		−0.052
Swedish	30 (2.2)		33 (2.4)		−0.015
Other	74 (5.4)		52 (3.8)		0.070
Educational level [a]					
Primary	220 (16.0)		199 (14.5)		0.044
Secondary	1005 (73.0)		990 (71.9)		0.023
Tertiary	152 (11.0)		188 (13.7)		−0.082
Completed matricular examination [a]	240 (17.4)		280 (20.3)		0.076
Socioeconomical class [a]					
Farmers and forestry entrepreneurs	59 (4.3)		59 (4.3)		0.000
Self-employed persons	117 (8.5)		113 (8.2)		0.010
Upper non-manual workers	52 (3.8)		78 (5.7)		−0.092
Lower non-manual workers	176 (12.8)		232 (16.8)		**−0.120**
Manual workers	869 (63.1)		821 (59.6)		0.070
Students	40 (2.9)		26 (1.9)		0.061
Other [d]	64 (4.6)		48 (3.5)		<0.1[e]
Earned income total in state taxation [b]		€25,978 (10,995)		€26,328 (12,558)	−0.032
Disposable income [b]					
1st quartile	470 (34.1)		461 (33.5)		0.015
2nd quartile	369 (26.8)		361 (26.2)		0.011
3rd quartile	315 (22.9)		312 (22.7)		0.005
4th quartile	223 (16.2)		243 (17.6)		−0.039
Sickness absence days [b]		20.3 (52.0)		11.8 (36.4)	**0.164**
12-month employment [b]	1118 (81.2)		1146 (83.2)		−0.052
Area of residence [a]					
Urban [d]	834 (60.6)		838 (60.9)		<0.1[e]
Rural [d]	530 (38.5)		530 (38.5)		<0.1[e]
Unknown	13 (0.9)		9 (0.7)		0.030
Marital status [c]					
Married or in registered partnership	595 (43.2)		599 (43.5)		0.039
Unmarried	671 (48.7)		644 (46.8)		−0.006
Widowed or divorced [d]	111 (8.1)		134 (9.7)		<0.1[e]
Family type [c]					
Couple with children [d]	660 (47.9)		664 (48.2)		<0.1[e]
Couple without children [d]	317 (23.0)		316 (22.9)		<0.1[e]

Table 1 (continued)

	VR recipients		Controls		
	N (%)	Mean (SD)	N (%)	Mean (SD)	SMD
Single parent [d]	103 (7.5)		100 (7.3)		<0.1[e]
Single without children or missing data	297 (21.6)		297 (21.6)		0.000
Number of children [c]		1.1 (1.2)		1.1 (1.2)	0.002
Follow-up start year		2014.1 (4.1)		2013.7 (4.0)	**0.104**

Full details used in the matching process, including data before matching, are provided in Supplementary Table S1

[a]at the time of OD recognition

[b]year before OD recognition

[c]at the beginning of follow-up

[d]Category collapsed for interpretability

[e]All SMDs for the collapsed category were within ± 0.1

were adjusted using the Holm correction. To minimize the impact of multiple testing on statistical power, we restricted formal comparisons to a subset of years of interest (− 1, 2, 3, 5, and 8). The limit for statistical significance was set to $p < 0.05$. The same methodology was used to analyze the effect of attained re-education or continuing education during VR and work participation by OD diagnosis. Matched pairs were extracted to diagnosis-specific subgroups from the main analysis.

Statistical analyses were performed using R Statistical Software (v4.0.5; R Core Team 2021).

Human Ethics

Ethical review was not required for a retrospective registry study with pseudonymized data. The study plan, including ethical considerations, was accepted by the Finnish Social and Health Data Permit Authority Findata, which was also responsible for ensuring the anonymity of the final results. For all datasets, personal identity codes and accident ID numbers were pseudonymized by Statistics Finland before releasing the data for analysis. Data management and analysis were conducted through remote access in a data-secured environment provided by Statistics Finland. Only members of the research team could process and analyze the data. The procedures followed were in accordance with the Declaration of Helsinki (2008).

Results

The dataset included 30,588 subjects with a recognized OD between 2005 and 2018, of whom 1621 received VR. Among the VR recipients, 1412 were eligible for matching. A matched control was found for 1377 of them (97.5%). The exclusion steps are illustrated in Fig. 1 for both the intervention and control groups.

Covariate balance for matched intervention and control groups is shown in Table 1, with selected variables collapsed for interpretability. Full balance before and after matching is provided in Supplementary Table S1. After matching, most covariates had standardized mean differences (SMDs) within ± 0.1. Residual differences between the intervention and control groups were observed for the proportion of lower non-manual workers (SMD − 0.120), pre-OD sickness absence days (SMD 0.164), and follow-up start year. Differences in non-manual workers and sickness absence favored the control group, whereas the difference in the follow-up start year was considered irrelevant.

The results of the work participation analysis for the intervention and control groups are illustrated in Fig. 2. The work participation one year before OD recognition was similar between the groups ($p = 0.71$). The control group had significantly higher work participation in follow-up years two and three ($p < 0.001$). By the fifth follow-up year, the intervention group had closed the gap with the control group, and the difference was again nonsignificant ($p = 0.66$). During the follow-up, neither of the groups achieved the initial work participation level observed before OD recognition. The trend in work participation during follow-up appeared more favorable in the intervention group, while the control group showed indications of a slight decline.

Approximately one quarter of subjects in the control pool experienced a career interruption during the follow-up gap. An uninterrupted career was associated with a higher likelihood of work participation in the fifth year of follow-up (OR 2.88, 95% CI 1.87–4.44). Among subjects with interrupted careers, work participation remained relatively stable over follow-up, with no clear positive trend (data not shown).

Follow-up datapoint loss was mainly due to the end of the data window (93.8%), with the retirement or death of either subject accounting for 3.4% and 1.3%, respectively, and missing data (e.g., moving abroad) accounting for 1.5%. The distribution of diagnoses differed between subjects with

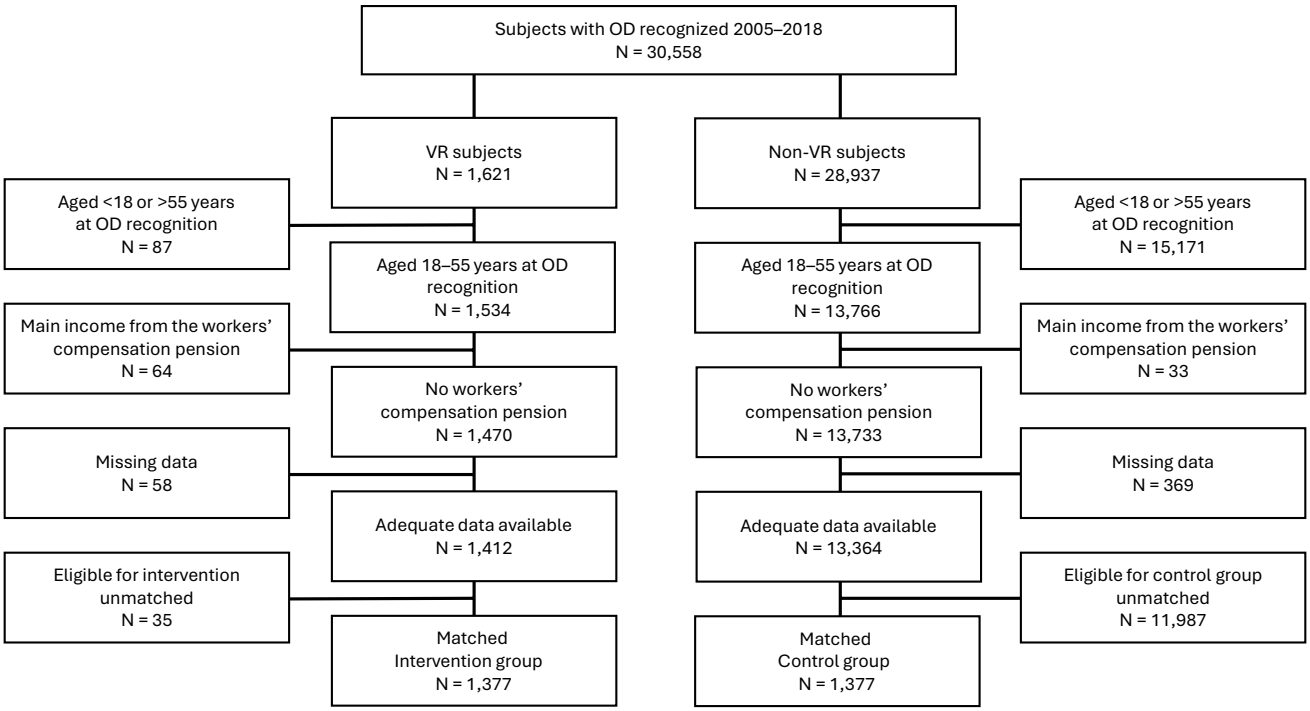

Fig. 1 Flowchart illustrating the selection of study participants and the formation of propensity score–matched intervention and control groups (VR = vocational rehabilitation, OD = occupational disease)

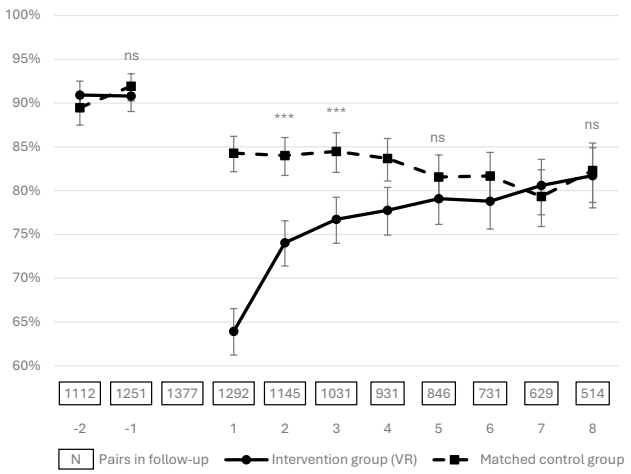

Fig. 2 Proportion of employed individuals during follow-up (VR = vocational rehabilitation, OD = occupational disease). Follow-up time in years. Years -2 and -1 before OD recognition. In the intervention group, follow-up year 1 was the last year of vocational rehabilitation, and the time from OD recognition varied between individuals. In the control group, follow-up year 1 was the third year from OD recognition. Statistical testing was performed at five time points and is indicated as ns (not significant), * = $p < .05$, ** = $p < .01$, and *** = $p < .001$

a short (≤ 4 years) and long (≥ 5 years) follow-up, with allergic contact dermatitis (ACD) being more common among those with a short follow-up. To assess potential bias, a sensitivity analysis excluding ACD subjects was performed, which did not change work participation levels (data not shown). Similarly, balancing sickness absence days in the matching procedure did not affect the work participation results, although it led to poorer overall matching (data not shown).

Work participation was analyzed separately for the most common diagnoses among VR recipients. The results for occupational asthma, occupational rhinitis, protein contact dermatitis or contact urticaria (PCD/CU), ACD, and irritant contact dermatitis (ICD) are presented in Fig. 3. No statistically significant differences in work participation were observed between the intervention and control groups during the year preceding OD recognition, regardless of diagnosis. Statistically significant differences were found only among individuals with ACD, and only at two time points during the follow-up: year 2 ($p < 0.001$) and year 3 ($p = 0.003$). For other OD diagnoses, and at years 5 and 8 of follow-up, no significant differences were detected. Our results suggest a higher employment rate among patients with asthma, rhinitis, or CU/PCD compared with those with ACD or ICD. However, as the groups were not mutually matched, no statistical testing was performed to assess the significance of this difference.

Among VR subjects eligible for matching, 672 (47.6%) had a recorded change in education, whereas 740 did not. Matching was achieved for 667 (99.3%) and 722 (97.6%),

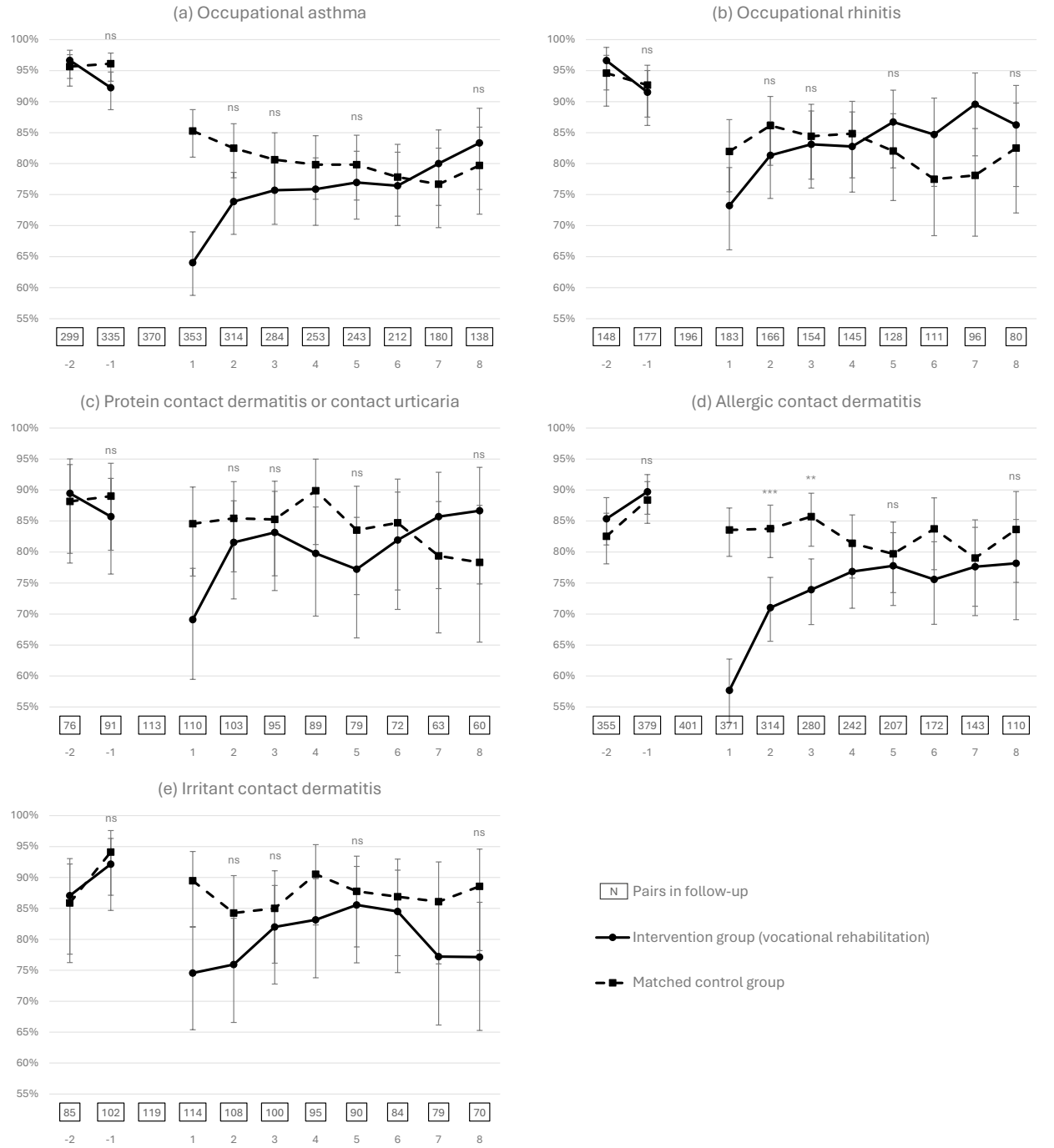

Fig. 3 Proportion of employed individuals during follow-up by diagnosis (OD = occupational disease). Follow-up time in years. Years -2 and -1 before OD recognition. In the intervention group, follow-up year 1 was the last year of vocational rehabilitation, and the time from OD recognition varied between individuals. In the control group, follow-up year 1 was the third year from OD recognition. Statistical testing was performed at five time points and is indicated as ns (not significant), * = $p < .05$, ** = $p < .01$, and *** = $p < .001$

respectively. Re-education or continuing education appeared to work well in maintaining OD patients' employability. Subjects in whom a rise in educational level or a degree update was observed during the VR period or the following year showed comparable work participation in comparison to their controls (Fig. 4a). The work participation of the control group appeared marginally better in follow-up year 2, but no significant differences were observed in the year preceding the index year or during follow-up years. At the end of the follow-up period, the work participation level

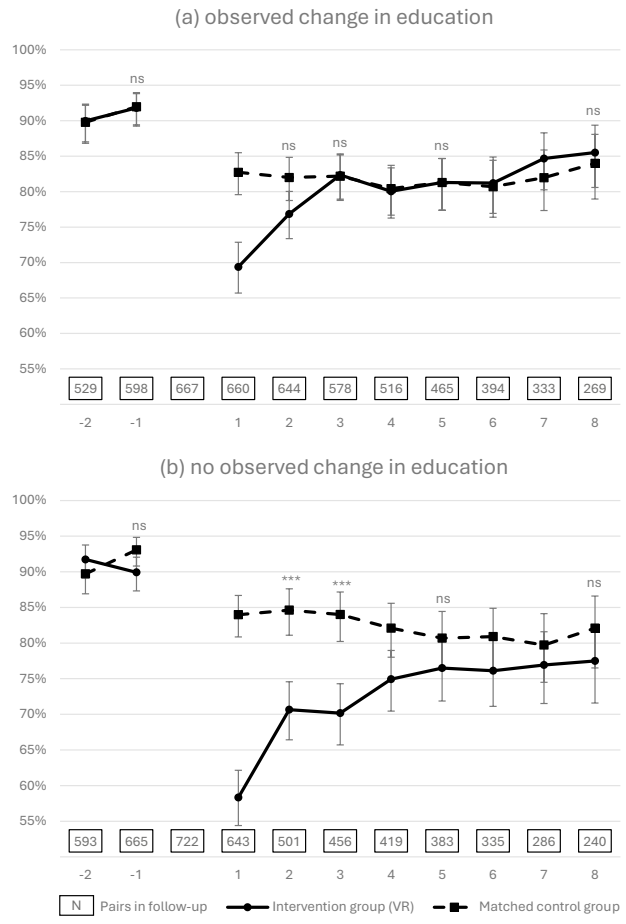

Fig. 4 Proportion of employed individuals during follow-up by educational change and group (VR = vocational rehabilitation, OD = occupational disease). **a** Detected change of educational level or year of completed degree during VR or one year after. **b** No change in education variables was observed during VR or one year after. Follow-up time in years. Years -2 and -1 before OD recognition. In the intervention group, follow-up year 1 was the last year of VR, and the time from OD recognition varied between individuals. In the control group, follow-up year 1 was the third year from OD recognition. Statistical testing was performed at five time points and is indicated as ns (not significant), * = $p < .05$, ** = $p < .01$, and *** = $p < .001$

was approximately 85% in both groups. Covariate balance between educated VR recipients and controls was similar (Supplementary Table S2).

VR subjects without an observed change in education showed a slightly poorer professional prognosis compared to their controls (Fig. 4b). Work participation levels were similar the year before the index year ($p = 0.146$), but the intervention group without educational change performed significantly poorer in follow-up years 2 and 3 ($p < 0.001$). In follow-up years 5 and 8, the differences between groups were again non-significant ($p = 0.373$ for both year 5 and year 8), although suggesting the worse employment of the intervention group. At the end of the follow-up, the work participation of the intervention group was 76%, compared to 83% for their controls. Covariate balance between VR recipients without educational change and their controls is shown in Supplementary Table S3.

Discussion

The work participation of OD patients receiving VR gradually approached that of the control group, with no statistically significant differences observed from year five onward. As all subjects regardless of group were subject to the same legislation and the equal right to receive VR, there probably were some underlying explanatory factors behind the rehabilitation decision [13, 18]. Opportunities for continued employment with the current employer are identified early in the OD diagnostic process and are crucial when making VR decisions. Job reassignment within the same company can often be achieved in large enterprises but is more challenging in small companies. Such interventions were considered VR only when financed through insurance, which employers may avoid because of potential increases in premiums. As VR is typically utilized when a probable career disruption is identified, it is likely that the post-OD work participation of the intervention group would have been lower without rehabilitation actions, like seen among controls with career interruption.

The lack of a plausible alternative to VR makes evaluating its effectiveness challenging. The control group of OD subjects who did not receive VR represented the best available reference, as these individuals had experienced work-related illnesses and had been strongly attached to the labor market prior to OD recognition. Thus, the control group primarily represents a target level of work participation and does not reflect a truly untreated comparison group. The American College of Occupational and Environmental Medicine's Work Disability Prevention and Management Guideline recommends the use of vocational rehabilitation in selected cases, despite evaluating the supporting evidence as insufficient [19].

We successfully performed a thorough matching process using several variables relevant to employability. After matching, the main difference between intervention and control groups was the insurer-identified need for VR, as sensitivity analysis suggested that sickness absence days had minimal impact. We interpret the comparable post-rehabilitation employment levels observed among VR recipients and controls as suggestive of successful rehabilitation. The relatively stable work participation among controls–that is non-rehabilitated patients–following the initial decline suggests that the selection of VR recipients effectively identifies those with a genuine need for rehabilitation. Nevertheless, some individuals outside the VR selection criteria

experienced challenges after career interruption following OD recognition.

The average work participation rate was approximately 70% in the Finnish working-age population (18–64 years) and 78% among the core working-age population (25–54 years) according to the Statistics Finland open data archives [20]. Post-OD employment levels in both the intervention and control groups exceeded those of the general Finnish population. However, this comparison should be interpreted cautiously, as the cohort included only individuals attached to the workforce, while the general population also includes individuals who never entered the labor market due to permanent disabilities, limiting comparability. Additionally, especially among the 18–64-year-old population, it was not possible to exclude subjects receiving old-age pensions from the general population data.

VR is a heterogeneous concept that varies considerably across country-specific social security systems, complicating both research and cross-country comparisons. Our findings indicate that the employment rate of VR recipients continues to increase long after the completion of vocational rehabilitation. Some previous studies have reported declining employment rates over time following VR interventions, but these studies focused on the general population, not on patients with ODs [21, 22]. A Finnish study on VR administered through the earnings-related pension scheme for individuals with musculoskeletal diseases or mental disorders reported a modest effectiveness and a slight positive trend; however, the short follow-up period may have underestimated the true impact of VR [9]. A large meta-analysis of active labor market programs finds that the positive employment effects of training programs typically emerge only after several years [23].

The context of VR in ODs differs from other settings. Individuals with OD are typically well-attached to the labor market prior to the diagnosis, and their work ability limitations due to the OD may be highly specific. A person with an OD may, under appropriate conditions, retain full work capacity. Post-VR employment rates in our data were notably higher than those reported in other VR study settings [22, 24, 25].

Diagnosis

The five largest diagnosis groups among VR recipients were analyzed separately, but the diagnosis was not a major factor influencing employment rate. Because diagnosis-specific subsamples were derived from the primary propensity score–matched cohort, covariate balance may differ across subsamples. Poor work participation was noted in some occupational diseases, such as hand-arm vibration syndrome and solvent-induced encephalopathy, but the number of subjects in these diagnosis groups was too low to draw reliable conclusions.

Existing evidence on post-OD employment has primarily relied on questionnaires or interviews. Our results from comprehensive registry data did not reveal conflicting findings, thereby reinforcing the validity of existing evidence. [1, 3, 4, 26, 27]

Education as a Means of VR

Re-education during VR was associated with the highest work participation in our study, although the difference between the educated intervention group and their controls was not statistically significant. The trend in employment rate was positive throughout the 8-year follow-up, suggesting the lasting effect of education on employability. Our findings differ from a Swedish study in which educational VR was considered detrimental to employment. The study cohorts also differed markedly. In the Swedish dataset, the inclusion required a minimum of 60 consecutive days of sickness absence. Approximately three-fourths of educational VR recipients had psychiatric or musculoskeletal diagnoses, and the mean age was considerably higher (39.1 vs 34.0 years). Moreover, educational VR was often applied to previously unemployed subjects with long-term sickness absence, which may explain the poorer outcomes [10]. In some studies, the effect of education has been reported to diminish over time in the long-term [22, 28]. However, a greater number of pre-injury education years has been identified as a significant predictor of work participation among VR recipients [29].

Comparing VR recipients without an educational change to their matched controls yielded somewhat different outcomes. In cases where VR did not involve formal education, it likely consisted of work tryouts and possibly additional training that did not lead to a degree. The employment rate of non-educated VR recipients increased over the first five years of follow-up and then plateaued. The work participation level in this group was approximately five percentage points lower than that of the controls in the final years of follow-up, but the difference did not reach statistical significance when assessed in year 5 or 8. Our findings contradict earlier studies, where on-the-job training was found to be more effective than education. This discrepancy may be due to the fact that our target population consisted of OD patients, whereas previous studies focused on subjects who were sick listed and belonged to the general population [10, 22]. OD patients have a pronounced need for education, as work-related illness may threaten their profession.

Strengths and Limitations

A major strength of this study is the use of comprehensive registry data covering all recognized occupational diseases and their compensations. To our knowledge, comparable results have not been published before on the VR of ODs. A key strength of this study is also the extended follow-up period of up to 8 years post-VR, during which a sufficient number of matched pairs remained available for analysis. This allowed for the assessment of longer-term outcomes, which are often lacking in previous VR studies.

The broad range of socio-demographic variables enabled the matching of the subjects in the intervention and control groups using propensity score matching. The large control pool resulted in a high rate of successful matching and only a minimal number of eligible but unmatched subjects. The conditions for remaining in previous or comparable employment likely differ between the VR recipients and controls, but the registry data did not allow this to be assessed. Regardless of the matching process, we probably were not able to create a truly comparable control population. While this represents a limitation of the study, evaluating the effectiveness of VR in a randomized controlled manner is not ethically feasible or possible. The comparison is typically performed between usual care and specific VR intervention, but not with a lack of rehabilitation [8]. Utilizing an internal control group of OD subjects without VR is not ideal but is often the only feasible option, as a truly eligible yet unrehabilitated group does not exist [30]. One key objective of VR in ODs is the cessation of exposure to the causative agent, which often necessitates a change of job or occupation. Unfortunately, we were unable to comprehensively assess whether this objective was achieved in the individual cases. Our data did not allow the identification of cases in which exposure had ceased or substantially declined, and thus the potential impact of VR on exposure avoidance remains unassessed. We decided to exclude the subjects with the main income coming from the workers' compensation pension at the end of follow-up, as the pension was considered as a direct consequence of the OD rather than the failure of the VR process. Insurance companies seldom grant a workers' compensation pension without the assessment of VR possibilities, which was typically seen as VR costs and a short VR period in the insurance data. Approximately two thirds of workers' compensation pension recipients had some VR expenses registered. The inclusion of these subjects in the intervention group would have resulted in a significant decline in work participation, thereby potentially yielding misleading conclusions about the effectiveness of VR interventions targeting the return to work.

Concluding Remarks

The impact of OD on work ability can vary considerably. In some cases, individuals can continue working with minor workplace adjustments, while in other cases, a change of profession may be necessary. VR is implemented when career disruption is identified in order to support and promote future work ability. Our results indicate that VR recipients achieved work participation levels comparable to those of their matched controls, suggesting the effectiveness of VR. Future research should pay particular attention to the positive trend in work participation that persisted for several years post-intervention, which underscores the importance of incorporating long-term follow-up assessments. Additional research is needed to evaluate whether exposure cessation is achieved across all OD subjects, irrespective of VR status.

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Author Contributions All authors contributed to the study conception and design. Material preparation and analysis were performed by Ville Ojanen and Mikko Korhonen. The first draft of the manuscript was written by Ville Ojanen and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability The datasets generated and analyzed during the present study are not publicly available.

Declarations

Competing interests Kirsi Koskela serves as Chief Medical Officer and Ville Ojanen as Medical Specialist at the Finnish Register of Occupational Diseases. Both are also employed at the Occupational Medicine Outpatient Clinic of Tampere University Hospital, operated by the Finnish Institute of Occupational Health. Tiia Reho provides consultancy services for LocalTapiola Insurance Company and is employed by Varma Mutual Pension Insurance Company. Riitta Sauni serves as a member of the Accident Appeal Board. Mikko Korhonen declares no competing interest.

Ethical Approval Study plan was evaluated by Finnish Social and Health Data Permit Authority Findata (data permit THL/3512/14.02.00/2021). Ethics committee approval was not required for a retrospective registry study with pseudonymized data.

Consent to participate Not applicable in registry-based study.

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