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Employment pathways in the five years after workers' compensation medical care ends: a sequence analysis of two Korean national cohorts

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Research Article

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Abstract

Purpose Return to work is usually assessed at one time point, although injured workers change employers and leave and re-enter work. We described five-year employment pathways after workers' compensation medical care ended and examined whether working for a different employer preceded leaving work.

Methods We analysed two national cohorts of the Panel Study of Workers' Compensation Insurance (PSWCI) whose care ended in 2012 (n = 1,514) or 2017 (n = 2,573) and who completed all five annual interviews. Annual states (employer at injury, different employer, self-employment, unemployment, out of the labour force) were grouped into pathways by sequence analysis. We estimated survey-weighted prevalence and fitted multinomial logistic and, among workers employed at the first interview, modified Poisson models.

Results Four stable pathways, reproduced in each cohort, corresponded to the state in which workers spent most years: the employer at injury (32.9% in cohort 1, 29.6% in cohort 2), a different employer (49.6%, 46.4%), self-employment (7.3%, 6.8%) and persistent non-employment (10.2%, 17.2%). Among workers employed at the first interview, working for a different employer was not clearly associated with subsequently leaving work (adjusted risk ratio 1.13; 95% CI 0.97–1.32), and self-employment was associated with a lower risk (0.52; 95% CI 0.33–0.82). Age ≥ 60 years and care > 12 months were associated with 27.4 and 26.2 percentage-point higher probabilities of persistent non-employment (survey-weighted: 22.8 and 16.1).

Conclusion Leaving the employer at injury usually meant working elsewhere, not leaving work. Older workers and workers with long medical care may need support after care ends.

Introduction

Returning to work is a central goal of occupational rehabilitation, but the first return to work is a poor marker of success. Workers who return may leave again, change employers or move between work and benefits, so outcomes measured at a single time point misclassify many of them [1, 2]. Return to work is better understood as a process that continues after the first day back [3, 4], and sustainable return to work has become a key outcome in the field [5]. Claims data show how often the first return fails: in Victoria, Australia, 94% of claimants returned to work at least once within two years, but only 79% achieved a sustained return [6], and failed returns were common after transport injuries [7].

Less is known about what happens after the compensation claim, and the medical care it pays for, has ended. In Washington State, workers with permanent impairment had delayed return, more interruptions and more quarters without wages over up to ten years after claim closure [8], and a year after closure many reported that their impairment made it difficult to keep their job [9]. Such outcomes involve several states and repeated changes and are hard to summarise with time-to-event measures. Sequence analysis describes whole employment histories—their order, timing and duration—and groups similar

histories into typical pathways [10–12]. Sequence and multistate analyses have described return-to-work trajectories after work-related musculoskeletal disorders [13] and labour market pathways after sickness absence, disability pension or injury [14–17], but evidence from Asian workers' compensation systems is scarce.

In Korea, the Korea Workers' Compensation & Welfare Service runs the national workers' compensation insurance, and its Panel Study of Workers' Compensation Insurance (PSWCI) follows samples of workers whose compensated medical care ended in a given year [18]. PSWCI studies have shown that the type of return matters: workers re-employed by a different employer were more likely than those who returned to their original workplace to leave their job within about three years [19, 20], and return to work and job retention were related to income over five years [21]. Union presence at the workplace of injury was associated with return to work [22], whereas unstable pre-injury employment was associated with re-employment in a new firm or unemployment rather than return to the pre-injury job [23, 24]. Recent PSWCI studies in this journal examined psychological resources and self-rated health trajectories [25, 26]. A Korean-language study described transition probabilities between employment states over the first three waves [27], and a recent Korean-language study applied sequence analysis to four-year job histories of the first two cohorts and identified five trajectory types [28].

These studies leave a practical question open: does leaving the employer at injury mean leaving work? Retention studies counted any job change as an event [19, 20], and the sequence analysis of the first two cohorts examined retention separately among workers who returned to the original workplace and among re-employed workers [28]. We compared these groups directly on a common outcome, exit from employment, and kept self-employment as a separate state. We also used all five annual interviews of both cohorts and estimated the survey-weighted prevalence of five-year pathways for the national populations of workers whose care ended.

We asked (1) which employment pathways workers follow in the five years after their compensated medical care ends and how common each pathway is; (2) which factors at injury are associated with pathway membership; (3) whether pathways and associations are similar in the two cohorts; and (4) among workers employed at the first interview, whether the type of employment predicts remaining in work. We hypothesised that older age, a severe disability grade, occupational disease, long medical care, non-regular employment and small firm size would be associated with persistent non-employment (H1), and that workers employed by a different employer or self-employed at the first interview would be less likely than those working for the employer at injury to remain employed (H2).

Methods

Data Source and Setting

The PSWCI is a national panel survey conducted by the Labor Welfare Research Institute of the Korea Workers' Compensation & Welfare Service. Each cohort is a stratified sample of workers whose

compensated medical care ended in one calendar year; foreign workers and residents of Jeju Island are excluded, and participants are interviewed face to face every August to October for five years [18]. Cohort 1 comprised 2,000 workers whose care ended in 2012 (survey population 82,493; allocation by disability grade, then proportional allocation across nine regions; interviews 2013–2017). Cohort 2 comprised 3,294 workers whose care ended in 2017 (survey population 75,392; priority allocation to disability grades 1–3 and to workers without a grade, square-root allocation across the remaining grades; interviews 2018–2022). The first interview therefore took place 8 to 21 months after care ended, so observation started at a variable time after, not at, the end of care. Occupational disease, duration of care, disability grade, job tenure and use of rehabilitation services come from insurance records. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [29] (Online Resource 1).

Study Population

We included participants who responded at all five interviews: 1,514 of 2,000 (75.7%) in cohort 1 and 2,573 of 3,294 (78.1%) in cohort 2. The employment item had no missing values among respondents. The survey's longitudinal weight for continuous respondents is positive for exactly these participants and sums to the survey population of each cohort. Participation by wave is shown in Online Resource 2 (Table S1).

Employment States and Sequences

At each interview the PSWCI classifies the respondent's economic activity in the previous week into six categories. We grouped them into five states: working for the employer at the time of injury (O); working for a different employer (R); self-employed or unpaid family worker (S); unemployed (U); and not in the labour force (N). Respondents who were employed at the previous interview were first asked whether they still held the same job (dependent interviewing). We call one worker's five annual states a sequence and a group of similar sequences a pathway.

Factors at Injury

We used factors that were known when care ended (Online Resource 2, Table S2): sex; age group (completed years in August of the first survey year, the only age available in the public data); education; occupational disease versus injury; duration of compensated medical care; disability grade (none, grades 10–14, grades 1–9; grades 1–3 were merged with grades 4–9 because only 88 participants had them); employment status at injury (regular, temporary or other, daily); firm size; trade union at the workplace of injury (yes, no, unknown or not asked); industry; job tenure at injury; marital status at injury; and cohort. Use of rehabilitation services was included only as a design variable because cohort 1 over-sampled service users; its coefficients are not reported. For the secondary analysis we added three measures from the first interview: pain interfering with daily life for a considerable time or always, long-lasting

limitation in walking, climbing stairs or lifting, and current chronic disease. No factor had missing values in the analytic sample.

Statistical Analysis

Analysis plan. Before any employment states were examined, we recorded a statistical analysis plan, including the rule for choosing the number of pathways and both hypotheses, in a local version-controlled (git) repository, and we recorded the pathway names before any model was fitted. The plan was not registered with a third party, and the commit times are the authors' own records (Online Resource 2, S1.8). One later change, a small penalty added to the imputation models of one sensitivity analysis because they did not converge, is documented in the plan. Analyses added after an internal review of the draft are labelled post hoc (Online Resource 2, S1.10).

Sequences and clustering. We computed distances between sequences with optimal matching, which adds up the costs of the substitutions, insertions and deletions needed to turn one sequence into another [10, 12]; with a substitution cost of 2 and an insertion–deletion cost of 1, the distance is smaller the more states two sequences share in the same order. Sequences from both cohorts were clustered together without weights; because cohort 2 contributed 63% of them, we also clustered each cohort separately. Ward's hierarchical method [30] provided starting medoids, the most central sequence of each group, for partitioning around medoids [31]. For two to ten pathways we computed the average silhouette width (ASW; how much closer workers are to their own pathway than to the nearest other one, from − 1 to 1) [32] and two further measures of separation, the point-biserial correlation and Hubert's C [33]. The pre-specified rule selected, among solutions with three to eight pathways in which every pathway included at least 3% of participants, the smallest number whose ASW was within 0.02 of the highest. Stability was assessed with 200 bootstrap resamples and the cluster-wise Jaccard coefficient, the overlap between a pathway and its best match in a resampled solution (1, identical) [34]. Pathways were named from their medoid sequences and state distributions. Post hoc, we compared the pathways with a simple rule that assigns each worker to the state among O, R, S and N in which the worker spent the most years.

Weighted prevalence. Pathway prevalence in each cohort was weighted with the longitudinal weight, with percentile 95% confidence intervals (CIs) from 1,000 bootstrap resamples of participants. The public data contain no stratum identifiers, so post hoc we repeated the bootstrap within approximate sampling strata.

Association models. Multinomial logistic regression related pathway membership to all factors at injury, cohort and service use (27 parameters per equation), with the pathway of sustained work for the employer at injury as reference and robust standard errors. We report relative risk ratios (RRRs), which compare the probability of a pathway relative to the reference pathway between factor levels, and average marginal effects (AMEs). An AME is the difference in the average predicted probability of a pathway when every participant is assigned the factor level rather than the reference level; its CI was

obtained with the delta method. As pre-specified, the main models were unweighted; because the sample over-represents workers with a disability grade and, in cohort 1, service users, we also report AMEs from models weighted with the longitudinal weight. Interactions between cohort and age group, disability grade and employment status were tested with Wald tests. H1 concerned the persistent non-employment pathway. Post hoc, we estimated unadjusted AMEs from models with one factor at a time and, because the self-employment equation had 9.3 events per parameter, refitted a reduced model with the H1 factors, sex, cohort and service use (17 parameters per equation).

Employment persistence (H2). Among participants employed at the first interview, the outcome was being unemployed or out of the labour force at any of the second to fifth interviews. Modified Poisson regression, a Poisson model with robust standard errors that estimates risk ratios for a binary outcome [35], estimated adjusted risk ratios (RRs) for working for a different employer or being self-employed, compared with working for the employer at injury, adjusted for all factors, cohort, service use and the three first-interview health measures. Within each cohort we used logistic regression and g-computation [36], which predicts each worker's probability under each type of employment and averages the predictions, to obtain standardised probabilities of being employed at every later interview, with bootstrap CIs. For the RRs we computed E-values [37]: the minimum strength of association, on the risk-ratio scale, that an unmeasured confounder would need with both the type of employment and the outcome to explain an RR away.

Additional analyses. Among participants not employed at the first interview, we estimated weighted proportions who were employed at any later interview and at both the fourth and fifth interviews. Exits from employment between the second and third interviews were compared descriptively between the cohorts (2014–2015 and 2019–2020, the first year of the COVID-19 pandemic).

Sensitivity analyses. All were pre-specified: Hamming distance and transition-rate substitution costs; solutions with one pathway fewer or more; latent class analysis; models weighted with the longitudinal weight; exclusion of participants aged ≥ 60 years or with occupational disease or commuting injuries; three-state and two-state sequences; and separate clustering of each cohort. Typologies were compared with the adjusted Rand index (ARI; 1, identical classifications; 0, chance agreement) [38]. Finally, we included all 5,294 participants, treating missed interviews as an additional state or imputing them with chained multinomial models (20 imputations) [39]. Post hoc, we tabulated the recorded reasons for missed interviews, including death, and repeated the imputation analysis without participants recorded as having died.

Software. Analyses used Python 3.10.11 (Python Software Foundation, Beaverton, OR, USA) with pandas 2.3.3, NumPy 2.2.6, SciPy 1.15.3, statsmodels 0.15.0 and pyreadstat 1.3.6; figures were drawn with matplotlib 3.10.9. Sequence distances, clustering, quality indices and the multinomial models were written by the authors. Unit tests checked them against SciPy, statsmodels and hand-calculated examples, and on the study data the multinomial model reproduced the statsmodels estimates and robust standard errors (differences < 10^{-13}).

Ethics

This study was a secondary analysis of publicly available, de-identified PSWCI data that contain no personally identifiable information. Under the Bioethics and Safety Act of Korea (Enforcement Rule, Article 13(1)(3): research using existing data disclosed to the general public without personally identifiable information), such research is exempt from institutional review board review, and no approval was required. The PSWCI is an official statistic under Article 17 of the Statistics Act (approval No. 439001), and responses are protected under Article 33 of the Act. The study followed the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Use of Generative Artificial Intelligence

Anthropic Claude Opus 5.5 (model claude-opus-5-5), used in November 2026 through Claude Code (Anthropic), drafted the statistical analysis plan, wrote and unit-tested the analysis code, ran the analyses, searched and screened the literature, checked bibliographic records against PubMed, Crossref and the Korea Citation Index, and drafted this manuscript. After a simulated peer review of the draft, also generated with Claude Code, it revised the manuscript and ran the analyses labelled post hoc. The authors checked the analyses and the text, revised the manuscript where needed and take full responsibility for its content.

Results

Participants

Of 2,000 and 3,294 participants at the first interview, 1,616 and 2,728 took part in the fifth interview and 1,514 and 2,573 responded at all five interviews (Online Resource 2, Table S1). Table 1 shows their characteristics. Compared with cohort 1, cohort 2 had a larger weighted share of participants aged ≥ 60 years (22.6% vs. 10.5%) and of participants with chronic disease (22.0% vs. 12.6%).

Table 1
Characteristics of workers who responded at all five interviews, by cohort

Characteristic	Cohort 1 (care ended 2012), n = 1,514	Cohort 2 (care ended 2017), n = 2,573
Female sex	261 (19.4)	466 (21.9)
Age group, years[a]		
≤ 39	297 (32.6)	392 (22.5)
40–49	372 (28.6)	507 (21.4)
50–59	554 (28.2)	916 (33.6)
≥ 60	291 (10.5)	758 (22.6)
Education		
Middle school or less	619 (29.2)	952 (31.2)
High school	666 (49.2)	1,165 (46.8)
College or higher	229 (21.6)	456 (22.0)
Occupational disease (vs. injury)[b]	131 (7.0)	147 (5.1)
Duration of compensated medical care[b]		
≤ 6 months	872 (75.1)	1,414 (76.5)
> 6–12 months	484 (19.1)	766 (18.3)
> 12 months	158 (5.8)	393 (5.3)
Disability grade[b]		
None	264 (61.0)	500 (64.8)
Grades 10–14	1,041 (32.8)	1,525 (31.3)
Grades 4–9	188 (5.6)	481 (3.5)
Grades 1–3	21 (0.6)	67 (0.4)
Employment status at injury		
Regular	851 (57.7)	1,479 (59.7)
Temporary or other	213 (17.2)	294 (11.7)
Daily	450 (25.2)	800 (28.6)
Firm size at injury, employees		
< 5	231 (16.6)	470 (20.3)

Characteristic	Cohort 1 (care ended 2012), n = 1,514	Cohort 2 (care ended 2017), n = 2,573
5–29	635 (40.8)	1,303 (49.4)
30–299	451 (28.6)	593 (22.6)
≥ 300	197 (13.9)	207 (7.7)
Trade union at the workplace of injury[c]		
Yes	155 (11.8)	190 (7.4)
No	1,273 (82.5)	2,172 (85.3)
Unknown or not asked	86 (5.7)	211 (7.4)
Industry at injury		
Manufacturing	589 (35.9)	853 (27.3)
Construction	391 (21.7)	800 (26.6)
Transport	60 (4.6)	96 (4.3)
Other	474 (37.7)	824 (41.8)
Job tenure at injury, years[b]		
< 1	965 (64.6)	1,594 (61.5)
1–5	300 (19.8)	560 (22.9)
≥ 5	249 (15.6)	419 (15.6)
Married at injury	1,100 (64.6)	1,766 (63.4)
Used rehabilitation services[b]	792 (25.6)	583 (11.5)
High pain interference at the first interview	453 (20.5)	907 (24.6)
Physical limitation at the first interview	521 (24.2)	906 (23.0)
Chronic disease at the first interview	242 (12.6)	657 (22.0)

Values are unweighted numbers of workers, with percentages weighted by the longitudinal weight for continuous respondents in parentheses; percentages may not sum to 100 because of rounding. [a] Completed years in August of the first survey year. [b] From insurance records. [c] Workers who were self-employed at injury in cohort 2 were not asked this question

Employment Pathways

The 4,087 participants had 389 distinct sequences. The pre-specified rule selected four pathways (ASW 0.69, compared with 0.62 for three and 0.56 for five pathways; Online Resource 2, Fig. S1). Figure 1 shows the state distributions and Table 2 the prevalence of each pathway. The medoids were five years in a single state: with the employer at injury, with a different employer, in self-employment and out of the labour force. Accordingly, pathway membership coincided with the state among O, R, S and N in which workers spent the most years for 4,076 of 4,087 workers (99.7%); the other 11 had equally many years in two states (Online Resource 2, Table S16). Unemployment (4.1% of person-years) did not define a pathway, and the different-employer pathway also included 83 workers who were unemployed or out of the labour force in three or more of the five years. The pathways were stable (mean bootstrap Jaccard coefficient ≥ 0.95 for each pathway; Online Resource 2, Table S4), and clustering each cohort separately reproduced them (ARI 0.99 in cohort 1 and 1.00 in cohort 2).

In cohort 1, 32.9% (95% CI 29.0–37.3) of the population followed the injury-employer pathway, 49.6% (45.1–53.8) the different-employer pathway, 7.3% (4.7–10.3) the self-employment pathway and 10.2% (8.1–12.8) the persistent non-employment pathway. In cohort 2 the corresponding figures were 29.6%, 46.4%, 6.8% and 17.2%; persistent non-employment was 7.0 percentage points (95% CI 3.7–9.8) more common than in cohort 1. The weighted share employed rose from 79.1% at the first to 85.8% at the fifth interview in cohort 1 and from 70.9% to 76.7% in cohort 2, while the share working for the employer at injury fell from 40.3% to 28.7% and from 35.6% to 23.5% (Online Resource 2, Table S5).

Table 2
Employment pathways in the five years after compensated medical care ended

Pathway	Most typical sequence (medoid)[a]	Mean years employed[b]	Cohort 1, n	Cohort 1, weighted % (95% CI)	Cohort 2, n	Cohort 2, weighted % (95% CI)	Difference, cohort 2 − cohort 1 (95% CI)[c]
Sustained work for the employer at injury	OOOOO	4.7	476	32.9 (29.0–37.3)	655	29.6 (26.8–32.5)	−3.2 (− 8.5 to 1.5)
Work for a different employer	RRRRR	4.3	718	49.6 (45.1–53.8)	1,109	46.4 (43.5–49.6)	−3.2 (− 8.7 to 2.1)
Self-employment	SSSSS	4.5	89	7.3 (4.7–10.3)	162	6.8 (5.2–8.2)	−0.6 (− 4.1 to 2.5)
Persistent non-employment	NNNNN	0.5	231	10.2 (8.1–12.8)	647	17.2 (15.1–19.3)	7.0 (3.7 to 9.8)

Percentages are weighted by the longitudinal weight for continuous respondents and estimate the distribution in each cohort's survey population; n are unweighted counts. 95% CIs are percentiles of 1,000 bootstrap resamples within cohort. [a] The sequence with the smallest total distance to the other sequences of the pathway; letters give the state at the five annual interviews: O, working for the employer at injury; R, working for a different employer; S, self-employed or unpaid family worker; U, unemployed; N, not in the labour force. [b] Number of the five annual interviews at which the worker was employed (states O, R or S), averaged over the workers in the pathway without weights. [c] Percentage points

Factors at Injury and Pathways

Consistent with H1, all pre-specified factors were associated with persistent non-employment relative to the injury-employer pathway (Online Resource 2, Table S6): age ≥ 60 years (RRR 6.30; 95% CI 4.07–9.76), care longer than 12 months (7.22; 95% CI 5.04–10.36), disability grades 1–9 (2.39; 95% CI 1.59–3.60), occupational disease (2.17; 95% CI 1.48–3.19), daily employment (1.76; 95% CI 1.26–2.47), temporary or other employment (2.04; 95% CI 1.41–2.94) and firms with fewer than five employees (2.05; 95% CI 1.24–3.40). On the absolute scale the factors differed (Table 3). The probability of persistent non-employment was higher for age ≥ 60 years (AME 27.4 percentage points; 95% CI 23.0–31.8), care longer than 12 months (26.2 percentage points; 95% CI 21.6–30.7) and disability grades 1–9 (12.9 percentage points; 95% CI 8.3–17.4), whereas the differences for daily employment (1.2 percentage points; 95% CI − 2.2 to 4.7) and small firms (4.7 percentage points; 95% CI − 0.7 to 10.1) were small. With survey weights, the AMEs for age ≥ 60 years and long care were smaller (22.8 and 16.1 percentage points), although the RRRs changed less (5.01 and 6.70; Online Resource 2, Table S8), mainly because persistent non-employment was less common in the weighted populations than in the unweighted sample (21.5%). Conditions of the job at injury mainly separated the injury-employer pathway from the different-employer pathway: tenure shorter than one year was associated with a lower probability of the injury-employer

pathway (− 31.0 percentage points; 95% CI − 35.8 to − 26.2), and a trade union at the workplace with a higher one (11.0 percentage points; 95% CI 5.3–16.7). Women (8.7 percentage points; 95% CI 5.1–12.3) and workers in cohort 2 (5.8 percentage points; 95% CI 3.2–8.3) were more likely to follow the persistent non-employment pathway. There was weak evidence that the association with age group differed between cohorts (interaction P = 0.09) and little evidence for disability grade (P = 0.83) or employment status (P = 0.59; Online Resource 2, Table S7). Unadjusted associations had the same direction as the adjusted ones for 87% of the 100 estimates but were usually larger, especially for job characteristics, which were correlated with one another (trade union and the injury-employer pathway: 42.2 vs. 11.0 percentage points; Online Resource 2, Table S17). In a reduced model with 14.8 events per parameter in the self-employment equation, AMEs for self-employment changed by at most 2.9 percentage points (Online Resource 2, Table S18).

Table 3

Average marginal effects of factors at injury on the probability of each employment pathway (percentage points, 95% CI)

Factor (reference)	Sustained work for the employer at injury	Work for a different employer	Self-employment	Persistent non-employment
Female (ref. male)	−5.6 (− 8.7 to − 2.6)	1.2 (− 2.9 to 5.3)	−4.3 (− 5.8 to − 2.8)	8.7 (5.1 to 12.3)
Age group, years (ref. ≤39)				
40–49	4.4 (0.7 to 8.2)	−0.6 (− 5.6 to 4.4)	−4.4 (− 8.0 to − 0.8)	0.6 (− 2.7 to 3.8)
50–59	4.3 (0.6 to 8.1)	−5.3 (− 10.4 to − 0.3)	−6.5 (− 10.1 to − 3.0)	7.5 (4.3 to 10.8)
≥ 60	−5.1 (− 9.4 to − 0.7)	−14.7 (− 20.5 to − 9.0)	−7.6 (− 11.4 to − 3.8)	27.4 (23.0 to 31.8)
Education (ref. college or higher)				
Middle school or less	−4.2 (− 8.2 to − 0.2)	−2.2 (− 7.3 to 2.8)	1.4 (− 1.2 to 4.0)	5.0 (0.9 to 9.1)
High school	0.1 (− 3.2 to 3.4)	−3.2 (− 7.5 to 1.1)	0.1 (− 1.9 to 2.1)	3.0 (− 0.7 to 6.7)
Occupational disease (ref. injury)	−6.6 (− 10.4 to − 2.7)	1.0 (− 5.2 to 7.1)	−1.1 (− 4.3 to 2.0)	6.7 (1.8 to 11.6)
Duration of medical care (ref. ≤6 months)				
> 6–12 months	−6.2 (− 9.1 to − 3.4)	1.1 (− 2.3 to 4.5)	0.7 (− 1.1 to 2.5)	4.4 (1.8 to 7.1)
> 12 months	−12.7 (− 16.6 to − 8.8)	−12.5 (− 17.6 to − 7.4)	−1.0 (− 3.6 to 1.6)	26.2 (21.6 to 30.7)
Disability grade (ref. none)				
Grades 10–14	−1.7 (− 5.0 to 1.6)	2.1 (− 1.9 to 6.1)	−0.4 (− 2.6 to 1.7)	0.1 (− 3.1 to 3.4)
Grades 1–9	−3.4 (− 8.1 to 1.4)	−8.4 (− 13.9 to − 2.9)	−1.1 (− 4.0 to 1.8)	12.9 (8.3 to 17.4)
Employment status at injury (ref. regular)				

Multinomial logistic regression including all factors shown, cohort and use of rehabilitation services (n = 4,087). An average marginal effect is the difference in the average predicted probability of a pathway when all workers are assigned the factor level rather than the reference level; the effects in a row sum to zero. CIs use robust standard errors and the delta method. Relative risk ratios are shown in Online Resource 2 (Table S6)

Factor (reference)	Sustained work for the employer at injury	Work for a different employer	Self-employment	Persistent non-employment
Temporary or other	−10.7 (− 14.7 to − 6.8)	7.4 (2.6 to 12.1)	1.1 (− 1.3 to 3.5)	2.2 (− 1.5 to 6.0)
Daily	−9.5 (− 13.4 to − 5.6)	4.9 (0.4 to 9.4)	3.3 (0.6 to 6.1)	1.2 (− 2.2 to 4.7)
Firm size at injury, employees (ref. ≥300)				
< 5	−8.9 (− 14.7 to − 3.1)	−1.5 (− 8.4 to 5.3)	5.8 (2.4 to 9.2)	4.7 (− 0.7 to 10.1)
5–29	−7.9 (− 13.1 to − 2.7)	3.8 (− 2.5 to 10.0)	2.0 (− 0.7 to 4.6)	2.2 (− 2.6 to 7.1)
30–299	−7.5 (− 12.6 to − 2.5)	4.7 (− 1.6 to 11.0)	0.5 (− 2.1 to 3.0)	2.4 (− 2.5 to 7.3)
Trade union at workplace (ref. no)				
Yes	11.0 (5.3 to 16.7)	−11.6 (− 18.7 to − 4.6)	−0.3 (− 4.4 to 3.8)	0.9 (− 4.7 to 6.6)
Unknown or not asked	−7.3 (− 12.5 to − 2.1)	0.4 (− 5.3 to 6.2)	5.0 (1.3 to 8.8)	1.8 (− 2.7 to 6.3)
Industry (ref. manufacturing)				
Construction	−7.3 (− 11.0 to − 3.5)	6.9 (2.3 to 11.6)	−2.0 (− 4.2 to 0.2)	2.4 (− 1.2 to 5.9)
Transport	2.4 (− 4.3 to 9.0)	−6.1 (− 14.3 to 2.0)	3.9 (− 1.3 to 9.0)	−0.1 (− 6.5 to 6.4)
Other	0.3 (− 2.7 to 3.3)	−1.8 (− 5.6 to 2.0)	0.4 (− 1.8 to 2.5)	1.1 (− 1.9 to 4.2)
Job tenure at injury, years (ref. ≥5)				
< 1	−31.0 (− 35.8 to − 26.2)	27.4 (22.5 to 32.3)	1.7 (− 0.8 to 4.2)	1.9 (− 2.1 to 5.9)
1–5	−16.5 (− 21.3 to − 11.8)	16.5 (11.5 to 21.6)	1.8 (− 0.8 to 4.4)	−1.8 (− 5.8 to 2.2)
Married at injury (ref. not married)	4.9 (2.2 to 7.7)	−2.6 (− 5.8 to 0.7)	3.3 (1.7 to 4.9)	−5.7 (− 8.4 to − 3.0)

Multinomial logistic regression including all factors shown, cohort and use of rehabilitation services (n = 4,087). An average marginal effect is the difference in the average predicted probability of a pathway when all workers are assigned the factor level rather than the reference level; the effects in a row sum to zero. CIs use robust standard errors and the delta method. Relative risk ratios are shown in Online Resource 2 (Table S6)

Factor (reference)	Sustained work for the employer at injury	Work for a different employer	Self-employment	Persistent non-employment
Cohort 2 (ref. cohort 1)	−5.0 (− 7.7 to − 2.3)	−1.4 (− 4.6 to 1.8)	0.6 (− 1.0 to 2.2)	5.8 (3.2 to 8.3)

Multinomial logistic regression including all factors shown, cohort and use of rehabilitation services (n = 4,087). An average marginal effect is the difference in the average predicted probability of a pathway when all workers are assigned the factor level rather than the reference level; the effects in a row sum to zero. CIs use robust standard errors and the delta method. Relative risk ratios are shown in Online Resource 2 (Table S6)

Employment Persistence

Of 2,670 participants employed at the first interview, 648 (24.3%) were unemployed or out of the labour force at least once at the following four interviews. Contrary to H2, working for a different employer was not clearly associated with leaving work (adjusted RR 1.13; 95% CI 0.97–1.32), and self-employment was associated with a lower risk (RR 0.52; 95% CI 0.33–0.82); these associations did not differ clearly between cohorts (P = 0.41; Online Resource 2, Table S9). In cohort 1 the standardised probability of being employed at every later interview was 85.6% (95% CI 82.2–88.7) for workers with the employer at injury and 76.6% (95% CI 72.5–81.0) for those with a different employer (difference − 8.9 percentage points; 95% CI − 14.5 to − 3.0); in cohort 2 the corresponding probabilities were 69.9% (95% CI 66.2–73.4) and 70.8% (95% CI 67.6–73.9) (difference 0.9 percentage points; 95% CI − 4.0 to 5.9). Self-employed workers had the highest probabilities in both cohorts (Fig. 2). The E-value for the self-employment association was 3.28 (1.74 for the confidence limit).

Additional and Sensitivity Analyses

Among participants not employed at the first interview (Online Resource 2, Table S10), 75.1% (95% CI 67.8–81.6) in cohort 1 and 69.8% (95% CI 65.9–74.1) in cohort 2 were employed at a later interview, but only 52.7% (95% CI 44.0–61.1) and 46.6% (95% CI 41.8–51.6) were employed at both the fourth and fifth interviews. Exits from employment between the second and third interviews (Online Resource 2, Table S12) were more frequent in cohort 2 (2019–2020) than in cohort 1 (2014–2015): 9.7% (95% CI 7.7–11.6) vs. 6.0% (95% CI 4.0–8.2), a difference of 3.7 percentage points (95% CI 0.8–6.5).

The typology was robust to Hamming distance (ARI 0.99) and to transition-rate costs (ARI 0.96; Online Resource 2, Table S13). With five pathways, the different-employer pathway split into steady work for a new employer and later entry into work (ARI 0.70; Online Resource 2, Table S15). Latent class analysis favoured 8 classes (ARI 0.73). Without the employer distinction, the pathways mainly differed by the timing of employment (three states: 6 pathways, ARI 0.26; two states: 7 pathways, ARI 0.24). Across the weighted model and the restricted samples, RRRs of persistent non-employment for age ≥ 60 years, long care and disability grades 1–9 ranged from 2.26 to 8.03. Including all participants with multiple imputation gave a slightly higher prevalence of persistent non-employment (11.8% in cohort 1 and 18.1% in cohort 2; Online Resource 2, Table S14). Of the participants who missed at least one interview, 16 in

cohort 1 and 54 in cohort 2 were recorded as having died (Online Resource 2, Table S19); excluding them changed these estimates to 11.6% and 17.8%. A bootstrap within approximate sampling strata gave CIs 0.95 to 1.03 times as wide as those in Table 2.

Discussion

In two national cohorts of Korean workers whose compensated medical care ended five years apart, leaving the employer at injury was common but was not clearly followed by leaving work. Only 32.9% and 29.6% of workers stayed mainly with the employer at injury over the next five years, whereas 49.6% and 46.4% worked mainly for a different employer and a small, stable group was self-employed. Among workers employed at the first interview, those with a different employer were not clearly more likely to leave work than those with the employer at injury, and the self-employed were less likely. Persistent non-employment (10.2% and 17.2%) was concentrated among older workers and workers with long medical care or a severe disability grade, whereas the conditions of the job at injury mainly determined whether workers stayed with that employer or moved to another.

Our pathways resemble the five trajectory types that a recent Korean-language analysis found in four-year histories of the same two cohorts, among them sustained return to the original workplace, sustained re-employment in other wage work and persistent economic inactivity, and the determinants it reported, such as older age, occupational disease and longer treatment [28]; employment states were also highly persistent over the first three waves of cohort 1 [27]. Our study differs in three substantive respects. First, the earlier analysis examined retention separately among workers who returned to the original workplace and among re-employed workers, whereas we compared these groups on a common outcome, exit from employment, and found that, overall, re-employment elsewhere was not clearly less durable. Second, none of its five types was defined by self-employment, which in our data formed a distinct pathway with the lowest risk of leaving work. Third, it reported that workers with a disability rating were more likely to sustain return to the original workplace than to remain economically inactive, whereas grades 1–9 were associated with persistent non-employment in our data; differences in the coding of disability, and that study's adjustment for work ability, which may lie on the path from impairment to employment, could explain this. We also report population-weighted prevalence.

PSWCI studies of job retention found that re-employed workers were more than twice as likely as workers back in their original workplace to leave their job [19, 20]. We found no clear corresponding difference in leaving work. The findings are compatible: retention studies count any job change as an event, whereas our outcome counted only exits into unemployment or out of the labour force, so workers who change employer may move between jobs without losing employment. The advantage of the injury employer may nevertheless depend on context. In cohort 1, workers with a different employer were less likely to remain employed than those with the employer at injury, whereas in cohort 2 the probabilities were similar, although the formal test of heterogeneity was inconclusive.

The sequence analysis showed that employment after the end of care was dominated by stable states rather than by complex trajectories. Because all four medoids were sequences of a single state, pathway membership almost exactly matched the state in which workers spent most of the five years. The timing of transitions separated a further group, later entry into work, only in the five-pathway solution, which the pre-specified rule did not select because its pathways were less well separated. The value of the sequence analysis therefore lay in showing, with data-driven groups that were stable and replicated, that the dominant state summarises five-year employment after care well. For monitoring, a simple classification by years in each state may suffice; questions about re-entry and exits need the transitions themselves, as in our analyses of later employment and of exits from work.

The concentration of persistent non-employment among older workers and those with long medical care or severe impairment agrees with claims-based studies from Australia and the United States [8, 40] and with reviews of factors affecting return to work after injury [41]. Qualitative work also points to particular barriers to sustainable return to work for ageing workers with a work disability [42]. Non-regular employment, short tenure and small firms were associated mainly with moving to another employer rather than with leaving work, which suggests that weak ties to the employer at injury shape where, rather than whether, workers return.

Self-employment formed a small but stable pathway, and the self-employed were the most likely to stay in work. In Europe, people with disabilities are more likely than others to be self-employed, and self-employment may allow a better fit between disability and working life [43]; our data cannot show whether it reflected choice, a lack of alternatives or earlier experience of self-employment, and unpaid family work was included in this state. The pathway comprised only 251 workers, but a reduced model with more events per parameter gave similar absolute associations.

Persistent non-employment was more common in cohort 2. This cohort was older, more often reported chronic disease and was followed during the COVID-19 pandemic, and exits from employment between 2019 and 2020 were more frequent than in the corresponding interval for cohort 1. Cohort remained associated with non-employment after adjustment, and the cohorts were sampled differently, so the difference cannot be attributed to any single cause.

The results have three implications for occupational rehabilitation. First, return to the employer at injury and staying in work are different outcomes. Leaving the employer at injury usually meant working elsewhere, and re-employment elsewhere was, at least in cohort 2, about as durable as return to the employer at injury, so programmes that count only returns to the original employer will miss many workers who stay in work; job matching and support after re-employment deserve attention alongside return to the original job [4]. Second, the end of compensated medical care is not an endpoint: 17.2% of workers in the more recent cohort remained out of work for five years, and among workers not employed at the first interview only 52.7% (cohort 1) and 46.6% (cohort 2) were employed at both of the last two interviews. Follow-up after care ends could prioritise older workers, workers with long medical care and those with severe disability grades. Third, return to the employer at injury was more likely for workers

with regular jobs, a union at the workplace and longer tenure; employer-focused support may help workers in small firms and non-regular jobs, who more often moved to other employers.

Strengths and Limitations

Strengths include two national cohorts recruited five years apart, survey weights, an analysis plan recorded before the outcomes were examined, validation of the typology by resampling and replication, and extensive sensitivity analyses. Several limitations apply. The analysis plan was not registered with a third party, so its timing rests on the authors' records. Annual measurements of the previous week's activity miss spells between interviews, and five-point sequences give coarse distances and a typology close to a classification by the dominant state, which conveys little about the timing of transitions. Dependent interviewing reduces spurious change between waves [44], but it may also lead some respondents to confirm a status that has changed. The main analyses were restricted to continuous respondents, who were alive at the fifth interview; the longitudinal weights and multiple imputation addressed attrition, and excluding participants recorded as having died changed the imputed estimates little, but dropout related to poor health cannot be excluded. Age was measured at the first interview, not at injury. Unweighted AMEs describe a sample that over-represents workers with a disability grade; weighted AMEs were smaller. Rehabilitation services were treated only as a design variable, so we draw no conclusion about their effects. Clustering involves analytic choices; the pre-specified rule and the sensitivity analyses limit, but do not remove, this subjectivity. The associations are not causal and may be affected by unmeasured confounding. Finally, the PSWCI excludes foreign workers and residents of Jeju Island, and the findings may not apply to other compensation systems.

Conclusion

Five years after workers' compensation medical care ended, most Korean injured workers were in employment-based pathways. Leaving the employer at injury usually meant working for another employer, not leaving work, and overall re-employment elsewhere was not clearly less durable than return to the employer at injury; return-to-work programmes should therefore count staying in work, not only return to the original employer. A distinct group of older workers and of workers with long medical care or severe impairment stayed out of work; rehabilitation and compensation systems should extend support beyond the end of medical care for them.

Declarations

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval

This study was a secondary analysis of publicly available, de-identified PSWCI data that contain no personally identifiable information. Under the Bioethics and Safety Act of Korea (Enforcement Rule, Article 13(1)(3)), such research is exempt from institutional review board review, and no approval was required. The study followed the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Consent to Participate

Not applicable. The authors analysed de-identified public-use data and had no contact with participants.

Consent to Publish

Not applicable. No identifiable individual data are reported.

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Author Contribution

Conceptualisation: N.H.; Methodology: N.H.; Formal analysis: N.H.; Writing—original draft: N.H.; Writing—review and editing: Z.L. All authors read and approved the final manuscript.

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Data Availability

The PSWCI data are public-use data released free of charge by the Labor Welfare Research Institute of the Korea Workers' Compensation & Welfare Service (https://www.pswci.or.kr/Data/Download.aspx) after online application, identity verification and acceptance of the conditions of use. The conditions prohibit transfer to third parties, so the authors cannot share the raw data. Aggregated results are provided in the Online Resources.

Code Availability

The analysis code, the analysis plan with its commit history and unit tests will be made publicly available in a GitHub repository on acceptance; the repository will contain no data.

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Figures

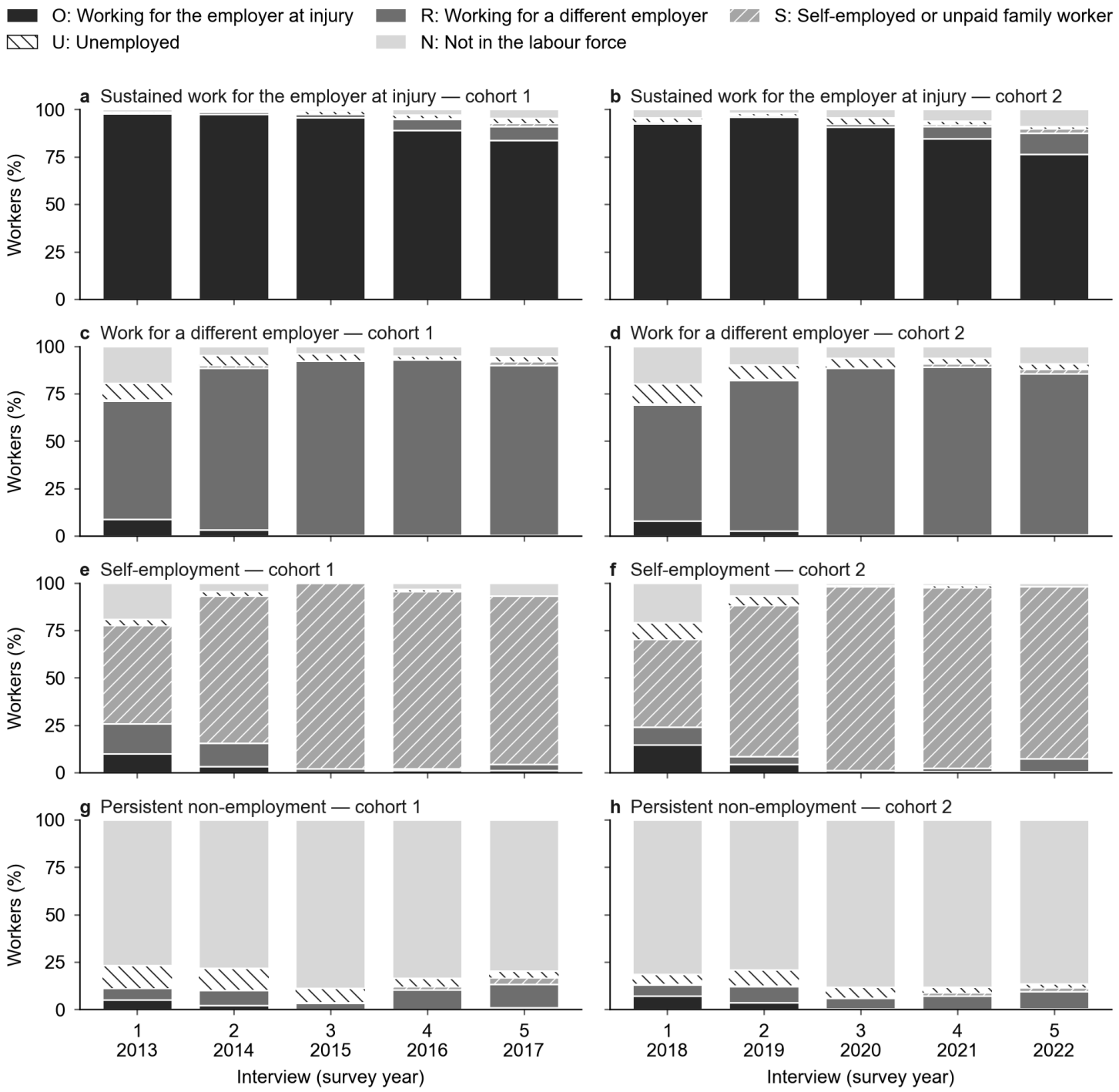

Figure 1

State distributions in the four employment pathways by annual interview, cohort 1 (care ended in 2012; a, c, e, g) and cohort 2 (care ended in 2017; b, d, f, h). Bars show the unweighted percentage of workers in each state at each interview; the number of workers in each pathway is given in Table 2. O, working for the employer at injury; R, working for a different employer; S, self-employed or unpaid family worker; U, unemployed; N, not in the labour force

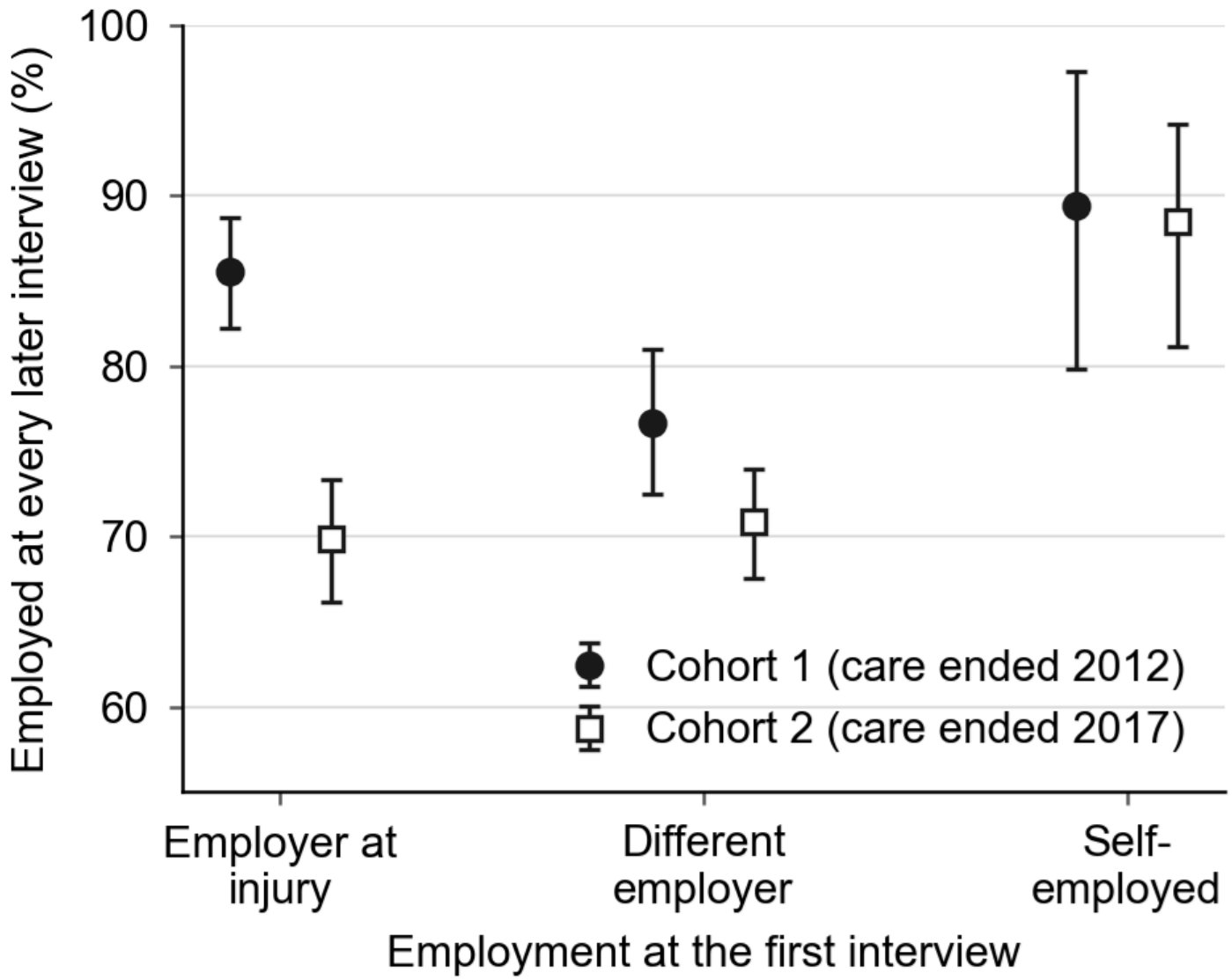

Figure 2

Standardised probability of being employed at every interview from the second to the fifth among workers employed at the first interview, by type of employment at the first interview and cohort. Probabilities were standardised to each cohort's workers employed at the first interview with logistic regression including all factors at injury, use of rehabilitation services and health at the first interview; error bars show percentile 95% CIs from 1,000 bootstrap resamples. Numbers of workers (employer at injury, different employer, self-employed): cohort 1, 551, 476 and 53; cohort 2, 763, 739 and 88

Supplementary Files

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