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The influence of chronic health problems on work ability and productivity at work: a longitudinal study among older employees

by Fenna RM Leijten, MSc,[1, 2] Swenne G van den Heuvel, PhD,[2], Jan Fekke Ybema, PhD,[2] Allard J van der Beek, PhD,[3, 4] Suzan JW Robroek, PhD,[1] Alex Burdorf, PhD [1]

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Objectives This study aimed to assess the influence of chronic health problems on work ability and productivity at work among older employees using different methodological approaches in the analysis of longitudinal studies.

Methods Data from employees, aged 45–64, of the longitudinal Study on Transitions in Employment, Ability and Motivation was used (N=8411). Using three annual online questionnaires, we assessed the presence of seven chronic health problems, work ability (scale 0–10), and productivity at work (scale 0–10). Three linear regression generalized estimating equations were used. The time-lag model analyzed the relation of health problems with work ability and productivity at work after one year; the autoregressive model adjusted for work ability and productivity in the preceding year; and the third model assessed the relation of incidence and recovery with changes in work ability and productivity at work within the same year.

Results Workers with health problems had lower work ability at one-year follow-up than workers without these health problems, varying from a 2.0% reduction with diabetes mellitus to a 9.5% reduction with psychological health problems relative to the overall mean (time-lag). Work ability of persons with health problems decreased slightly more during one-year follow-up than that of persons without these health problems, ranging from 1.4% with circulatory to 5.9% with psychological health problems (autoregressive). Incidence related to larger decreases in work ability, from 0.6% with diabetes mellitus to 19.0% with psychological health problems, than recovery related to changes in work ability, from a 1.8% decrease with circulatory to an 8.5% increase with psychological health problems (incidence-recovery). Only workers with musculoskeletal and psychological health problems had lower productivity at work at one-year follow-up than workers without those health problems (1.2% and 5.6%, respectively, time-lag).

Conclusions All methodological approaches indicated that chronic health problems were associated with decreased work ability and, to a much lesser extent, lower productivity at work. The choice for a particular methodological approach considerably influenced the strength of the associations, with the incidence of health problems resulting in the largest decreases in work ability and productivity at work.

Key terms analysis of change; autoregressive; chronic condition; GEE; incidence; older worker; recovery; STREAM; sustainable employability; time-lag.

The population is aging, and the proportion aged over 50 years is expected to continue to grow rapidly (1). In parallel, the workforce is aging, leading to potential strains on social security systems. In order to deal with this, many Western countries have increased the statutory retirement age. In an aging workforce, health problems will become more prevalent. Employees with health problems could be faced with decreased work ability (2), quantitative productivity loss at work (3, 4), sickness absence (5), and even exit the labor force (6). Work ability can be defined as the balance between an individual's resources (eg, health, functional abilities, competencies) and work demands (eg, work environment, contents, demands) (7).

1 Department of Public Health, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands.
2 Netherlands Organisation for Applied Scientific Research TNO, Hoofddorp, The Netherlands.
3 Department of Public and Occupational Health, the EMGO+ Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands.
4 Body@Work, Research Center on Physical Activity, Work and Health, TNO-VU/VUmc, Amsterdam, The Netherlands.

Correspondence to: Alex Burdorf, Department of Public Health, Erasmus MC, University Medical Center Rotterdam, PO Box 2040, 3000 CA Rotterdam, The Netherlands. [E-mail: a.burdorf@erasmusmc.nl]

Several studies have shown that health problems are related to unfavorable work outcomes. Psychological health problems are associated with sickness absence and reduced work productivity (8, 9). Other studies have shown that different musculoskeletal pain complaints are also associated with productivity loss at work (10). Most findings on relations of health with work outcomes come from studies with a cross-sectional design. A few longitudinal studies have, however, shown that psychological health problems are related to an increased risk of sickness absence in the following year (5) and that especially general physical health is related to reduced work ability at one-year follow-up (2). These studies have used different definitions of health problems and work outcomes, which makes the comparison of the influence of different chronic health problems on work outcomes difficult. Thus, longitudinal studies that incorporate multiple health problems are needed (11, 12).

Comparison between studies is further hampered by the different methodological approaches used, which require nuanced interpretations. A critical issue in establishing causality is the temporality of the observed association, ie, that the cause precedes the effect in time. In longitudinal studies, a determinant is thus often related to an outcome that is measured at a later point in time by using a time-lag (eg, 13).

In the present longitudinal study, we assess the relation of self-reported chronic health problems with self-reported work ability and productivity at work one year later (time-lag model). Although in this design the determinant, ie, the health problem, was present prior to the assessment of work ability and productivity at work, it may still be difficult to rule out reverse causality (14). It is possible that the outcome has influenced the determinant prior to the study period, especially since both measures are based on self-reports and their correlation could remain stable throughout the study period. In order to deal with this, an autoregressive technique is often used whereby the outcome of interest is adjusted for its baseline value (15, 16). Hence, such an analysis relates the determinant to a change in the outcome during the follow-up period. We apply this autoregressive approach to analyze whether the presence of a health problem predicts a decrease in work ability and productivity at work during one-year follow-up.

Since longitudinal studies cover a limited period of the lives of older employees, it is not unreasonable to ask what the appropriate timeframe would be for common health problems to cause a decrease in work ability and productivity at work. For example, does the influence become noticeable within one year or only as a gradual process over time? It is possible that persons with health problems have lower work ability and productivity at work than persons without health problems, but that the mere presence of such problems does not cause a decrease in work ability and productivity within one year. In a recent study, changes in self-perceived economic difficulties were associated with a decline in mental and physical functioning during a 4–7 year follow-up period (17). In the third model, we apply a similar approach and specifically relate changes in health (ie, incidence and recovery) during a particular year to direct changes in work ability and productivity at work during that same year.

This longitudinal study is novel in that both work ability and productivity at work are included as outcomes, it comprises several common health problems, and uses three common approaches of assessing longitudinal relations between health and these outcomes.

Methods

Study design

The Study on Transitions in Employment, Ability, and Motivation (STREAM) is a four-year (2010–2013) longitudinal prospective cohort study among a stratified sample of older persons (aged 45–64 years) in the Netherlands (18). STREAM participants annually complete an online questionnaire on topics such as work characteristics, health, employment status and transitions, work ability, and work productivity.

The current study used data from three STREAM waves, whereby respondents in 2010 (T1) were also approached for participation in 2011 (T2) and in 2012 (T3). At baseline (T1, 2010) 15 118 persons participated in STREAM, 71% of all invited persons. In 2011 (T2) 82.2% of the baseline sample responded (N=12 430). In 2012 (T3), a total of 12 057 persons responded, of which 1105 persons had only participated at T1 and not at T2, and 10 952 had also participated at T2. Thus 10 952 persons participated in all three waves, representing 72.4% of the original sample.

Persons were included in the current study if they participated in all three waves (N=10 952) or in T1 and T2 (an additional 1478 persons). Participants who were self- or non-employed (N=3959) or missing information on work ability or productivity at work (N=60) were excluded. This resulted in a final sample of 8411 persons, of whom 7322 participated in all three waves.

The Medical Ethical Committee of the VU University Medical Center (Amsterdam) declared that the Medical Research Involving Human Subjects Act does not apply to the STREAM study and had no objection to the execution of this research. In the information that accompanied the online questionnaire, it was emphasized that privacy would be guaranteed and that all data would be treated confidentially and stored in secured computer systems.

Measures

Outcomes. Work ability was assessed using the first dimension of the Work Ability Index (WAI), in which a worker assesses his/her current work ability as compared to their lifetime best (7). Answers ranged from 0="not able to work" to 10="work ability at lifetime best." It has been shown that this first WAI item is strongly associated with the overall WAI (19, 20).

Productivity at work was assessed with the following item: "How much work have you done in the last 4 weeks compared to normal?" Answer scores ranged from 0="much less than normal" to 5="the same as normal" and 10="much more than normal".

Health problems. The presence of health problems was assessed with the question: "Do you (currently) have one or more of the following chronic diseases, disorders, or handicaps?" (21). The following seven health problems were referenced: musculoskeletal, migraine or severe headaches, circulatory, respiratory, digestive, diabetes mellitus, and psychological. Health problems were not mutually exclusive. Incidence, recovery, and recurrence of health problems were defined over consecutive one-year follow-up periods. Incidence was defined as not having the health problem at one wave and having it the following wave. Recovery was defined as having the health problem at one wave and not having it the following wave. Recurrence was defined as having the health problem at one wave and also the following wave.

Covariates. The following individual factors were included as potential confounders included in the analyses: age, gender, and highest attained educational level. Age was categorized into four 5-year groups. Educational level was categorized into three groups: low (lower general secondary educational, preparatory secondary vocational education), medium (intermediate vocational training, higher general secondary education, pre-university education), and high (higher vocational education, university education).

Four work-related factors were also included in the analyses as potential confounders: (i) physical load was measured with four items (Cronbach's alpha=0.85) (21–23), (ii) psychological job demands were measured with four items (Cronbach's alpha=0.87) (24), (iii) autonomy was measured with four items (Cronbach's alpha=0.77) (24), and support from colleagues/supervisor was measured with five items (Cronbach's alpha=0.80) (25). Each item had a 5-point continuous answer scale. Mean scores across all items within each work-related factor were calculated for each participant. For more details on these work-related factors please see Ybema et al (18) on the design of the STREAM cohort.

Statistical analysis

Descriptive statistics were used to provide information on participants' age, gender, educational level, work ability, and productivity at work. A non-response analysis was conducted by comparing work ability and productivity scores at baseline of sustained and lost-to-follow up participants. To determine and compare the within- and between-subject variance in work ability and productivity at work, an analyses of variance was conducted. The within-subject variance from this analysis represents how much individuals' work ability and productivity at work scores, on average, varied throughout the three waves. The between-subject variance represents how much variation there was between different individuals. The Pearson-r correlation between work ability and productivity scores at each wave was also calculated.

Generalized estimating equations (GEE) with linear regression analyses were used since GEE takes into account the correlation between the different waves during the study. Three different specifications of the statistical model were used (see table 1) (14). The relation between health problems and work ability and productivity at work after one year was first analyzed in a time-lag model. In this model, regression coefficients represent the mean differences in work ability and productivity after one year between persons with and without the health problems. Next, an autoregressive model was used that adjusted for work ability and productivity at work the preceding year. The regression coefficients in this case represent the mean differences in one-year change in work ability and productivity at work between persons with and without the health problem. In the third model, the relation between changes in health, ie, incidence and recovery, with changes in work ability and productivity at work was assessed. The regression coefficients in this model represent the mean differences in one-year change in work ability and productivity at work between persons with changes in health status and those with stable health status. In these analyses, two separate comparisons were made, namely between incident cases and persons who did not have the health problem at both waves, and between persons with recovery from health problems and those with recurrent or persistent health problems at both waves.

In the time-lag model, an exchangeable working correlation structure was used, in which correlations between measurements are assumed to be equal regardless of the time interval between them (ie, one or two waves) (14). For the other models, independent working correlation structures were used, in which the correlation between measurements is assumed to be zero because in these models the correlation between measurements has already been accounted for by adjusting for work

Table 1. Three specifications of a Generalized Estimating Equations (GEE) model in the analysis of the influence of health problems on work ability and productivity at work in a longitudinal study with three annual waves (T1, T2, and T3). Note: The same analyses were done with productivity at work as the outcome.

Models	Outcome (Y)	Predictors (X)	Covariates
Time-lag $Y_{(t)} = ß_0 + ß_1 X_{(t-1)}$	Work ability (T2)	Health problem (T1)	Other health problems (T1) Work-related factors (T1) Individual factors (T1)
	Work ability (T3)	Health problem (T2)	Other health problems (T2) Work-related factors (T2) Individual factors (T1)
Autoregressive $Y_{(t)} = ß_0 + ß_1 X_{(t-1)} + ß_2 Y_{(t-1)}$	Work ability (T2)	Health problem (T1)	Other health problems (T1) Work-related factors (T1) Individual factors (T1) Work ability (T1)
	Work ability (T3)	Health problem (T2)	Other health problems (T2) Work-related factors (T2) Individual factors (T1) Work ability (T2)
Incidence-recovery $Y_{(t)} = ß_0 + ß_1 (X_t - X_{t-1}) + ß_2 Y_{(t-1)}$	Work ability (T2)	Incident health problem (T1-T2) Recovered health problem(T1-T2)	Other health problems (T1) Work-related factors (T1) Individual factors (T1) Work ability (T1)
	Work ability (T3)	Incident health problem (T2-T3) Recovered health problem(T2-T3)	Other health problems (T2) Work-related factors (T2) Individual factors (T1) Work ability (T2)

ability and productivity at work the preceding year (14). All presented results are from multivariate analyses that include each time (ie, wave), all health problems, and individual and work-related factors. For the incidence-recovery model, analyses were stratified on the basis of prevalence at the preceding year. Thus separate comparisons were made between those with incidence of health problems relative to those free from these complaints and between those who recovered from health problems relative to those with continued presence of health problems. Unstandardized regression coefficients (B) and their 95% confidence intervals (95% CI) based on the Wald-statistic were reported. In order to better interpret the regression coefficients with regard to the work ability and productivity at work, these were also expressed in percent of difference (time-lag model) and change (other models) relative to the overall mean work ability and productivity at work in the study population. All analyses were done with SPSS version 20.0 (IBM Corp, Armonk, NY, USA).

Results

Sample characteristics and time trends

Slightly more men than women were included in this study, mainly in the age groups <60 years, and the majority had a medium or high educational background (see table 2). Employees lost to follow-up after T1 did not statistically significantly differ in work ability (mean difference 0.02, 95% CI -0.06–0.10) or productivity at work (mean difference -0.05, 95% CI -0.14–0.04) from those employees not lost to follow-up.

At all three waves, musculoskeletal problems were the most prevalent and psychological health problems the least (see table 3). The proportion of recurrent cases with regard to prevalent cases the preceding year ranged from 48.3% for psychological health problems to 95% for diabetes mellitus. Recovery ranged from 5% for diabetes mellitus to 51.7% for psychological health problems. The highest incidence was seen for musculoskeletal problems (14.7%). The proportion of prevalent, incident, recovered, and recurrent cases of chronic health problems was stable throughout the waves.

At baseline, the three most prevalent combinations of health problems were musculoskeletal health problems with severe headaches and migraines (N=335, 4.0% of the total sample), musculoskeletal and respiratory health problems (N=269, 3.2% of the total sample), and musculoskeletal and digestive health problems (N=262, 3.1% of the total sample).

The average work ability and productivity at work remained very stable throughout the study period (see table 4). Individual variation was greater in productivity at work than work ability during the study period. Work ability scores throughout the three waves had a stronger correlation (Pearson's r range 0.37–0.44) than productivity at work scores (Pearson's r range: 0.21–0.27). Work ability and productivity at work were positively correlated (Pearson's r=0.23, P<0.01).

At baseline, younger persons and those with a higher education had a higher work ability and productivity at

work than older persons and those with a lower education, respectively. No differences were found between baseline work ability and productivity at work for men and women. Concerning the work-related factors, lower physical load, higher autonomy, and higher social support were related to higher work ability scores. Higher psychological job demands and higher autonomy were related to higher productivity at work (Appendix, table A, www.sjweh.fi/data_repository.php).

Table 2. Individual characteristics, work-related factors, work ability, and productivity at work among older Dutch employees at baseline in the longitudinal study with two years follow-up (N=8411). Note, for the work-related factors the following sample sizes are reported on due to missing baseline information: physical load (N=8391), psychological job demands (N=8380), autonomy (N=8400), and support (N=8409). [SD=standard deviation.]

	T1 (2010)						
					Percentiles		
	%	N	Mean	SD	25th	50th	75th
Gender (Female)	44.0	3703					
Age (years)			53.57	5.17			
45–49	26.7	2249					
50–54	27.9	2345					
55–59	30.2	2536					
60–64	15.2	1281					
Education							
Low	26.3	2214					
Medium	39.4	3313					
High	34.3	2884					
Work Ability (range 0–10)			7.96	1.50	7.00	8.00	9.00
Productivity at work (range 0–10)			5.77	1.80	5.00	5.00	7.00
Work-related factors (range 1–5)							
Physical load			1.79	0.88	1.00	1.40	2.40
Psychological job demands			3.14	0.77	2.75	3.25	3.75
Autonomy			3.84	0.70	3.40	4.00	4.20
Support			3.59	0.76	3.00	3.75	4.00

Health and work ability

All health problems were related to lower work ability at one-year follow-up (table 5). Workers with psychological health problems had a 0.75 (95% CI 0.57–0.92) point lower work ability than workers without psychological health problems, reflecting a difference of 9.5% in mean work ability. For the other health problems, work ability was 0.16–0.35 points lower, reflecting a difference of 2.0–4.4% in mean work ability. When health problems were present, work ability decreased more during the one-year follow-up than when health problems were not present. For example, work ability decreased from 0.10 points among workers with circulatory problems to 0.44 points among workers with psychological health problems (ie, 1.2–5.1%). The effect estimates in the autoregressive model were consistently smaller than in the time-lag model, varying from a reduction in effect estimates of 18% with diabetes mellitus to 52% with circulatory health problems.

For incidence of health problems, one-year decreases in work ability differed from 0.08 points for diabetes mellitus (1.0%) to 1.48 points for psychological health problems (18.7%) compared to persons remaining without those health problems. For recovery from health problems, the changes in work ability ranged from a 0.14 point decrease for severe headaches and migraines (1.8%) to a 0.66 point increase for psychological health problems (8.2%) compared to persons with those health problems two years in a row. In general, the relation of incidence with decreases in work ability was much stronger than that of recovery with increases in work ability.

Health and productivity at work

Some chronic health problems were related to lower productivity at work at one-year follow-up, with the largest

Table 3. Prevalence, recovery, incidence, and recurrence of self-reported health problems among older Dutch employees in a longitudinal study with a two-year follow-up period with complete information at each annual wave (N=7322).

	Musculoskeletal		Severe headaches or migraines		Circulatory		Respiratory		Digestive		Diabetes mellitus		Psychological	
	%	N	%	N	%	N	%	N	%	N	%	N	%	N
T1 (2010)														
Prevalence	31.5	2309	8.3	605	9.2	675	7.3	532	6.0	438	6.4	466	3.6	265
T2 (2011)														
Recovery	28.5	659	37.2	225	32.3	218	22.9	122	44.5	195	9.3	43	49.1	130
Incidence	14.7	738	2.6	172	3.5	230	1.7	115	2.6	178	0.9	59	1.9	134
Recurrence	71.4	1650	58.5	380	67.7	457	77.1	410	55.5	243	90.8	423	50.9	135
Prevalence	32.6	2388	7.5	552	9.4	687	7.2	525	5.7	421	6.6	482	3.7	269
T3 (2012)														
Recovery	26.5	631	34.4	190	26.7	184	21.7	114	41.8	176	5.0	24	51.7	139
Incidence	14.2	701	2.7	187	3.2	210	1.9	129	3.3	227	1.2	83	1.7	119
Recurrence	73.6	1757	65.6	362	73.2	503	78.3	411	58.2	245	95.0	458	48.3	130
Prevalence	33.6	2458	7.5	549	9.7	713	7.4	540	6.4	472	7.4	541	3.4	249

Table 4. The three-year mean and variance of work ability and productivity at work of older employees (N=8411). Note, sample includes respondents at T1, T2, and T3 (N=7322) and T1 and T2 (N=1089). [SD=standard deviation.]

	T1 (2010)		T2 (2011)		T3 (2012)		Variance	
	Mean	SD	Mean	SD	Mean	SD	Within-subject (%)	Between-subject (%)
Work ability	7.96	1.50	7.92	1.49	7.86	1.59	37.3	61.7
Productivity at work	5.77	1.80	5.74	1.79	5.67	1.82	49.4	50.6

difference of 0.33 points (5.7%) for psychological health problems (table 5). Only slight differences in one-year decreases in productivity at work were found between persons with and without health problems. Effect estimates were much smaller in the autoregressive model than in the time-lag model, as was seen for work ability.

For incidence of health problems, one-year decreases in productivity at work ranged from 0.02 points with severe headaches and migraines (0.3%) to 0.92 points with psychological health problems (16.1%). For recovery from health problems, the changes in productivity at work ranged from a 0.25 point decrease with circulatory (4.4%) to 0.16 increase with digestive (2.8%) health problems. As with work ability, incidence was more strongly related than recovery to productivity at work.

Discussion

Workers with chronic health problems had lower work ability at one-year follow-up. The greatest differences in work ability were found between persons with and without psychological health problems (9.4%) and musculoskeletal problems (4.2%) and the smallest differences between persons with and without circulatory health problems (2.7%) and diabetes mellitus (2.0%). The largest effects were observed for the influence of incident psychological health problems on work ability with an 18.7% decrease during one year follow-up. The smallest observed effects were of the presence of a health problem on changes in work ability during one-year follow-up, with a maximum difference of decrease in work ability of 5.6% between persons with and without psychological health problems. For productivity at work, associations were much smaller and only workers with musculoskeletal problems (1.2%) and psychological health problems (5.8%) had statistically significantly lower productivity at work at one-year follow-up compared to persons without these health problems. The magnitude of the influence of health problems on both work ability and productivity at work was comparable to a 15 year increase in age (ie, from the 45–49 age group to the 60–64 year age group), but substantially greater than that of gender and the incorporated work-related factors.

In accordance with the findings from the current study, a recent study found that psychological health problems influenced work performance more than other chronic health problems (26). Another study that compared and examined similar health problems showed that psychological health problems had the strongest effects on work productivity and sickness absence as compared to other health problems (8). The strong effects of psychological health problems on work ability and produc-

Table 5. Longitudinal analyses using linear regression generalized estimating equations (GEE) of the relation between health problems with work ability and productivity in a sample of older employees (N=8401). Multivariate analyses including: all health problems, wave, age, gender, education, and work-related factors (ie, physical load, psychological job demands, autonomy, support). Sample includes respondents at T1, T2, and T3 (N=7,322), respondents at T1 and T2 (N=1,089) and excludes persons with missing information on work-related factors (N=10).

Health problem	Model	Work ability		Productivity at work	
		B	95% CI	B	95% CI
Musculoskeletal	Time-lag	-0.33	-0.38– -0.27 [a]	-0.07	-0.14– -0.01 [b]
	Autoregressive	-0.24	-0.29– -0.19 [a]	-0.06	-0.13–0.00 [b]
	Incidence	-0.28	-0.36– -0.20 [a]	-0.07	-0.17–0.03
	Recovery	0.09	-0.01– 0.19	-0.11	-0.23–0.00
Severe headaches or migraines	Time-lag	-0.22	-0.33– -0.12 [a]	-0.10	-0.22–0.02
	Autoregressive	-0.13	-0.22– -0.05 [a]	-0.09	-0.20–0.02
	Incidence	-0.26	-0.43– -0.09 [a]	-0.02	-0.21–0.17
	Recovery	-0.14	-0.33– 0.05	-0.11	-0.35–0.14
Circulatory	Time-lag	-0.21	-0.30– -0.12 [a]	-0.06	-0.16–0.04
	Autoregressive	-0.10	-0.18– -0.02 [a]	-0.04	-0.13–0.06
	Incidence	-0.30	-0.44– -0.15 [a]	-0.21	-0.39– -0.02 [b]
	Recovery	0.03	-0.15– 0.20	-0.25	-0.45– -0.05 [b]
Respiratory	Time-lag	-0.30	-0.42– -0.18 [a]	-0.07	-0.20–0.06
	Autoregressive	-0.20	-0.30– -0.10 [a]	-0.07	-0.19–0.05
	Incidence	-0.21	-0.37– -0.05 [b]	-0.09	-0.34–0.15
	Recovery	0.03	-0.21– 0.27	0.02	-0.26–0.29
Digestive	Time-lag	-0.30	-0.43– -0.18 [a]	-0.03	-0.17–0.11
	Autoregressive	-0.24	-0.35– -0.12 [a]	-0.03	-0.16–0.11
	Incidence	-0.41	-0.59– -0.24 [a]	-0.17	-0.36–0.02
	Recovery	-0.01	-0.23– 0.21	0.16	-0.11–0.42
Diabetes mellitus	Time-lag	-0.16	-0.28– -0.04 [b]	-0.05	-0.17–0.08
	Autoregressive	-0.13	-0.22– -0.03 [b]	-0.05	-0.16–0.06
	Incidence	-0.08	-0.38–0.22	-0.07	-0.37–0.24
	Recovery	0.21	-0.20– 0.61	-0.02	-0.41–0.37
Psychological	Time-lag	-0.75	-0.92– -0.57 [a]	-0.33	-0.51– -0.14 [a]
	Autoregressive	-0.44	-0.61– -0.30 [a]	-0.24	-0.41– -0.06 [a]
	Incidence	-1.48	-1.78– -1.18 [a]	-0.92	-1.22– -0.62 [a]
	Recovery	0.65	0.37–0.93 [a]	-0.07	-0.42–0.28

[a] P<0.01.
[b] P<0.05.

tivity at work could potentially be explained by clear presence of symptoms and complaints, whereas, for example, circulatory health problems may be diagnosed by a physician but be unaccompanied by perceivable symptoms. It would be interesting in future research to have more extensive health information in order to compare multiple self-report measures as well as general practitioner, hospital, and pharmacy registry data.

Co- or multi-morbidity may be present among participants, the highest comorbidity in the current study was seen for persons with musculoskeletal health problems. All health problems were included simultaneously for the multivariate results. The findings from univariate analyses, in which only one health problem was incorporated, were very similar to the multivariate analyses (results not shown). In extra analyses, the potentially synergistic effects of mental and physical health problems were explored by assessing the joint effects of psychological problems with other health problems (ie, musculoskeletal, severe headaches or migraines, circulatory, respiratory, digestive, and diabetes) on work ability and productivity at work in the time-lag model. We found no indications for such synergistic effects.

In this study, health problems were more strongly related to work ability than productivity at work. It is possible that health is more inherent to work ability because work ability takes an individual's work demands and resources into account – good health is in itself a resource (7). Past studies have shown that poor health is a strong predictor of reduced work ability (2), but also that health problems relate to productivity loss at work (8, 27). Our findings differ from these latter studies in that only two of the seven health problems were related to productivity at work. This could be because the productivity at work measure used in this study was not specifically health-related productivity loss, ie, presenteeism. Productivity is an output that can be influenced both by the individual him- or herself as well as by tangible devices (eg, computers) or social factors (eg, cooperative and productive colleagues) that are necessary for an individual to conduct his/her work productively (27). This supports the notion to study similarities and differences between general productivity loss at work and presenteeism.

The extent of comparability between the work ability and productivity at work scales should also be considered. Less variance was observed in work ability than productivity at work, as was reflected in the standard deviation. Work ability fluctuated less over the three waves than productivity at work, as could be seen in the lower percentage of within- versus between-subject variance. The differences in variation and fluctuation could be related to the recall period (ie, four weeks for productivity at work and now for work ability) and end- and mid-points of the work ability and productivity at work scales. It is likely that the effects of health on productivity found were smaller because the changes in productivity could be both better or worse than normal, whereas work ability could only be as good as the lifetime best or worse. Furthermore, the subjective perceived reference point of normal may have already shifted in light of health problems, whereas lifetime best may be a more set reference point. Finally, it might also be that random measurement error is higher for productivity at work than work ability. It is thus important to consider the construction of the productivity at work and work ability scales.

The observed findings differed between the three methodological approaches in this study. Effect estimates were almost halved between the time-lag and autoregressive models. Effect estimates in the autoregressive model reflect differences in changes in mean scores between groups with and without a chronic health problem, whereas effect estimates in the time-lag model represent absolute differences in mean scores between these groups. Thus the time-lag model pertains to between-subject differences and the autoregressive model in essence pertains to within-subject differences. The results from the current study indicate that the presence of a health problem does not relate as strongly to changes in work ability and productivity at work, but rather lower work ability and productivity at work. It is thus possible that the health problem initially caused a decrease in work ability and productivity at work, but that the workers have learned to cope with their problems and only experience small changes during the follow-up period.

In the incidence-recovery model, we observed that changes in health problems coincided with one-year changes in work ability in the same year. This may suggest that the influence of a chronic health problem on work ability is a short-term effect rather than a gradual process. However, the negative effects of incident health problems were consistently larger than positive effects of recovery of these health problems, which also points towards long-term effects of chronic health problems. For some health (ie, circulatory) problems, recovery in a given year was even associated with a further decrease in work ability. This has also been found in two recent studies. Namely, Lallukka and colleagues assessed the influence of economic difficulties on self-rated health and found that a reduction in economic difficulties still related to poorer physical health during the 4–7 years of follow-up (17). Furthermore, De Raeve and colleagues assessed the relation between one-year changes in work schedules, working hours, and working overtime with one-year changes in self-reported health outcomes such as fatigue and psychological distress, and found that the presumed positive changes in working conditions were occasionally also related to worsening health (28). It is

possible that it takes longer than one year to reverse the effects of a health problem. It is also possible that having ever had the chronic health problem has long-term effects on work ability and productivity at work.

The preferred choice between methodological approaches in a longitudinal study should depend on the hypothesized nature of the association between the determinant and outcome. When the outcome under study is an irreversible first event, eg, stroke, heart attack, or death, reversed causality is not a concern. In the current study, however, we cannot be sure that the change in work ability and productivity at work occurred after the change in health during the follow-up period, nor can we be sure how much time elapsed between the two changes. In a sensitivity analysis, incidence of health problems was also related to changes in work ability one-year later, essentially introducing a time-lag of one year. The statistically significant ($P<0.01$) effect estimates in this adjusted incidence-recovery model were smaller (range 10–39%) than those in the original model. This suggests that the effects of changes in health problems on work ability are most likely to occur in a shorter period of time, ie, within the same year, where after it is possible that adjustments are made. This is supported by findings from a qualitative study in a comparable study population, which showed that many adjustments were made in order to allow employees to cope with their health problems at work and restore a balance in their demands and resources (27).

Strengths of this study include its longitudinal design, relatively low drop-out, large sample size and high power, which allowed for various methodological approaches to be compared. GEE analyses were used in the current study, which provide population-averaged regression coefficients and take the correlation between repeated waves into account (14). Furthermore, such GEE analyses seem to be robust against the wrong choice of a working correlation structure (14). In addition to an exchangeable correlation structure, we also tested the time-lag model with an unstructured correlation structure and found no differences in observed effect estimates. The model with the exchangeable correlation structure was chosen because in this model less parameters need to be estimated. A potential limitation of GEE analyses versus individual-based repeated measurement analyses, such as random coefficients or multilevel analyses, is the assumption that values are missing completely at random. It is, however, unlikely that this was problematic in the current study because of the large sample size and because the outcome variables were on continuous scales (29).

Continuous scales of the work ability and productivity at work measures were used in the current study. We chose not to dichotomize the outcome variables because there are no standard cut-off values available for these scales, and thus categorization on a certain level may be arbitrary and can lead to a loss of information. However, in order to ensure the robustness of our findings, we ran exploratory logistic regression GEE analyses in which we compared participants with the lowest tertiles to those in the higher two tertiles of the outcomes (Appendix, table B, www.sjweh.fi/data_repository.php). The results from these analyses confirm our conclusions that (i) stronger effects were seen for health problems relating to work ability than productivity at work, (ii) incidence of health problems predicted the greatest loss of work ability and productivity during follow-up, and (iii) psychological health problems showed the largest effects.

The annual questionnaire provided only point prevalence information on common chronic health problems. Thus, the episodic character of some of the health problems within the follow-up year could not be assessed. In order to explore the influence of long- and short-term changes in health problems on work-related outcomes, it is advisable to gather repeated information over timeframes shorter than one year. Furthermore, in this study different specific health problems were clustered due to the nature of the online questionnaire and in order to focus on main groups, for example for musculoskeletal complaints the body region affected was not distinguished.

In conclusion, this study provides novel insights into the relations between chronic health problems and work ability and productivity at work. The strength of the associations found between health and work ability and productivity at work differed substantially per methodological approach for analyzing longitudinal studies. The strongest associations were observed when changes in chronic health problems were related to changes in work ability and productivity at work during the same year of observation. The results support several past findings that especially psychological health problems have adverse effects on work ability and productivity at work and thus should be seen as an important risk factor for inhibiting sustainable employability and, hence, a key focus of (workplace) health interventions.

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Conflict of interest

The authors declare no conflict of interest.

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