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This study uses a prospective design to investigate if internal and external resources buffer the effect of psychosocial work stressors on depressive disorders. Our study shows that psychosocial work stressors increase, and resources reduce, the risk of developing depressive disorder. However, our findings do not support the assumption that resources buffer the association between work stress and depressive disorders.

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Original article

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Do resources buffer the prospective association of psychosocial work stress with depression? Longitudinal evidence from ageing workers

by Thorsten Lunau, PhD,[1] Morten Wahrendorf, PhD,[1] Andreas Müller, PhD,[2, 3] Bradley Wright, PhD,[4] Nico Dragano, PhD [1]

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Objectives There is now convincing evidence that psychosocial work stressors are linked to depression. Few studies, however, have tested if individual resources can buffer the longitudinal effects of psychosocial work stressors on depressive symptoms. This study investigates how two types of resources (internal and external resources) affect the association between psychosocial work stressors and depressive symptoms.

Methods Data were obtained from the US Health and Retirement Study, with baseline information on psychosocial work stressors [job strain and effort–reward imbalance (ERI)] and on internal ("high mastery" and "low constraints") and external resources ("private social support") among initially healthy workers. This information was linked to elevated depressive symptoms two years later. The sample includes 5473 observations and we report relative risks (RR) and effect modification on the additive and multiplicative scale.

Results Psychosocial stressors and low resources (internal and external) were both independently related to depressive symptoms. Individuals with both, psychosocial stressors and low resources, had the highest risk of developing elevated depressive symptoms (eg, $RR_{ERI\text{-}LowMastery}$ 3.32, 95% CI 2.49–4.42; $RR_{JobStrain\text{-}LowMastery}$ 2.89, 95% CI 2.18–3.84). Yet, based on interaction analyses, only social support from friends buffered the association between work stressors and depressive symptoms.

Conclusions Our findings have demonstrated that psychosocial stressors at work are related to mental health, and that in most cases this relationship holds true both for people with high and with low resources. Therefore, there is no clear indication that internal or external resources buffer the association between psychosocial work stressors and depressive symptoms.

Key terms depressive symptom; effort–reward imbalance; ERI; job strain; longitudinal study; mental health; psychosocial working condition; external resource; internal resource.

Depression is a common mental disorder with a 12-month prevalence rate of 7% in both the United States (1) and Europe (2). This disorder is linked to a reduction in the quality of life, premature retirement, and more years with disability (3). With regard to its causes, depression is known to be a multifactorial disorder with biological, environmental, and psychological factors involved in its development (4–8), including psychosocial work stressors (9–11). To date, most studies have investigated the association between psychosocial work stressors and depression measuring work stressors according to the models of effort–reward imbalance (ERI) and job strain. Job strain describes working conditions where high demands are combined with low decision latitude or task control (12). ERI is based on the notion of failed contractual reciprocity between efforts spent and rewards received at work, where rewards include money, promotion prospects, job security, and esteem (13). The majority of these studies suggest that ERI and job strain or specific components of these stressors are related to the onset of depression (9, 10, 14).

Besides the identification of specific psychosocial stressors at work it is also important to study the association between these stressors and health more compre-

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hensively, for example, to determine if associations are modified by specific characteristics. A basic assumption of modern stress theory is that resources play an important role in the stress process (15). Resources have an influence on the likelihood of exposure to work stressors, to the stress appraised, and they can buffer the detrimental effects of stress on (mental) health (16). There are several resources with a potential influence on the stress-health relationship. Internal resources such as genetic predispositions or personality factors (eg, hardiness or optimism) have been assumed to act as a moderator in the stress process (16). An important internal resource which can moderate the stress-depression relationship is a sense of personal control (17). Sense of control is defined as the belief that one can exert influence over their life circumstances. Persons with a high sense of control show better coping mechanisms and therefore experience lower stress reactions than individuals with a low sense of control (18). Sense of control has a long history in psychological research and is a general overarching construct that is also referred to as "perceived control" or "control belief". Sense of control consists of two facets: constraints and mastery. Mastery represents the perception an individual has of their ability to achieve desired goals. Perceived constraints refer to perceptions that external factors have an influence on the ability to control life circumstances. Most often these two facets are combined, however, a recent study suggests that constraints and mastery have different effects on mental health and should therefore be analyzed separately (19).

Money, education, or the absence of other life stressors are all examples of external resources. Social support is an important external resource which is said to buffer the effects of work stress (16). Social support is broadly divided between private life (20) and work environments. Based on the assumption that workplace social support has an influence on the stress process, the job–demand–control model was extended to the job–demand–control–support model (21). Several studies investigated the job–demand–control–support model and the evidence for interactive effects as predicted by the buffer hypotheses was rather weak (22). However, substantially less studies have investigated the influence of personal social support on the association between work stressors and depression (20, 23–25).

To our knowledge no studies analyzing the buffering effect of mastery/constraints on the association between ERI/job strain and depressive symptoms exist. There are some studies using related concepts, such as locus of control or sense of coherence, which suggest moderating effects (26–30). However, these studies are mainly based on cross-sectional designs with rather small sample sizes. The influence of private life social support on psychosocial working conditions and depressive symptoms has only been tested in a few studies and these studies failed to demonstrate interactions between private life social support and psychosocial work stressors (20, 23–25).

A substantive amount of research supports the assumption that psychosocial work stressors are related to depression, yet few studies have examined the influence of resources on the effects of psychosocial work stressors. Our research team has previously reported prospective associations of ERI and job control with risk of depressive symptoms in the US Health and Retirement Study (HRS) (11) and has further examined effect modification by national labor and social policies (31). In the present study, we will build on this evidence by investigating if internal and external individual resources buffer the prospective association of psychosocial work stressors and risk of depressive symptoms in HRS.

Methods

Data

Data were obtained from the US HRS (waves 8–12; RAND HRS data file). The HRS was developed to investigate sociological, economic, and health-related topics for individuals aged ≥50 years (32). The study started in 1992 with ongoing waves of data collection in two-year intervals based on representative samples of the ≥50 years population. Data on psychosocial variables, including work stressors and resources, were collected as part of the Psychosocial and Lifestyle Questionnaire (33). This self-administered questionnaire was first introduced in 2006, with alternating data collection among two random half of the sample (50% in 2006 and 2010 and 50% in 2008 and 2012). For our analyses we used data from the years 2006, 2008, 2010, and 2012 to create baseline observations for the measurement of psychosocial working conditions and resources (see table 1). The outcome measure was information on depressive symptoms assessed two years after each assessment of work stressors and resources. Individuals with elevated depressive symptoms at baseline were excluded from the analyses. This resulted in a sample of 4575 participants, where 898 participants contributed twice (563 with baseline in 2006 and 2010; 335 with baseline in 2008 and 2012). These latter participants were included as two separate (but not independent) observations in the analyses. In sum, this resulted in 5473 observations in the analyses, comprising all observations with information on work stressors and no missings on the remaining variables under study.

Measures

Work stressors were assessed by short versions of validated scales taken from questionnaires which assess

Table 1. Description of baseline and follow-up data (number of participants=4575; observations=5473)

Baseline assessments [a]	Follow-up [b]	N	%
2006	2008	1179	25.8
2008	2010	919	20.1
2010	2012	820	17.9
2012	2014	759	16.6
2006 and 2010 [c]	2008 and 2012	563	12.3
2008 and 2012 [c]	2010 and 2014	335	7.3
Total (respondents)		4575	100
Total (observations)		5473	

[a] Psychosocial working conditions and resources.
[b] Depressive symptoms.
[c] Those who participated in two waves. Depressive symptoms were assessed two years after the respective baseline assessment.

the demand–control (34) and the ERI model (35). The demand–control model was assessed with three items measuring demands and three items measuring control. We dichotomized demands and control into high and low by their study-specific medians and defined job strain as the combination of high demands and low control, which is the method most often used to define job strain (36). In the case of ERI, effort was measured with two items and reward with five items. To define an imbalance between effort and reward we calculated the ratio of both sum scores (adjusted for unequal number of items). The scores of the ERI scale were split into tertiles with participants in the upper tertile considered to experience stressful working conditions, which is a standard procedure to define ERI (11).

Depressive symptoms were measured with the 8-item Centre for Epidemiologic Studies Depression scale (CES-D). The total number of depressive symptoms was summed to create a score ranging from 0–8. We used binary indicators to identify individuals with elevated depressive symptoms in the waves that follow the psychosocial work stressors and the resources measure. We used cut-off points (≥4 depressive symptoms) to identify clinically relevant depressive symptoms (37).

Sense of control was measured with the two dimensions: mastery, and perceived constraints. Mastery and constraints were both measured with five items based on the Midlife Development Inventory (mastery, eg,: "I can do just about anything I really set my mind to do"; constraints, eg,: "What happens in my life is often beyond my control") (33, 38). The responses were provided on a 6-point scale (1=strongly disagree to 6=strongly agree). We measured social support from spouse/partner, family, friends and children. Each relationship category was assessed with three items (How much do they really understand the way you feel about things?; How much can you rely on them if you have a serious problem?; How much can you open up to them if you need to talk about your worries?). The response scale was 1=not at all 2=a little 3=some and 4=a lot. We created social support scales for each relationship category by averaging the scores within each category. The scales measuring mastery, constraints and the different support categories were additive. Higher scores indicated higher levels of these resources in case of mastery and social support whereas in case of constraints lower scores indicated higher levels of resources. The final score was set to missing if there were more than three items with missing values for mastery or constraints scales and more than one item for the different social support scales. Finally, we dichotomized the scores using a median split and created variables measuring high or low resources. The low social support variables also included individuals without a partner/spouse, children, etc. For a detailed description of the items used to measure effort-reward imbalance, job strain, mastery, constraints and support see supplementary table S1 (www.sjweh.fi/show_abstract.php?abstract_id=3694).

We also included sex, age and education, which are associated with the exposure variables and depressive symptoms, as additional variables in the analyses to control for potential confounding of those characteristics.

Statistical analyses

Following a basic sample description (table 2), binomial regression models were used to assess the associations between psychosocial work stressors and resources at baseline and depressive symptoms two years later. Persons with elevated depressive symptoms at baseline were excluded from the analyses to assess the association between work stress and incident depressive symptoms. Log binomial regression models allowed us to present relative risks (RR). To test if internal and external resources moderate the association between psychosocial work stressors and depressive symptoms, we followed recommendations by Knol & van der Weele (39) and present measures of effect modification on the additive (departure from additivity) and multiplicative scale (departure from multiplicativity).

We conducted two sets of analyses: the first one assessed effect modification on the additive scale and the second on a multiplicative scale. To assess effect modification on the additive scale, we included the separate and the joint effects of psychosocial working conditions and resources in the regression models. Specifically, we created a variable with four possible combinations of psychosocial working conditions and resources: (i) work stress and low resources (RR_{11}); (ii) no work stress and low resources (RR_{01}); (iii) work stress and resources (RR_{10}); (iv) no work stress and resources (RR_{00} – reference group). To measure effect modification on the additive scale we used the relative excess risk due to interaction (RERI) (40). This measure

Table 2. Sample description (5473 observations from five waves with N=4575)

Variable	%	Mean	Observations
Sex			
Male	48.2		2640
Female	51.8		2833
Age		60.9	5473
Education			
Low	9.1		500
Medium	56.7		3101
High	34.2		1872
Effort–reward imbalance			
No	71.3		3903
Yes	28.7		1570
Job strain			
No	75.4		4125
Yes	24.6		1348
Mastery			
High	51.8		2837
Low	48.2		2636
Constraints			
Low	67.3		3681
High	32.7		1792
Social support spouse			
Low/No spouse	68.7		3758
High	31.3		1715
Social support children			
Low/no children	64.7		3542
High	35.3		1931
Social support family			
Low/no family	60.7		3322
High	39.3		2151
Social support friends			
Low/no friends	56.8		3107
High	43.2		2366
Elevated depressive symptoms			
No	94.2		5154
Yes	5.8		319

was calculated as follows: RERI = RR_{11}-RR_{01}-RR_{10}+1. An effect modification was found when RERI differed significantly from 0. RERI >0 indicates super additivity and RERI <0 indicates subadditivity.

We also tested effect modification on a multiplicative scale. This was achieved by adding a product term to the regression models (work stress × resources). Additionally, we used this regression model to estimate the RR in the strata of high and low resources. The product term represented the ratio of the stratum specific RR. All calculations are produced with Stata 14. To take the clustering of observations within individuals into account we used cluster-robust standard errors (41) [Stata option vce(cluster)].

Results

Table 2 gives an overview of the sample characteristics. The mean age of the sample is 60.9 years. Most respondents have medium (56.7%) or high education (34.2%). Firstly, we analyzed the association between psychosocial work stressors, resources and depressive symptoms (results not shown in tables). The results support the existing evidence that work stressors are associated with depressive symptoms (RR_{ERI} 2.11, 95% CI 1.71–2.61, $RR_{JobStrain}$ 1.84, 95% CI 1.48–2.28) and that resources are protective ($RR_{HighMastery}$ 0.54, 95% CI 0.43–0.67; $RR_{Low-Constraints}$ 0.45, 95% CI 0.36–0.56; $RR_{SocialSupportSpouse/Partner}$ 0.54, 95% CI 0.41–0.71; $RR_{SocialSupportChildren}$ 0.72, 95% CI 0.57–0.92; $RR_{SocialSupportFamily}$ 0.81, 95% CI 0.64–1.02; $RR_{SocialSupportFriends}$ 0.64, 95% CI 0.51–0.80).

Next, we tested the hypothesis that individual and external resources would modify the association between psychosocial working conditions and depressive symptoms. The RR shown in tables 3–5 are based on log-binomial regression models and are computed in two separate analyses. In the first analysis the joint effects of psychosocial working conditions and resources were estimated to test for effect modification on the additive scale. Table 3a presents the joint effects for ERI and mastery. Persons with ERI and high mastery and persons with low mastery and no ERI have an elevated risk of developing elevated depressive symptoms. The highest risks were found for individuals reporting a combination of ERI and low mastery. Although the risk estimate suggests an effect modification on the additive scale (super additivity), the RERI score was not statistically significant. In the second analysis, we tested the effect modification on a multiplicative scale. The product term (RR 0.98, 95% CI 0.62–1.53) revealed no effect modification on the multiplicative scale.

We found similar results for job strain and mastery (table 3b) and for the two psychosocial work stressors and constraints (tables 4a and 4b). The results revealed significant associations whereby individuals reporting work stressors and high constraints had the highest risk of developing elevated depressive symptoms.

With regards to the external resource "private social support", a significant effect modification on the additive scale was observed only for social support by friends (tables 5a and 5b). The effect modification for social support from partner, family or children and psychosocial working conditions were not significant (see supplementary tables S2a-c, www.sjweh.fi/show_abstract.php?abstract_id=3694).

In additional analyses, we adjusted for depressive symptoms at baseline to test if variation in depressive symptoms below the cut-off point impacted on our results (see supplementary tables S3a-c, www.sjweh.fi/show_abstract.php?abstract_id=3694). Although the association between work stressors and depressive symptoms was attenuated in these analyses, the results remained statistically significant. However, the statistical significant interaction effects for job strain and social support by friends became non-significant after controlling for depressive symptoms at baseline.

Table 3a. Modification of the prospective association of effort–reward imbalance (ERI) with depressive symptoms (DS) by mastery: 5473 observations from five waves with N= 4575. Results based on log-binomial regression models from two separate analyses: (1) effect modification on the additive scale and (2) multiplicative scale. [Obs=Observations, RR=relative risk, 95% CI=95% confidence interval.]

	High mastery					Low mastery				
	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]
Additive scale [c]										
No ERI	73/2103	3.4	1			97/1630	5.6	1.71	<0.001	1.27–2.31
ERI	45/616	6.8	1.99	<0.001	1.38–2.86	104/805	11.4	3.32	<0.001	2.49–4.42
Multiplicative scale [d]										
ERI within strata of mastery			1.99	<0.001	1.38–2.86			1.94	<0.001	1.49–2.52

[a] RR are adjusted for gender, age and education.
[b] Cluster-robust standard errors were used to take the clustering of observations within individuals into account.
[c] Measure of effect modification on additive scale: Relative excess risk due to interaction (RERI) 0.62 (95% CI -0.27–1.51); P=0.17.
[d] Measure of effect modification on multiplicative scale: Ratio of RR 0.98 (95% CI 0.62–1.53); P=0.91.

Table 3b. Modification of the prospective association of job strain with depressive symptoms (DS) by mastery: 5473 observations from five waves with N=4575. Results based on log-binomial regression models from two separate analyses: (1) effect modification on the additive scale and (2) multiplicative scale. [Obs=Observations, RR=relative risk, 95% CI=95% confidence interval.]

	High mastery					Low mastery				
	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]
Additive scale [c]										
No job strain	84/2224	3.6	1			111/1706	6.1	1.69	<0.001	1.28–2.23
Job strain	34/495	6.4	1.61	0.018	1.09–2.40	90/729	11.0	2.89	<0.001	2.18–3.84
Multiplicative scale [d]										
Job strain within strata of mastery			1.61	0.018	1.09–2.40			1.71	<0.001	1.31–2.23

[a] RR are adjusted for gender, age and education.
[b] Cluster-robust standard errors were used to take the clustering of observations within individuals into account.
[c] Measure of effect modification on additive scale: Relative excess risk due to interaction (RERI) 0.59 (95% CI -0.25–1.42); P=0.17.
[d] Measure of effect modification on multiplicative scale: Ratio of RR 1.06 (0.66–1.70); P=0.81.

Discussion

The aim of this study was to extend the current knowledge on the association between psychosocial working conditions and depressive symptoms by investigating if individual and external resources have an influence on this association. More specifically, we wanted to assess if resources buffer the negative impact of psychosocial work stressors.

Our first set of analyses is in line with previous studies (14) and showed that ERI and job strain lead to a higher risk of developing elevated depressive symptoms. The results on the association between psychosocial stressors and depressive symptoms in the US HRS have already been published by our research group (11, 31). Beyond these previous findings, the present study shows that individuals with high individual and external resources had a significantly lower risk of reporting elevated depressive symptoms two years later than individuals with low resources. We also observed that individuals reporting work stress and low resources had the highest risk of developing depressive symptoms. The assumption that resources weaken the association between psychosocial work stressors and depressive symptoms was only confirmed for social support by friends and this interaction effect was no longer significant after controlling for depressive symptoms at baseline.

Overall, individuals with high resources reported lower levels of elevated depressive symptoms compared with individuals with low resources. Yet, both individuals with low and high resources had an increased risk to develop elevated depressive symptoms when reporting stressful work environments.

How do these results correspond to previous studies? We are not aware of any studies analyzing the buffering effect of mastery/constraints on the association between ERI/job strain and depressive symptoms. However, a few other studies have investigated the buffering effect of other related concepts on the association between psychosocial working conditions and mental health. Several studies have shown that internal resources such as sense of coherence or coping mechanisms buffer the mental health effects of psychosocial work stressors (26–30). These studies are in conflict with our results,

Table 4a. Modification of the prospective association of effort–reward imbalance (ERI) with depressive symptoms (DS) by constraints: 5473 observations from five waves with N= 4575. Results based on log-binomial regression models from two separate analyses: (1) effect modification on the additive scale and (2) multiplicative scale. [Obs=Observations, RR=relative risk, 95% CI=95% confidence interval.]

	Low constraints					High constraints				
	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]
Additive scale [c]										
No ERI	93/2742	3.3	1			77/991	7.2	2.11	<0.001	1.57–2.83
ERI	57/789	6.7	2.01	<0.001	1.46–2.76	92/632	12.7	3.64	<0.001	2.76–4.80
Multiplicative scale [d]										
ERI within strata of constraints			2.01	<0.001	1.46–2.76			1.73	<0.001	1.30–2.29

[a] RR are adjusted for gender, age and education.
[b] Cluster-robust standard errors were used to take the clustering of observations within individuals into account.
[c] Measure of effect modification on additive scale: Relative excess risk due to interaction (RERI) 0.52 (95% CI -0.44–1.49); P=0.29.
[d] Measure of effect modification on multiplicative scale: Ratio of RR 0.86 (95% CI 0.56–1.32); P=0.49.

Table 4b. Modification of the prospective association of job strain with depressive symptoms (DS) by constraints: 5473 observations from five waves with N=4575. Results based on log-binomial regression models from two separate analyses: (1) effect modification on the additive scale and (2) multiplicative scale. [Obs=Observations, RR=relative risk, 95% CI=95% confidence interval.]

	Low constraints					High constraints				
	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]
Additive scale [c]										
No job strain	103/2847	3.5	1			92/1083	7.8	2.14	<0.001	1.63–2.83
Job strain	47/684	6.4	1.73	0.002	1.23–2.42	77/540	12.5	3.26	<0.001	2.46–4.33
Multiplicative scale [d]										
Job strain within strata of constraints			1.61	0.018	1.08–2.40			1.52	<0.001	1.15–2.02

[a] RR are adjusted for gender, age and education.
[b] Cluster-robust standard errors were used to take the clustering of observations within individuals into account.
[c] Measure of effect modification on additive scale: Relative excess risk due to interaction (RERI) 0.39 (95% CI -0.53–1.31); P=0.40.
[d] Measure of effect modification on multiplicative scale: Ratio of RR 0.88 (0.57–1.36); P=0.57.

which suggest that resources do not have a buffering effect on the relation between psychosocial work stressors and depressive symptoms. One possible explanation for these discrepancies is the different operationalization of internal resources and psychosocial work stressors. It is possible that only certain resources have an influence on the association between psychosocial stressors and depressive symptoms. Perhaps the resources we used in our analyses are not specific enough to have a buffering effect. It is possible that work-related resources (eg, mastery to achieve work-related goals) might buffer the association between work stressors and depression. Another possible explanation is the cross-sectional design of the previous studies, which limits the causal attributions between measures.

With regard to external resources, some studies have analyzed the influence of private life social support on psychosocial working conditions and depressive symptoms (20, 23–25). Most of these studies failed to demonstrate interactions between private life social support and psychosocial work stressors. One longitudinal study suggested that high strain work may increase the risk of depressive symptoms, but only among individuals with low social support (20). However, the interaction effects in this study were not significant. The authors suggested that future studies need larger samples to further investigate the role of private life social support as a buffer of the association between psychosocial work stressors and depression. Most of the private life social support research has relied on cross sectional studies with small sample sizes. Our study extends the current state of this research and provides longitudinal information on the buffering effect of external and internal resources on the basis of a large database of people working in paid employment.

Although we didn't find convincing results supporting our assumption that individual resources buffer the association between work stressors on depression, other studies from our research group provided the first indications for an effect modification by national labor and social policies (31). Future studies should further explore if such collective resources are better suited to buffer the association between work stressors and depression than individual resources.

The following limitations must be considered when interpreting the results. First, the measurement of psychosocial work stressors was restricted to short assessments of two established work stress models: ERI and job strain.

Table 5a. Modification of the prospective association of effort–reward imbalance (ERI) with depressive symptoms (DS) by social support from friends: 5473 observations from five waves with N= 4575. Results based on log-binomial regression models from two separate analyses: (1) effect modification on the additive scale and (2) multiplicative scale. [Obs=Observations, RR=relative risk, 95% CI=95% confidence interval.]

	High support					Low support				
	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]
Additive scale [c]										
No ERI	69/1708	3.9	1			101/2025	4.8	1.35	0.050	1.00–1.83
ERI	41/548	6.9	1.78	0.003	1.23–2.58	108/873	11.0	2.97	<0.001	2.21–3.99
Multiplicative scale [d]										
ERI within strata of social support			1.78	0.003	1.23–2.58			2.20	<0.001	1.69–2.85

[a] RR are adjusted for gender, age and education.
[b] Cluster-robust standard errors were used to take the clustering of observations within individuals into account.
[c] Measure of effect modification on additive scale: Relative excess risk due to interaction (RERI) 0.84 (95% CI 0.04–1.64); P=0.04.
[d] Measure of effect modification on multiplicative scale: Ratio of RR 1.24 (95% CI 0.78–1.95); P=0.37.

Table 5b. Modification of the prospective association of job strain with depressive symptoms (DS) by social support from friends: 5473 observations from five waves with N=4575. Results based on log-binomial regression models from two separate analyses:(1) effect modification on the additive scale and (2) multiplicative scale. [Obs=Observations, RR=relative risk, 95%CI=95% confidence interval.]

	High support					Low support				
	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]	Obs (with/ without DS)	% with DS	RR [a]	P-value	95% CI [b]
Additive scale [c]										
No job strain	80/1773	4.3	1			115/2157	5.1	1.28	0.089	0.96–1.69
Job strain	30/483	5.9	1.29	0.218	0.86–1.95	94/741	11.3	2.60	<0.001	1.95–3.47
Multiplicative scale [d]										
Job strain within strata of social support			1.29	0.218	0.86–1.95		2.04	<0.001		1.57–2.65

[a] RR are adjusted for gender, age and education.
[b] Cluster-robust standard errors were used to take the clustering of observations within individuals into account.
[c] Measure of effect modification on additive scale: Relative excess risk due to interaction (RERI) 1.03 (95% CI 0.33–1.74); P=0.004,
[d] Measure of effect modification on multiplicative scale: Ratio of RR 1.58 (0.97–2.55); P=0.064,

There is also a potential overlap in the measurement of control, mastery and constraints. Control is a component of job strain and some may argue that it overlaps with low mastery or high perceived constraints. However, mastery and constraints are rather general personality-related concepts and low control as part of the job–demand–control model is related to the work situation. We also tested the association between the job control and the mastery/ constraints scale and the correlation is only moderate (supplementary table S4, www.sjweh.fi/show_abstract.php?abstract_id=3694). A second limitation is the measurement of depression. The CES-D is a validated screening instrument, and it is possible to identify individuals with increased depressive symptoms (42), but it does not allow a clinical diagnosis. In addition, we only had information on incident depressive symptoms two years after the baseline assessment. We did not have any information about depressive symptoms between baseline and follow-up or before baseline. Furthermore, we have to address the problem of common method variance. It is possible that individuals with depressive symptoms overestimate work stressors and underestimate individual resources. Although we excluded individuals with elevated depressive symptoms at baseline, there are still individuals with different levels of depressive symptoms in our analyses. In sensitivity analyses, we additionally adjusted for baseline depressive symptoms. After this adjustment the interaction effects for job strain and social support by friends were no longer statistically significant. Although we used a large dataset with 5473 observations it is possible that small interaction effects will reach statistical significance in larger datasets with more statistical power.

Another possible limitation is that the study population consisted of men and women aged ≥50 years. The assumption that resources buffer the association between psychosocial work stressors and depressive symptoms was not confirmed in this sample of older people working in paid employment and therefore future studies should test if an effect modification can be observed in younger age groups who have less work experience.

The study also has several important strengths. Although we could only use short assessments of work stress models, these assessments are based on validated questionnaires from internationally established work stress models (12, 13). In addition, the CES-D is an established screening instrument for depressive symptoms that is used in epidemiological studies worldwide. By combining several waves from the HRS study, we

obtained a large dataset with 5473 observations from 4575 individuals. Another strength is the longitudinal dataset. This is an improvement on most investigations that employ cross sectional designs.

Concluding remarks

In conclusion, our study has shown that psychosocial work stressors increase, and internal and external resources reduce, the risk of developing elevated depressive symptoms. However, our findings did not support the assumption that internal or external resources buffer the association between work stressors and depressive symptoms. Instead, the results of this study suggest that individuals with high internal or external resources are at increased risk of developing a depressive disorder when they experience ERI or job strain in the workplace. Further, individuals not experiencing ERI or job strain in the workplace are at increased risk of developing a depressive disorder when they experience low internal and external resources. The results suggest that the promotion of individual resources cannot prevent individuals with ERI or job strain from developing depressive symptoms. Potentially, the implication is that improvement in both individual resources and working conditions may be required to help prevent depression.

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