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Unrewarding work and major depressive episode: Cross-sectional and prospective evidence from the U.S. MIDUS study

Timothy A. Matthews [a], Natalie Porter [b], Johannes Siegrist [c], Jian Li [a,d,*]

[a] Department of Environmental Health Sciences, Fielding School of Public Health, University of California, Los Angeles, United States
[b] Department of Community Health Sciences, Fielding School of Public Health, University of California, Los Angeles, United States
[c] Institute of Medical Sociology, Faculty of Medicine, University of Düsseldorf, Germany
[d] School of Nursing, University of California, Los Angeles, United States

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ABSTRACT

Depression is a serious mental health condition and is the leading cause of disability worldwide. Previous research has demonstrated that work stress may contribute to the development of depression through psychophysiological pathways. The present study assessed associations of work stress – in terms of the effort-reward imbalance (ERI) model measuring unrewarding work – with major depressive episode (MDE). Data were from the Mid-life in the United States study, a national, population-based sample of U.S. workers with 9-year follow-up prospective cohort design. The cross-sectional sample at baseline had 2204 workers, and the prospective sample had 1591 workers at follow-up (78.7% follow-up rate). Multivariable Bayesian logistic regression and Poisson regression were applied for examining cross-sectional and prospective associations, respectively. ERI was assessed by a validated 17-item scale at baseline, and MDE in the past 12 months was assessed by the Composite International Diagnostic Interview Short Form at both baseline and follow-up. It was found that ERI at baseline was associated with higher odds of prevalent MDE in the cross-sectional sample (OR = 1.47, HPD interval [1.26–1.69]), and with higher risk of MDE at follow-up in the prospective sample (RR = 1.29, HPD interval [1.01–1.60]). In both cross-sectional and prospective analyses, strongest associations were observed among workers with the highest quartile of ERI, after adjusting for demographic, socioeconomic, lifestyle, and other psychosocial factors. The stable and robust findings strengthen and extend previous findings that unrewarding work is a risk factor of mental health. If confirmed by further evidence, intervention targeting work stress reduction is warranted.

1. Introduction

Depression is a serious mental health condition and is the leading cause of disability worldwide (World Health Organization, 2021). Depression is associated with increased all-cause mortality and is characterized by persistent sad or irritable mood, a loss of pleasure in interests, and feelings of guilt or hopelessness, among a constellation of other potentially debilitating symptoms (Machado et al., 2018; World Health Organization, 2021). Depression is of particular concern in the workplace due to the economic and productivity costs associated with depressed workers (Bender and Farvolden, 2008). Certainly, evidence indicates a prominent role of psychosocial workplace stressors and employment factors in depression and other psychiatric conditions (Matthews et al., 2021a, 2022b; Siegrist, 2008; Siegrist and Wege, 2020). In a meta-analysis of environmental risk factors for depression across the lifespan, psychosocial work stress met criteria for convincing prospective evidence as a putative predictor (Köhler et al., 2018; Madsen et al., 2017). Furthermore, a systematic review of potentially modifiable risk factors for mental disorders estimated a global population attributable fraction (PAF) of 18% for stressful work environment and depression, with stress at work emerging as the third-largest global PAF among 28 exposure-outcome relationships (Dragioti et al., 2022).

Research on work stress and health has focused on three theoretical models: job strain, organizational injustice, and effort-reward imbalance (Siegrist and Wege, 2020). The first model operationalizes job strain as the combination of high job demand with low job control (Karasek,

* Corresponding author. Department of Environmental Health Sciences, Fielding School of Public Health, School of Nursing, University of California, Los Angeles. 650 Charles E. Young Drive South, Los Angeles, CA, 90095, United States.
E-mail address: jianli2019@ucla.edu (J. Li).

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1979), with substantial prior evidence indicating associations of job strain with depression (Madsen et al., 2017; Matthews et al., 2021b; Stansfeld et al., 2012; Theorell et al., 2014; Wang et al., 2009). The model of organizational injustice deals with perceived inequities of workers' behaviors in formal organizations, majorly referring to procedural injustice and interactional injustice (Elovainio et al., 2002). A number of studies suggested notable effects of organizational injustice on depression and other health issues (Ndjaboué et al., 2012; Virtanen and Elovainio, 2018). The Effort Reward Imbalance (ERI) model is based on the core principle of reciprocity in social exchange (Gouldner, 1960). The violation of this norm in terms of high effort spent and low reward received in turn is expected to elicit strong negative emotions and psychobiologic stress reactions. This notion was applied to the work role (Siegrist, 1996). In many studies, exposure to ERI was shown to be prospectively associated with elevated risks of stress-related disorders, such as coronary heart disease (Dragano et al., 2017), depression (see below), type 2 diabetes (Pena-Gralle et al., 2022), as well as with psychobiologic stress markers (Eddy et al., 2017).

Despite a number of studies documenting associations of ERI with depression (Mikkelsen et al., 2021; Siegrist and Wege, 2020), evidence based on prospective cohort studies is still restricted, with the majority of data drawn from Europe and Canada (Rugulies et al., 2017). In addition, due to methodological concerns such as the use of non-clinical measures of depression (self-reported depression or questionnaire-based depressive symptoms) and lack of consideration of other work-related or non-work-related psychosocial risk factors, empirical evidence suggesting a causal link between stressful working conditions (including ERI) and depression was judged as inconclusive (Mikkelsen et al., 2021). To the best of our knowledge, only one U.S. study reported that high effort-reward imbalance at baseline was associated with increased risk of newly manifested depressive symptoms (OR and 95% CI = 1.64 [0.87, 3.09]). However, several limitations were obvious in this study – the study subjects were older workers (50–64 years), the outcome was not clinical depression, and the follow-up period was short (i.e., 2 years) (Siegrist et al., 2012). Therefore, our objective was to provide novel research evidence on ERI and risk of major depressive episode (MDE) over a 9-year follow-up period among the U.S. general working population, taking other psychosocial risk factors into account. We hypothesize that ERI at baseline is cross-sectionally and prospectively associated with MDE in the past 12 months.

2. Subjects and methods

2.1. Study population

The Mid-life in the United States (MIDUS) study is a longitudinal, national, population-based study examining psychological, social, and behavioral determinants of health among mid-life US adults (Ryff et al., 2007). The MIDUS core sample was based on a Random Digit Dial (RDD) national sample of American adults aged 24–74, selected from working telephone banks in the coterminous United States. In addition, the siblings of cooperating RDD respondents were invited to participate, and a national sample of twin pairs was also included from a national household screening project. MIDUS data collection was done through phone interviews which were accompanied by self-administered questionnaires. The MIDUS sampling procedures and cohort profile have been described in detail previously (Radler, 2014).

In total, 7108 people participated in the initial MIDUS I study (1995–1996), with an overall response rate of 61%. In 2004–2006, 4963 participants from the initial cohort were successfully contacted in the MIDUS II study. It has been observed that individuals with better health and higher educational attainment had higher retention rates between the MIDUS I and MIDUS II surveys (Radler and Ryff, 2010). In this present study, we set the baseline as the MIDUS II survey, and the follow-up as the MIDUS III survey (2013–2014). Out of the 4963 participants in Wave II, 2313 reported current employment. Among employed people, 2211 had complete data on ERI, and 2204 had complete data on all covariates. At Wave III, 1734 individuals were followed up (follow-up rate = 78.7%). Participants who experienced MDE in the past 12 months at baseline were excluded from prospective analyses. The final cross-sectional sample included 2204 participants, and the prospective sample included 1591 participants (seeFig. 1). This work was carried out in accordance with the Declaration of Helsinki. All participants provided written informed consent. This study was reviewed and approved for exemption by the University of California, Los Angeles Institutional Review Board (IRB#20–001044).

2.2. Measures

A 17-item scale was used to measure ERI at work at Wave II (baseline), including 10 items for effort and 7 items for reward. This measure was recently validated in the MIDUS study (Li et al., 2021). The Cronbach's alpha coefficients for the two sub-scales of effort and reward were 0.74 and 0.76, respectively. The core variable E-R ratio was calculated by dividing the sum scores of effort by the sum scores of reward, weighted by the number of items contributing to each construct. The E-R ratio was operationalized across separate regression models alternatively as a categorical measure, using quartiles as cut-points, and as a continuous measure (standardized Z-score) as well. Strengths and limitations of this approach are addressed in the Discussion section.

MDE in the past 12 months was assessed with the 19-item WHO Composite International Diagnostic Interview Short Form (CIDI-SF), a validated scale with high specificity and sensitivity (Kessler et al., 1998). Diagnosis of MDE requires both depressed mood or anhedonia for most of the day nearly every day, and four or more symptoms (such as fatigue, appetite change, insomnia) for at least 2 weeks. Data regarding MDE in the past 12 months was collected during each wave of MIDUS. Details of the ERI and MDE measures are presented in Supplementary Tables 1 and 2.

Sociodemographic characteristics were measured at baseline, including sex, age (<46; 46 to 55; 56+), race (white; black; other), marital status (married; never married; divorced/widowed/separated), educational attainment (high school or less; some college; University degree or more), household annual income (<$60,000; $60,000 to $99,999; 100,000+), current smoking (no; yes), alcohol consumption (low or moderate – up to two drinks per day for men and one drink per day for women; heavy drinking – more than moderate drinking), and frequency of vigorous leisure time physical exercise (low – never; moderate – once a week; high – several times a week) (Choi et al., 2010; Matthews et al., 2022a; 2022c; U.S. Department of Agriculture and U.S.

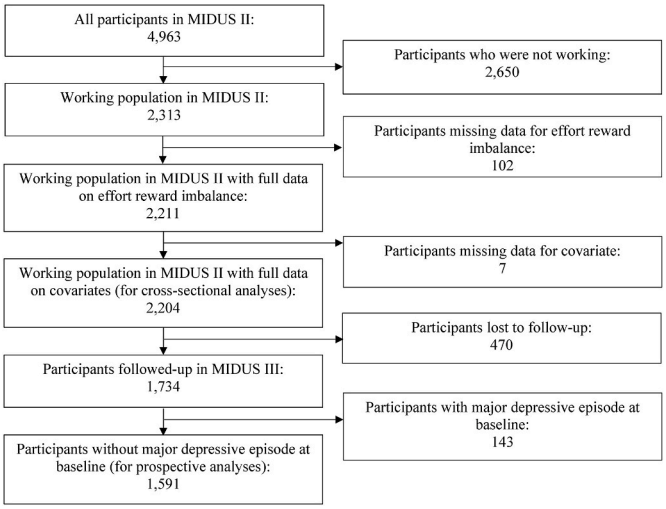

Fig. 1. Sample size selection.

Department of Health and Human Services, 2020). Other psychosocial factors including job control (9 items, range = 9–45) and family strain (4 items, range = 1–4) were operationalized in accordance with prior analyses in the MIDUS study, given their contribution of explanatory power to risk of MDE (Matthews et al., 2021b).

2.3. Statistical analysis

First, descriptive statistics were generated. Means and standard deviations (SDs) were investigated for continuous variables, and relative frequencies were examined for categorical variables. Second, we analyzed cross-sectional associations between ERI and MDE in the past 12 months assessed at baseline among 2204 participants, using multivariable Bayesian logistic regression. The results are presented as odds ratios (ORs) with highest posterior density (HPD) intervals (Congdon, 2014). Third, the prospective associations of ERI at baseline with risk of MDE within the 12 months prior to the follow-up were estimated using Bayesian Poisson regression with a log-link function and empirical (robust) variance in 1591 participants, and the results were expressed as risk ratios (RRs) with HPD intervals (Congdon, 2014; Zou, 2004). Bayesian analyses were performed using normal priors for all coefficients and large variance via the Gamerman algorithm for generalized linear models and with 20,000 samples of posterior simulation iterations (Congdon, 2014). Multivariable regression models were conducted in four steps: Model I adjusted for sex and age; Model II additionally adjusted race, marital status, educational attainment, and annual household income; Model III included additional adjustment for the health-related behaviors of smoking, alcohol consumption, and physical activity; and Model IV additionally adjusted for job control and family strain at baseline. To examine potential interaction between E-R ratio and sex, age, job control and family strain in the analyses, as suggested by previous studies (Matthews et al., 2021b), we included an interaction term between E-R ratio and these variables, respectively, in the fully adjusted regression models (Matthews et al., 2021b; Wege et al., 2018). All analyses were conducted using the SAS 9.4 software package.

3. Results

The characteristics of the study sample in the 2204 baseline and 1591 follow-up participants are shown in Table 1. The sample was predominantly middle aged, white, married, college or higher educated, non-smoking, and engaged in low or moderate drinking and physical activity. Participants lost during the 9-year follow-up were more likely to be a racial or ethnic minority, less educated, with lower income, divorced or otherwise separated, smokers, and less engaged in high-level physical exercise. Notably, subjects with low job control and high E-R ratio were more likely to be lost during follow-up. However, we did not observe obvious differences in family strain or prevalence of MDE between individuals who were followed up and subjects who were lost during follow-up (details in Supplementary Table 3).

Bayesian logistic regression results for the cross-sectional sample are shown in Table 2. The overall prevalence of MDE in the past 12 months was 8.67%. Being in the top quartile for E-R ratio was associated with increased odds of having MDE in the past 12 months in all models, including the fully adjusted model (OR = 2.61 and HPD interval [1.41, 3.87]). The associations were slightly attenuated after adjustment for covariates through Models I to IV. Each increase in SD of E-R ratio was associated with 47% increased odds (fully-adjusted OR = 1.47 and HPD interval [1.26, 1.69]) of having MDE in the past 12 months.

In the prospective sample, there were 94 new cases of MDE in the past 12 months at follow-up (5.91%). A similar pattern of associations was observed as with the cross-sectional sample (see Table 3). At 9-year follow-up, the highest quartile of E-R ratio had an increased RR of experiencing MDE in the past 12 months compared to the lowest quartile (fully-adjusted RR = 2.38 and HPD interval [1.04, 4.19]). Each SD increase in the E-R ratio was associated with a 29% elevated risk of MDE (fully-adjusted RR = 1.29 and HPD interval [1.01, 1.60]).

In all regression analyses, we did not obverse meaningful interactions between E-R ratio and sex, age, job control and family strain (all $p > 0.30$).

Table 1
Study characteristics at baseline.

Variables (N, %)	Baseline Sample (N = 2204)	Prospective Sample (N = 1591)
Age (years)		
<46	700 (31.76%)	481 (30.23%)
46-55	825 (37.43%)	601 (37.78%)
≥56	679 (30.81%)	509 (31.99%)
Sex		
Men	1078 (48.91%)	804 (50.53%)
Women	1126 (51.09%)	787 (49.47%)
Race		
White	2029 (92.06%)	1480 (93.02%)
Black	72 (3.27%)	46 (2.89%)
Other	103 (4.67%)	65 (4.09%)
Marital Status		
Married	1620 (73.50%)	1214 (76.30%)
Never Married	193 (8.76%)	136 (8.55%)
Other	391 (17.74%)	241 (15.15%)
Education		
High School or Less	588 (26.68%)	387 (24.32%)
Some College	626 (28.40%)	433 (27.22%)
University degree or More	990 (44.92%)	771 (48.46%)
Annual household Income (US dollars)		
<60,000	818 (37.11%)	557 (35.01%)
60,000–99,999	716 (32.49%)	529 (33.25%)
≥100,000	670 (30.40%)	505 (31.74%)
Current Smoking		
No	1876 (85.12%)	1393 (87.55%)
Yes	328 (14.88%)	198 (12.45%)
Alcohol Consumption		
Low or Moderate	2152 (97.64%)	1553 (97.61%)
Heavy	52 (2.36%)	38 (2.39%)
Physical Exercise		
High	892 (40.47%)	681 (42.81%)
Moderate	793 (35.98%)	544 (34.19%)
Low	519 (23.55%)	366 (23.00%)
Job control (mean ± SD)	33.25 ± 5.82	33.45 ± 5.61
Family strain (mean ± SD)	2.07 ± 0.58	2.06 ± 0.56
E-R ratio (mean ± SD)	0.73 ± 0.22	0.71 ± 0.21

4. Discussion

The purpose of this study was to investigate the role of work stress, as operationalized by the ERI model, in the development of MDE in U.S. workers. To the best of our knowledge, this is the first instance of research evidence assessing the contribution of ERI to clinical depression using prospective cohort data from a large, national sample of U.S. workers. Using a validated measure of ERI, it was found that ERI at baseline was associated with higher odds of prevalent MDE, as well as higher risk of MDE. Critically, the relationships were rather consistent in both cross-sectional and prospective designs within the same study, indicating that the associations are stable and robust. Furthermore, the associations persisted even upon adjustment for other psychosocial factors of job control and family strain, which are exposures that have been previously demonstrated to be associated with MDE in the same MIDUS study sample (Matthews et al., 2021b). The lack of attenuated association and the minimal change in effect size upon adjustment for job control and family strain further demonstrate that the contributions of ERI to MDE identified in the present study are highly robust.

Participants in the highest quartile of E-R ratio experienced the greatest odds of having MDE in the past 12 months at baseline, as well as the greatest risk of MDE in the past 12 months at follow-up. This finding

Table 2
Cross-sectional associations of effort-reward imbalance at baseline and prevalent major depressive episode (ORs and HPD Intervals) (N = 2204).

	Prevalent cases of major depressive episode at baseline (N, %)	Model I	Model II	Model III	Model IV
E-R ratio divided into quartiles					
Low quartile	30 (5.44%)	1.00	1.00	1.00	1.00
Medium-low quartile	42 (8.08%)	1.56 (0.81, 2.31)	1.56 (0.80, 2.34)	1.62 (0.90, 2.43)	1.59 (0.83, 2.38)
Medium-high quartile	41 (7.17%)	1.41 (0.80, 1.15)	1.28 (0.60, 1.90)	1.38 (0.77, 2.08)	1.30 (0.67, 2.01)
High quartile	78 (13.90%)	3.03 (1.86, 4.52)	2.62 (1.56, 3.95)	2.95 (1.64, 4.27)	2.61 (1.41, 3.87)
E-R ratio continuous					
Increase per SD	191 (8.67%)	1.49 (1.30, 1.68)	1.47 (1.26, 1.69)	1.52 (1.32, 1.71)	1.47 (1.26, 1.69)

HPD, highest posterior density; OR, odds ratio; SD, standard deviation.
Bayesian logistic regression.
Model I: adjustment for age and sex at baseline.
Model II: Model I + additional adjustment for race, marital status, educational attainment, and household income at baseline.
Model III: Model II + additional adjustment for smoking, alcohol consumption, and physical exercise at baseline.
Model IV: Model III + additional adjustment for job control and family strain at baseline.

is consistent with the ERI model, which states that unrewarding work – where effort is perceived as being greater than the rewards received from work – is a particularly stressful experience with impacts on mental and physical health (Dragano et al., 2017; Eddy et al., 2017; Pena-Gralle et al., 2022; Rugulies et al., 2017). In the prospective sample, we observed a gradual increase in risk of MDE with increasing E-R ratio, indicating a dose-response relationship between ERI and MDE.

Collectively, these findings are largely in agreement with the current international literature demonstrating associations of ERI with mental health outcomes, including depression. In concert, recent systematic reviews and meta-analyses have identified consistent and stable prospective associations of ERI with depression (Mikkelsen et al., 2021; Rugulies et al., 2017; Siegrist and Wege, 2020). A burgeoning body of evidence has largely substantiated associations of ERI with depression in European samples, yet there is a paucity of data regarding U.S. populations (Åhlin et al., 2020; Hoven et al., 2021; Juvani et al., 2014; Kivimäki et al., 2007; Li et al., 2019; Nielsen et al., 2016; Nigatu and Wang, 2018; Rugulies et al., 2013; Siegrist et al., 2012; Wang et al., 2012; Wege et al., 2018). Large studies of workers in Nordic countries identified prospective associations of ERI with risk of depression, with studies from Finland offering the advantage of statistical adjustment for the psychosocial workplace stressor of organizational injustice, which was not assessed in the our study due to lack of data (Kivimäki et al., 2007). A recent study of 26,483 employees in France demonstrated a role of ERI in explaining "the association between discontinuous employment and depression", underscoring the consequences of ERI-related depression in terms of job discontinuity, job instability, and cumulative disadvantage (Hoven et al., 2021). Among European working populations, similarly positive findings were reported across studies that used self-reported depression (Hoven et al., 2021; Kivimäki et al., 2007; Wege et al., 2018) and depressive symptoms as defined by a variety of scales, including the 6-item Symptom Checklist-core depression ($SCL\text{-}CD_6$) (Åhlin et al., 2020; Li et al., 2019), the 12-item European Depression Scale (EURO-D) (Siegrist et al., 2012), and the 5-item Mental Health Inventory (MHI-5) (Rugulies et al., 2013). However, two studies with registry data for depression-related outcomes exerted contradictory evidence. A Finnish study found ERI was a remarkable risk factor for disability pension due to depression with confirmed diagnosis by the International Statistical Classification of Diseases (ICD) 10th revision (Juvani et al., 2014), whereas null association between ERI and antidepressant treatment was observed in a Danish study (Nielsen et al., 2016). Yet, this latter finding may be due to outcome misclassification, as antidepressants are often used to treat conditions other than depression, and some individuals with depression are not treated with antidepressants.

Beyond the evidence originating in Europe, in two longitudinal studies from Alberta, Canada with follow-up periods of 1–5 years, ERI at baseline was associated with increased risk of clinically defined major depression at follow-up as assessed by the WHO-CIDI, after adjustment for demographic variables and other psychosocial factors, including job strain and work-family conflict (Nigatu and Wang, 2018; Wang et al., 2012). The overall pattern of research findings from Canada is quite comparable to the results observed in our 9-year follow-up study in the U.S. While the preponderance of international evidence demonstrates clear associations of ERI with depression, this current study fills a critical and hitherto unaddressed research gap by offering a first assessment of this relationship in a national prospective cohort study of U.S. workers. The only prior evidence from the U.S. was drawn from the Health and Retirement Study, where incident depressive symptoms (measured by 8-item Centre for Epidemiologic Studies Depression, CES-D) were weakly related to ERI in a sample of 589 workers above 50 years old (Siegrist et al., 2012).

Potential bio-medical mechanisms underlying associations of ERI with MDE have been previously identified, with major emphasis on dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, which is strongly implicated in the etiology of depressive disorders (Rugulies et al., 2016). Adverse sequelae of HPA disruption include "loss of neuroplasticity, inhibition of neurogenesis, and increased inflammation", as

Table 3
Prospective associations of effort-reward imbalance at baseline and risk of major depressive episode at follow-up (RRs and HPD Intervals) (N = 1591).

	New cases of major depressive episode at follow-up (N, %)	Model I	Model II	Model III	Model IV
E-R ratio divided into quartiles					
Low quartile	14 (3.33%)	1.00	1.00	1.00	1.00
Medium-low quartile	21 (5.38%)	1.29 (0.69, 1.97)	1.32 (0.71, 2.07)	1.25 (0.67, 1.90)	1.29 (0.66, 2.06)
Medium-high quartile	29 (6.82%)	1.66 (0.80, 2.60)	1.64 (0.69, 2.67)	1.55 (0.83, 2.51)	1.57 (0.71, 2.49)
High quartile	30 (8.43%)	2.67 (1.21, 4.51)	2.63 (1.07, 4.58)	2.44 (0.99, 4.20)	2.38 (1.04, 4.19)
E-R ratio continuous					
Increase per SD	94 (5.91%)	1.28 (1.04, 1.52)	1.30 (1.04, 1.58)	1.26 (1.03, 1.53)	1.29 (1.01, 1.60)

HPD, highest posterior density; RR, risk ratio; SD, standard deviation.
Bayesian Poisson regression.
Model I: adjustment for age and sex at baseline.
Model II: Model I + additional adjustment for race, marital status, educational attainment, and household income at baseline.
Model III: Model II + additional adjustment for smoking, alcohol consumption, and physical exercise at baseline.
Model IV: Model III + additional adjustment for job control and family strain at baseline.

well as indicators of both acute and chronic stress, such as increased plasma, salivary, and hair cortisol concentrations (Bellingrath et al., 2013; Penz et al., 2019; Rugulies et al., 2016; Siegrist, 2008). ERI has also been shown to be associated with increased lipopolysaccharide and interleukin-6 production, demonstrating increases in proinflammatory signaling, which in turn can provoke depressive symptoms (Bellingrath et al., 2013; Vogelzangs et al., 2016).

The major strengths of this study are grounded in the large, national, population-based MIDUS sample and the validated and robust measures utilized. The MIDUS study includes an extensive and diverse range of American workers across the general spectrum of sociodemographic categories, which increases the generalizability of the results. ERI was assessed using a recently validated measure (Li et al., 2021), and the well-evidenced and widely used WHO CIDI-SF (Kessler et al., 1998) was used to assess the clinically defined outcome of MDE, offering an advantage over previous studies of psychosocial workplace stressors that were limited to only measuring self-reported depression or depressive symptoms (Mikkelsen et al., 2021; Rugulies et al., 2017; Siegrist and Wege, 2020; Theorell et al., 2015). Another methodological strength of this study is the inclusion of regression models with further adjustment for the highly impactful psychosocial stressors of job control and family strain, wherein the associations of ERI with past 12-month MDE remained stable.

There are several methodological limitations that should be addressed for this study. While the WHO CIDI-SF is highly sensitive and specific (Kessler et al., 1998), the instrument used was only able to identify instances of MDE in the past 12 months. Any occurrences of MDE prior to the past 12 months in the lifetime of the participant and the total number of depressive episodes were not captured. Participants may have experienced MDE at any point in the 9-year window preceding the follow-up study visit. Thus, the number of MDEs recorded at the follow-up survey may be an underestimate of the true burden of depression within the sample. Additionally, the Healthy Worker Survivor Effect (HWSE) may have also impacted our results (Brown et al., 2017). For example, the experience of unrewarding work may prompt job transitions or early exit from the workforce, and we were unable to account for the effects of such behavioral choices in our analyses. Notably, participants with low job control and a high E-R ratio were more likely to be lost during the follow-up; furthermore, non-participants were found to be more socially disadvantaged, such as being a racial or ethnic minority, less educated, and economically poorer. Therefore, the observed associations would be underestimated, due to clear selection bias. Another limitation of this study concerns the statistical analysis of ERI data. There are several ways of testing joint effects of the two sub-scales 'effort' and 'reward' in order to examine the core theoretical notion of this model (additive interaction; e.g. Bosma et al., 1998; adjustment of effects of single scales in a multivariable model using the E-R ratio; e.g. Siegrist et al., 2019). In this study, we did not explore these approaches as our main aim was to examine the consistency of observed effects with those reported in previous studies using the E-R ratio. However, this methodological restriction may reduce the generalizability of our findings. Moreover, our measure of the model was restricted to the extrinsic components as no data on its intrinsic component 'over-commitment' was available. Given an additional predictive role of this component for depression (Siegrist and Wege, 2020) we may have underestimated the explanatory contribution of this model. Furthermore, a previous study suggested that exposure to cumulative ERI across two time points was associated with elevated risk of poor mental health (including depressive symptoms) at follow-up (Godin et al., 2005). However, such sophisticated analysis was not feasible due to restricted exposure data in our study. Finally, weighting procedures were not applied in our analyses, because population weighting information was available in the main RDD sample only, which accounted for 43% of the analytic sample of workers. Thus, the representativeness of our sample was, to some extent, not well addressed.

In conclusion, effort-reward imbalance at work was found to be associated with higher odds of prevalent MDE (cross-sectionally) and elevated risk of MDE after 9-year follow up (prospectively) in a large, national, population-based sample of U.S. adults. The stable and robust associations between ERI and MDE implicate failed reciprocity between high efforts spent at work and low rewards received in turn as a risk factor of mental health outcomes. If confirmed by further prospective evidence, intervention targeting work stress reduction at both organizational and individual levels is warranted, given promising findings from clinical trials in the workplace for the management of mental disorders in workers (Bourbonnais et al., 2011; Li et al., 2017).

Contributions

Timothy A. Matthews: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. Natalie Porter: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. Timothy A. Matthews and Natalie Porter had equal contribution to this research project. Johannes Siegrist: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. Jian Li: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. All authors have read and approved the final version of the manuscript.

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Role of the funder/sponsor

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Disclaimer

Views and opinions expressed hereby are the sole responsibility of the authors and do not necessarily reflect those of the funding agencies.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2022.11.009.

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