

## Three job-related stress models and depression: a population-based study

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### Abstract

**Objectives** To estimate the current prevalence of major depression in a sample of working population, and to examine the associations between job strain, effort–reward imbalance and family–work conflicts and major depression.

**Methods** A sample of employees who were between the ages of 25 and 65 years and who were working in Alberta at the time of survey was recruited using the method of random digit dialing ( $n = 4,302$ ). Data about job stress, effort–reward imbalance and work–family conflicts and depression were collected via telephone. Depression was assessed by the Patient Health Questionnaire (PHQ-9) for depression.

**Results** The 2-week prevalence of major depression based on the DSM algorithm was 3.2%. The prevalence of

severe depression was 0.8%. Job strain, effort–reward imbalance and work–family conflicts were strongly associated with continuous depression score. Effort–reward imbalance was significantly associated with depression scores in women, but not in men. Effort–reward imbalance was significantly associated with depression scores in participants with job strain ratio  $>1$ , but not in those with a lower job strain ratio. The association between work to family conflict and depression score was stronger in participants with a job strain ratio greater than one than in those whose job strain ratio was one or less.

**Conclusions** The three job-related stress models are widely used in occupational health research. They are equally important in predicting depression and interact with each other. Improving work environment based on these models holds potentials to reduce the synergetic effects, therefore, improving employees' mental health.

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**Keywords** Job strain · Effort–reward imbalance · Work–family conflicts · Depression · Population-based longitudinal study

### Introduction

Mental disorders are prevalent in the labor force [1]. With the fast changes in the world economy and in industrial re-organization in the past years, employees have been facing mounting pressure to be more competitive and such changes are generating job insecurities for workers [2] and demanding more cerebral skills and mental performance [3]. These work environmental factors may precipitate the onset of mental disorders [4]. Mental health problems have a significant impact on productivity [5], work loss

and work cutback [6–8] and job turnover [9]. Maintaining a productive workforce and recruiting and retaining the most productive personnel are crucial for the business community.

A thorough understanding of the determinants of mental health problems at workplaces is critical to the development of effective prevention and promotion strategies. The circumstances in which people live and work are major influences on health. Therefore, the demand–control model [10], effort–reward imbalance model [11] and work–family conflicts model [12] have been widely used in occupational health research. The demand–control model posits that the negative health outcomes, such as fatigue, depression, and other physical illnesses, result from the situations in which one’s control over one’s work is low and the psychological demands imposed by one’s work are high [10]. The effort–reward imbalance model conceptualizes that the experience of a lack of reciprocity in terms of high costs and low gains elicits negative emotions in exposed people [11]. Feelings of not being appreciated in an adequate way or of being treated unfairly and disappointments resulting from inappropriate rewards are paralleled by sustained strain reactions in the autonomic nervous system [11]. Work to family conflict occurs when efforts to fulfill the demands of the employee role interfere with the ability to fulfill the demands of the roles as a spouse, parent or care provider [12]. Conversely, family to work conflict may be an obstacle to successfully meeting work-related demands and responsibilities, thereby undermining a person’s ability to construct and maintain a positive work-related self-image [12]. Epidemiological studies have found that job strain or work stress and work–family conflicts are strongly associated with major depression [13–17]. Effort–reward imbalance has been found to be associated with depressive symptoms [18–20].

Several studies used both the demand–control model and the effort–reward balance model to assess the impacts of work environmental factors on workers’ mental health. The results from these studies are not consistent. A cross-sectional study [21] of working men and women aged 45–64 years, randomly selected from population registers in Novosibirsk (Russia), Krakow (Poland) and Karvina-Havirov (Czech Republic) found that effort–reward ratio was strongly related to depression scores measured by the Center for Epidemiological Studies Depression Scale [22]. Job control was inversely associated with depression score in Poland and the Czech Republic (not in Russia), but the association was largely eliminated by controlling for socioeconomic characteristics [21]. A stronger association between effort–reward imbalance and depressive symptoms than that with job strain was also reported in studies involving Japanese [23], Dutch employees [24] and German populations [18, 19].

Theoretically, the demand–control and effort–reward models lead to different types of action. On the other hand, workers’ mental health is not only related to the characteristics of the work environments, but also to the family with whom they live and the society within which they are embedded. To this extent, the work–family conflict model defines a link between work and family/personal lives. Conceptually, there are similarities between the demand–control and the effort–reward imbalance model. They both represent general models of work stress with a selective analytical focus. However, the two models are different from each other in that the demand–control model has been measured as a concept that is restricted to the structural aspects of the psychosocial work environment, whereas the effort–reward imbalance includes both structural and personal characteristics [11]. Given that it is possible that the demand–control model interacts with the effort–reward model in relation to the risk of depression. As the work–family conflicts model serves as a link between work and family/personal lives, it is also possible that the work–family conflict and the psychosocial factors in the workplaces interact with each other to affect employees’ mental health. However, the work/family conflicts model has not been compared with the demand–control model and the effort–reward balance model. There has not been a study examining the inter-relationships among the three models and how these three models interact with each other in relation to the risk of mental health problems and such studies can contribute to not only academic research, but also redesigning organizational policies and primary prevention.

The objectives of this study were to (1) estimate the current prevalence of major depression in a sample of working population and (2) examine the associations between job strain, effort–reward imbalance and family–work conflicts and major depression.

## Methods

The current analysis used data from the baseline survey of an ongoing longitudinal cohort. In January 2008, we started building a longitudinal cohort of working population in the province of Alberta. The goal of the longitudinal study was to examine and compare the three job stress models (demand–control, effort–reward imbalance and work–family conflict) in relation to the risk of depressive and anxiety disorders. The target population includes employees who were between 25 and 65 years and who were residing or working in Alberta at the time of baseline survey. The baseline survey involved two stages. The first stage involved sampling, recruitment and screening for depressive and anxiety disorders. At the second stage,

participants who were screened positive for depressive and anxiety disorders were selected for in-depth psychiatric interviews.

### Participant recruitment

Sampling, recruitment and screening were conducted by interviewers of the Survey Unit, Calgary Health Region, Alberta Health Services. Data were collected using the method of computer-assisted telephone interview. A listing of provincial residential telephone numbers is maintained and updated by the survey unit. The survey unit subscribes to a frequently updated database of listed Alberta telephone numbers. For this study, a simple random sample of these numbers was initially selected. Rather than adopting a traditional random digit dialing technique, such as the Mitosfsky–Waksberg approach, which requires clustering [25], numbers were generated by single digit substitution (i.e. replacing the last digit of a listed telephone number with a randomly generated one). This ensured inclusion of unlisted numbers in the sample while maximizing the probability of reaching households.

When a household was reached, the interviewer asked the number of people in the household who were working and who were between the ages of 25 and 65 years. If there was more than one person in the household who were potentially eligible, the “last birthday” method was used to randomly select a single subject from the household. The household contact was asked to retrieve, or provide contact information (e.g. a first name) of the household resident who had most recently had a birthday [26].

Once an eligible participant in the household was identified, the interviewer invited this eligible participant to take part in the study. Before each interview, the eligible participant was explained the purpose and the procedures of the study. In addition, the potential participant was informed that this was the baseline of a longitudinal study and some might be selected for an in-depth mental health interview as part of the baseline study. Based on the information provided by the interviewer, if the person agreed to participate in follow-up interviews and provide contact information, she/he was included in the cohort and was administered questions about demographic and socioeconomic characteristics, work environment, screening questions for depressive and anxiety disorders and an assessment scale for depression—Patient Health Questionnaire (PHQ-9) [27]. Ethics approval for this study was obtained from the Conjoint Health Research Ethics Board of the University of Calgary.

During the sampling, 81,240 calls were made. The calls reached 9,776 potential participants. Refusals were fairly common because we required that they should agree to

participate in two annual follow-up interviews and provide primary (at least 2 of the followings: name, mailing address, work phone number and email) and secondary contact information. Detailed call decomposition can be found in previous publication [28]. Among those who were eligible by age and working status, 5,456 refused to participate and 40 completed the baseline interview partially. There were 4,302 individuals who completed the baseline screening interviews. The response rate at the individual level was 44%.

### Work environment factors

Work environment was assessed by the full version of the Job Content Questionnaire (JCQ) [29], the effort–reward imbalance questionnaire (JCQ) [11] and the eight-item work–family conflict (WFC) scale [30]. These instruments were administered in all participants in the baseline, irrespective of the screening results.

We used the JCQ [29] to assess work stress in five dimensions, namely skill discretion (6 items), decision authority (3 items), psychological demand (5 items), job insecurity (3 items) and supervisor/co-work social support (8 items). For each question, one of four answers was possible, strongly disagree, disagree, agree and strongly agree. Each answer was scored 1 (strongly disagree) to 4 (strongly agree). Reversed coding for some items was employed. The dimensional scores were calculated using the formula provided in the JCQ manual [29]. High-dimensional scores mean high skill discretion, high decision authority, high psychological demand, high job insecurity and high social support. In this study, the alpha value for the 5 subscales was 0.72, 0.71, 0.67, 0.52 and 0.85, respectively. The JCQ has been extensively used in studies worldwide. Using the scores of psychological demand, skill discretion and decision authority, we created a job strain ratio variable as  $\text{job strain ratio} = \frac{\text{psychological demand}}{[(\text{skill discretion} + \text{decision authority})/2]}$ . The job strain ratio is calculated in the way that is consistent with that of Statistics Canada [31]. A job strain ratio of 1 means balance between psychological demand and decision control; a job strain ratio greater than 1 means psychological demand is greater than decision control.

The ERI questionnaire used in our study focused on two elements: perceived effort (5 items) and rewards (11 items). The imbalance between effort and reward is determined by a ratio according to the formula:  $e/(r \times c)$  where “*e*” is the sum score of the effort scale, “*r*” is the sum score of the reward scale and “*c*” defines a correction factor for different number of items in the denominator and numerator [11]. The correction factor is 0.454545 as the numerator contains five items. A higher ERI ratio score indicates a

higher level of effort–reward imbalance. In the analysis, the cutoff for the ERI ratio was one, e.g., one or less versus greater than one. In this study, the  $\alpha$  values of the effort and rewards scales were 0.79 and 0.80.

The WFC questionnaire has separate scales for work to family conflict and family to work conflict [30]. Each contains four questions. Each question assesses potential conflict based on a possible answer of “not at all”, “to some extent” and “a great deal”. Each subscale had a possible summary score ranging from 4 to 12. The alpha values of the two subscales were 0.56 and 0.73, respectively.

### Depression

Depression was measured using the PHQ-9. The PHQ-9 is a self-report instrument deriving from the PRIME-MD diagnostic instrument for common mental disorders. The PHQ-9 is the depression module, which scores each of the 9 DSM-IV criteria as “0” (not at all) to “3” (nearly every day) [27]. A PHQ-9 score  $\geq 10$  had a sensitivity of 88% and a specificity of 88% for major depression [27]. The PHQ can also be interpreted using a cut-point applied to the symptom severity score. PHQ-9 scores of 5, 10, 15 and 20 represented mild, moderate, moderately severe and severe depression. The PHQ-9 can be scored either as a depression severity rating (the sum of 9-item scores each assigned a value of 0–3, for a range of possible scores of 0–27) or with an algorithm based on the DSM-IV definition [27]. This algorithm requires that one or both of depressed mood or loss of interest be endorsed at the “most days” level and that a total of five items be scored at this level. One exception is that a suicidal ideation item can be counted toward the required five symptoms even if it is only endorsed at the “several days” level. In this analysis, we presented both severity scores with cut points and major depressive episode based on the DSM-IV definition. The alpha value of the PHQ-9 was 0.83 in this study.

### Demographic and socioeconomic variables

The variables included gender, age (continuous variable), marital status (married/common-law/partnership, single/never married, separated/divorced/widowed), educational levels (less than high school, high school and college, university), personal annual income (<\$30,000, \$30,000–\$59,999, \$60,000–\$79,999, \$80,000 and more (all currency values are in Canadian dollars), and job gradient (ordinary worker, supervisor, manager/executive).

### Statistical analysis

The distribution of PHQ-9 scores by severity cut offs was described. The prevalence of major depression based on

PHQ-9 as defined by the DSM-IV algorithm was estimated. To fully use the information from the PHQ-9 scores, we examined the relations between work environmental factors and depression using linear regression modeling. Preliminary analysis showed that the distribution of the PHQ-9 scores was skewed (Kurtosis statistics 7.5). The PHQ-9 scores were then square root transformed. The distribution of the transformed PHQ-9 scores was approximately normal (Kurtosis statistics 2.5). The square root transformed PHQ-9 was used as dependent variable in the linear regression modeling. We first examined the associations between job strain, effort–reward imbalance, work–family conflict (continuous variable) and depression scores, controlling for the effects of gender and age.

Effect modifications between sociodemographic variables and the work environmental factors in relation to depression scores were examined. Because sampling weights were used in the modeling and estimations, likelihood ratio tests could not be performed to determine the significance of effect modifications. In this analysis, we determined the presence of an effect modification by the significance level ( $p$  value) of the product term in the model. We also examined whether the work environmental factors interacted with each other in relation to depression scores. If a significant interaction was found, stratum-specific associations were presented by the levels of the effect modifier, adjusting for the effects of demographics and socioeconomic variables in the models. The analyses were repeated using logistic regression modeling with major depression defined by DSM-IV algorithm as the dependent variable.

For the baseline participants, sampling weights were developed, accounting for the effects of number of telephone lines in the household and gender-age distributions in Albertans who were working and who were between the ages of 25 and 65 years based on the 2006 census data collected by Statistics Canada. These sampling weights were used in proportion estimations and regression modeling. The analysis was conducted using STATA 10.0 [32].

## Results

The demographic and socioeconomic characteristics and perceived work environment of the participants are presented in Table 1. The distribution of PHQ-9 scores according to the severity levels is as follows: minimal (0–4), 74.7%; mild (5–9), 17.2%; moderate (10–14) 5.4%; moderately severe (15–19) 1.9%; severe (20–27), 0.8%. With application of the standard PHQ scoring algorithm, the prevalence of major depressive episode in the past 2 weeks was 3.2%.

Adjusting for the effects of gender and age, perceived job strain ( $\beta = 0.56$ ,  $SE = 0.04$ ), effort–reward imbalance

**Table 1** The demographic and socioeconomic characteristics and perceived work environment of the baseline participants who were working at the time of survey ( $n = 4,302$ )

Variables	$n$ (weighted %)
Men	1,930 (53.7)
Women	2,372 (46.3)
25–34 years	831 (26.8)
35–44 years	1,154 (29.2)
45–54 years	1,525 (29.0)
55–65 years	792 (15.0)
Married/common-law/partner	3,101 (72.7)
Single/never married	578 (15.0)
Divorced/separated/widowed	619 (12.3)
Less than high school	252 (5.9)
High school/college	2,633 (60.5)
University or higher	1,412 (33.6)
Personal annual income	
<\$30,000	504 (11.4)
\$30,000–\$59,999	1,435 (34.5)
\$60,000–\$79,999	858 (21.7)
\$80,000 and more	1,246 (32.4)
Ordinary worker	2,705 (63.1)
Supervisor	751 (18.3)
Manager/executive	795 (18.6)
Job strain ratio >1	1,037 (23.4)
Job strain ratio $\leq$ 1	3,153 (76.6)
Effort–reward ratio >1	517 (11.2)
Effort–reward ratio $\leq$ 1	3,739 (88.8)
Work to family conflict	4,264 (mean = 6.8, SE = 0.03)
Family to work conflict	4,265 (mean = 6.4, SE = 0.03)

( $\beta = 0.40$ , SE = 0.06), work to family conflict ( $\beta = 0.22$ , SE = 0.01) and family to work conflict ( $\beta = 0.19$ , SE = 0.01) were positively associated with square root-transformed PHQ-9 depression scores in linear regression models.

We found significant effect modifications by gender and family to work conflict ( $p = 0.007$ ), gender and effort–reward imbalance ( $p = 0.02$ ), job strain and work to family conflict ( $p = 0.03$ ), and job strain and effort–reward imbalance ( $p = 0.009$ ) in the models with square root-transformed PHQ-9 scores. As such, linear regression modeling was conducted by gender and by levels of job strain ratio. Because work to family conflict and family to work conflict were strongly correlated (correlation = 0.42), they were not included in the same model.

It was found that effort–reward imbalance was significantly associated with depression scores in women, but not in men (Table 2). The association between family to work conflict and depression was stronger in men than in

women. Effort–reward imbalance was significantly associated with depression scores only in participants who reported a job strain ratio greater than 1 (Table 3). The association between work to family conflict and depression was stronger in participants with a job strain ratio >1 than in those whose job strain ratio was one or less.

Logistic regression models were carried out to examine the associations between the selected variables and major depression defined by the DSM algorithm. Participants who reported job strain (OR = 4.04, 95% CI 2.81, 5.82), effort–reward imbalance (OR = 3.20, 95% CI 2.17, 4.73), work to family conflict (OR = 1.50, 95% CI 1.35, 1.66) and family to work conflict (OR = 1.35, 95% CI 1.23, 1.49) were more likely to have had major depression. Participants who reported more supervisor/co-worker social support were less likely to have had major depression (OR = 0.84, 95% CI 0.80, 0.89). These variables were included in separate models, controlling for the effects of gender and age.

No interactions were found in logistic regression modeling with major depression as dependent variable. Therefore, the work environmental variables were included in one model, except that work to family conflict and family to work conflict were in separate models (Table 4), controlling for the effects of gender, age, marital status and personal annual income. Job strain, effort–reward imbalance, work to family conflict and family to work conflict were found to be significantly associated with major depression. Including supervisor/co-worker social support in the models did not significantly change the associations.

## Discussion

To our knowledge, this was the first population-based study examining the relations between three job-related stress models, depression severity and major depression. The data showed that job strain, effort–reward imbalance and work–family conflict were strongly associated with severity of depression and having a major depressive disorder. It was not obvious which factor was a stronger factor than others as reflected by the regression coefficients and odds ratios. In linear regression with the PHQ score as outcome variable, the coefficients related to work–family conflict were smaller than others. It should be noted that work–family conflict was analyzed as continuous variables, whereas job strain and effort–reward imbalance were categorical variables in the models. The associations between effort–reward imbalance, work–family conflicts and depression scores differed by gender and by perceived job strain. However, the effect modifications with gender and job strain were not found in logistic regression models with major depressive disorder as dependent variable.

**Table 2** Results of multivariate linear regression modeling with PHQ-9 scores as outcome variable, by gender

Variables	Men		Women	
	$\beta$ (SE) ( <i>n</i> = 1,782)	$\beta$ (SE) ( <i>n</i> = 1,776)	$\beta$ (SE) ( <i>n</i> = 2,101)	$\beta$ (SE) ( <i>n</i> = 2,104)
Age	0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
Non-married	0.28 (0.05)*	0.25 (0.05)*	0.19 (0.03)*	0.14 (0.03)*
Low educational level	0.12 (0.04)*	0.07 (0.04)	0.22 (0.05)*	0.22 (0.05)*
High personal income	−0.14 (0.03)*	−0.19 (0.03)*	−0.03 (0.02)	−0.11 (0.03)*
Job strain	0.40 (0.08)*	0.28 (0.07)*	0.40 (0.06)*	0.27 (0.06)*
Effort–reward imbalance	0.09 (0.10)	0.05 (0.09)	0.43 (0.08)*	0.32 (0.08)*
Family to work conflict	0.23 (0.01)*		0.19 (0.01)*	
Work to family conflict		0.25 (0.01)*		0.24 (0.01)*

\*  $p < 0.001$ 

Marital status was in three groups: married/common-law/partner (reference group), single/never married, divorced/separated/widowed

Income was in four groups: &lt;\$30,000 (reference group), \$30,000–\$59,999, \$60,000–\$79,999, \$80,000 and more

**Table 3** Results of multivariate linear regression modeling with PHQ-9 depression scores as outcome variable, by job strain

Variables	Job strain >1		Job strain ≤1	
	$\beta$ (SE) ( <i>n</i> = 947)	$\beta$ (SE) ( <i>n</i> = 944)	$\beta$ (SE) ( <i>n</i> = 2,933)	$\beta$ (SE) ( <i>n</i> = 2,939)
Women	0.07 (0.08)	0.04 (0.08)	0.11 (0.04)*	0.03 (0.04)
Age	−0.00 (0.00)	0.00 (0.00)	−0.00 (0.00)	−0.00 (0.00)
Unmarried	0.16 (0.05)*	0.21 (0.05)**	0.21 (0.03)**	0.24 (0.03)**
Low educational level	0.10 (0.07)	0.17 (0.07)	0.13 (0.04)**	0.15 (0.04)**
High personal income	−0.20 (0.04)**	−0.07 (0.04)	−0.13 (0.02)**	−0.09 (0.02)**
Effort–reward imbalance	0.30 (0.11)*	0.51 (0.12)**	0.11 (0.07)	0.13 (0.07)
Work to family conflict	0.30 (0.02)**		0.23 (0.01)**	
Family to work conflict		0.23 (0.02)**		0.21 (0.01)**

Marital status was in three groups: married/common-law/partner (reference group), single/never married, divorced/separated/widowed

Income was in four groups: &lt;\$30,000 (reference group), \$30,000–\$59,999, \$60,000–\$79,999, \$80,000 and more

\*  $p < 0.01$ , \*\*  $p < 0.001$ 

In comparison with the results of previous research, the current prevalence of major depression of this study (3.2%) resembled that (3.3%) of a study using the same instrument and random digit dialing method in a general population sample from the same province [33] and was comparable with the that (3.8%) of a German general population sample [34]. With respect to the associations between perceived job strain, effort–reward imbalance, work–family conflicts and depression, the results of this study differed from previous research that effort–reward imbalance is a stronger risk factor than job strain for depression [18, 23, 24]. The reasons for the discrepancy may be that the instrument for depression and the analytic approaches are different. These studies [18, 23, 24] used the Center for Epidemiological Studies Depression scale [22] and defined depression by a cut off. In our study, we analyzed the PHQ-9 depression severity scores using linear regression

modeling, without applying for a cut-off point. We defined major depression using a scoring algorithm based on the DSM-IV criteria.

Work and family conflicts were positively associated with depression score, irrespective of gender. This is consistent with the previous studies [16, 35]. However, our data showed that effort–reward imbalance was associated with major depression; effort–reward imbalance was associated with depression score only in women; linear regression results showed that family–work conflict appeared to have more negative effect on men than on women. The gender differences were not reported by previous studies. We considered that the interactions by gender were possible. Although in recent years, men have been more likely to be involved in family responsibilities than before, career achievement and work performance are still highly valued by men. Therefore, when family role

**Table 4** Results of multivariate logistic regression model

Variables	Major depression Odds ratio (95% CI) ( <i>n</i> = 3,887)	Major depression Odds ratio (95% CI) ( <i>n</i> = 3,885)
Women	0.92 (0.58, 1.45)	1.13 (0.72, 1.76)
Age	1.00 (0.98, 1.02)	1.00 (0.98, 1.02)
Unmarried	1.55 (1.24, 1.93)	1.50 (1.20, 1.89)
Low educational level	1.60 (1.08, 2.36)	1.59 (1.07, 2.36)
High personal income	0.71 (0.57, 0.88)	0.65 (0.51, 0.81)
Job strain	2.91 (1.97, 4.31)	2.25 (1.51, 3.34)
Effort–reward imbalance	2.78 (1.81, 4.25)	2.26 (1.47, 3.46)
Family to work conflict	1.34 (1.21, 1.48)	
Work to family conflict		1.45 (1.29, 1.63)

Marital status was in three groups: married/common-law/partner (reference group), single/never married, divorced/separated/widowed  
Income was in four groups: <\$30,000 (reference group), \$30,000–\$59,999, \$60,000–\$79,999, \$80,000 and more

interferes with work, or work interferes with family role, men may be more likely to become depressed than women, despite that family to work conflict was positively associated with depression scores in both men and women. With our data, it was not entirely clear why effort–reward imbalance affected women more than men in depression scores, but was associated with major depression in multivariate logistic regression models. In our additional analysis, we found that effort–reward imbalance was associated with major depression in women in multivariate logistic regression model, but not in men. Although the odds ratio in men was close to 2, the 95% confidence interval was very wide, which could be related to a small number of cases of major depression in men. The PHQ-9 scores in the linear regression were square root transformed. Because of less major depression cases in men than in women, there was no difference in the distribution of the transformed PHQ-9 scores by levels of effort–reward imbalance in men, whereas the difference existed in women. This may partly contribute to the gender difference in the relationship between effort–reward imbalance and the depression scores. We could not compare the results with the previous studies. If this can be replicated by future studies, some qualitative investigations may be needed to understand the underlying process by which effort–reward imbalance affects men and women differently.

The results indicated that there are interactions among workplace psychosocial factors and between psychosocial factors inside and outside of workplace in relation to depression severity. The inter-relations among psychosocial factors inside and outside the workplace for depression are complex. If job demand exceeds one's ability of control, it is reasonable to believe that it will lead to work to

family conflict and in the situation of perceived effort–reward imbalance and the level of distress will increase. Therefore, improving the work environment and reducing perceived job strain may not only directly reduce the risk of depression, but also attenuate the impacts of effort–reward imbalance and work to family conflict on depression.

Psychosocial factors inside of workplace may also interact with each other in relation to depression severity as reflected by the significant effect modification between job strain and effort–reward imbalance. Previous studies have found that both job strain and effort–reward imbalance are risk factors for depression. The effect modification observed in this study suggests that when employees expose to both factors, a synergistic effect may be generated to increase the severity of depression. As the effort–reward model is relatively new, there has not been much research about the jobs characterized by high job strain and high imbalance. Our additional analysis found that the characteristic of high job strain and high imbalance did not differ by job grade or job types (full time, part time). There was an indication that such characteristics may vary by industrial sectors. However, we could not make meaningful comparisons between industrial sectors because the number of participants who reported both high job strain ratio and high effort–reward imbalance ratio was small.

Effect modifications were not found in the associations with normally defined major depression. This may be because participants with major depression represented more severe cases of depression. It is also possible that gender and workplace psychosocial factors may only interact with each other to increase the severity of symptom levels, but not directly to the clinical level. This needs to be confirmed by longitudinal studies. Nevertheless, the development of major depression is a process often starting initially with minimal symptoms and progressing to a severe clinical case. If effect modifications among workplace psychosocial factors in relation to the severity of depression exist, reducing perceived job strain may slow or arrest the progression from minimal depressive symptoms to a more severe level. In long-term, this may lead to a lowered prevalence of major depression in the working population.

The strong associations between the three models and major depression defined by the DSM algorithm were expected and were consistent with the previous studies [13–17, 35]. Given the strong associations and the potential interactions between psychosocial factors inside and outside of workplace, improving work environment may potentially reduce the synergistic effects among these risk factors and eventually reduce the prevalence and incidence of mental disorders in this population [17]. However, the gender differences in the associations observed in this study should be considered in designing interventions.

This study had several limitations. The baseline data were cross-sectional in nature. One cannot therefore make causal inferences. For example, depressive symptoms include more negative perceptions of one's environment and future. Hence, it is possible that depression was influencing workplace ratings rather than, or in addition to, an effect of the work environment on depression. The data were based on the self-report. Thus, recall and reporting biases were possible. Because the sampling and recruitment of participants were to build a longitudinal cohort, only those who agreed to participate in follow-up interviews in the coming years and in in-depth psychiatric interviews were screened and included in the baseline. As such, the baseline response rate at the individual level was relatively low. A low response rate is often associated with selection bias in cross-sectional studies. However, the sample was standardized by the gender-age distribution of the working population in the same age range of the province and by number of telephone lines in the household. The prevalence of major depression observed in this population was comparable with the previous studies and the direction and magnitude of association between perceived job strain and major depression resembled to those of previous research [36]. Therefore, selection bias may not have a significant impact on the results of this study.

The models of demand–control, effort–reward imbalance and work–family conflicts are widely used in occupational health research. Some may perceive that one particular model is superior to the other in predicting health outcomes. Data from this population-based study indicate that they are equally important in their relations to depression. Moreover, there may be effect modifications among stressors inside and outside of the workplaces in relation to the risk of depression. Improving work environment based on these models holds potentials to reduce the synergetic effects, therefore, improving employees' mental health.

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