



## Original Contribution

# Effects of Externally Rated Job Demand and Control on Depression Diagnosis Claims in an Industrial Cohort

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This study examined whether externally rated job demand and control were associated with depression diagnosis claims in a heavy industrial cohort. The retrospective cohort sample consisted of 7,566 hourly workers aged 18–64 years who were actively employed at 11 US plants between January 1, 1996, and December 31, 2003, and free of depression diagnosis claims during an initial 2-year run-in period. Logistic regression analysis was used to model the effect of tertiles of demand and control exposure on depression diagnosis claims. Demand had a significant positive association with depression diagnosis claims in bivariate models and models adjusted for demographic (age, gender, race, education, job grade, tenure) and lifestyle (smoking status, body mass index, cholesterol level) variables (high demand odds ratio = 1.39, 95% confidence interval: 1.04, 1.86). Control was associated with greater risk of depression diagnosis at moderate levels in unadjusted models only (odds ratio = 1.47, 95% confidence interval: 1.12, 1.93), while low control, contrary to expectation, was not associated with depression. The effects of the externally rated demand exposure were lost with adjustment for location. This may reflect differences in measurement or classification of exposure, differences in depression diagnosis by location, or other location-specific factors.

depression; depressive disorder; mental health; occupational health; stress, psychological

Abbreviation: CI, confidence interval.

Global economic changes in the workplace, requiring employees to work harder and produce more, create a context in which psychosocial factors such as psychological demand and control potentially play an important role in the etiology of disease. Psychosocial factors at work are associated with a variety of diseases including depression (1–3). Depression is a leading source of disease burden internationally and of disability-adjusted life-years in high-income countries (4). Given this, a better understanding of the role of psychosocial factors in the development of depression could impact worker's disease burden.

Karasek's job strain model measures exposure to psychological work demands and decision latitude or control (2). Several studies find significant risk of depression with high demand (5–10) and low control (5, 7–11). In addition, combined levels of high demand and low control ("high strain")

are associated with depression risk (3, 10, 12–14). However, studies also find no significant effects for high demand, low control, or high strain (3, 6, 11, 15–22).

Limitations of prior work include few longitudinal cohort studies evaluating high strain exposure predicting major depressive disorder. Most studies use self-reported depressive symptoms (12, 16, 19, 23, 24) versus diagnosis or diagnostic interview to determine depression (3, 14, 25). Physician diagnosis involves an individual's answering subjective symptom questions. However, diagnosis is made at the time of symptoms, allowing for prior knowledge of the individual and nonverbal observation in interpretation of answers. In addition, serious penalty occurs with submission of inaccurate insurance claims. The tendency to report negative affect and distress is a difficulty with self-report, particularly if exposure is subjectively assessed. Interpretation of results

may not be straightforward, particularly with focus on a mental health outcome (26).

Formulating psychosocial stressors based on subjective perception does not fully measure workplace context. If aspects of exposure are not mediated by subjective perception, then objective assessment of demand and control may enhance understanding of the effects of work on health. Comparison of subjective and objective control ratings in the Whitehall II study found only moderate correlation ( $r = 0.41$ ) between ratings (27). However, this study also found that subjective and objective ratings of psychosocial factors similarly predicted cardiovascular disease risk (27). It is possible that subjective perceptions are proxy for other unmeasured aspects of the individual independent of the objective environment. Thus, use of objective ratings is a different approach, but interpretation must include awareness that the 2 kinds of measures may not be equivalent. A job exposure matrix with assignment of exposure by job title alone is another way to identify external or objective ratings. Use of national data on broad groupings of jobs (28–37) is less sensitive than the ratings specific to job, department, and location used in this study.

A focus on the individual using subjective perception of exposure promotes individual intervention versus work culture or organizational context intervention. Equivalent in the realm of physical exposure would be intervention only in workers vulnerable to disease associated with a chemical or physical exposure. Focus only on workers responding poorly to exposure does not encourage healthful change for all employees, as in the elimination of hazardous exposures for all. Hazardous physical exposures are removed for all. Why should psychosocial exposures be different?

The unique aspects of this study include use of physician diagnosis of depressive disorder versus self-reported responses to questionnaire. In addition, objective assessment of psychosocial exposure in the workplace is utilized. Finally, little is known of the effect of psychosocial factors in heavy industrial settings, the focus of this study.

The objective of this study is to evaluate the effect of externally rated psychological demand and control on the incidence of depression diagnosis. It uses a retrospective cohort design to evaluate risk of depression diagnosis from administrative health claims.

## MATERIALS AND METHODS

The study sample consists of workers at a large US aluminum manufacturer, made possible due to an ongoing collaboration between this manufacturer and a university Occupational Medicine Program. Studies ongoing in the population relate to chronic diseases, injury, hearing, and disability (38–47), as well as exposures including personal risk factors and physical and chemical hazards. An array of administrative and health-related claims data have been obtained and linked. The study uses a historical cohort design with information from both administrative (human resources, occupational health, industrial hygiene) sources and personal health insurance claims data from 1996 to 2003.

To participate, individuals were required to be hourly workers aged 18–64 years with 2 years of employment, health benefit enrollment, and psychological demand and control exposure ratings available ( $n = 8,257$  workers from 11 US plants). Of these, 7,867 (95.3%) were active workers between 1996 and 2003 and eligible for study inclusion. A 2-year run-in period (1996–1998) was used to determine prevalent depression diagnosis claims by using one or more health insurance claims for depression (*International Classification of Diseases*, Ninth Revision, codes 296, 309, and 311) from face-to-face physician office visits to exclude 301 individuals, leaving a cohort of 7,566 depression-free workers for follow-up from 1998 to 2003, with a median length of follow-up of 4.7 years (interquartile range, 2.3–6.0 years). During the study period, 72% of the sample remained employed, while 28% left employment (mean length of follow-up, 2.7 years) and were censored from the analysis at that time. In those leaving employment, there was no significant difference in demand exposure. Significant differences were found in factors reducing depression risk including holding a job of higher control, male, older, African-American race, and higher job grade. Thus, it is unlikely that leaving employment caused underestimation of depression diagnosis risk.

Objective ratings of physical and psychosocial job demands using a pilot job demand survey were provided by a safety and hygiene manager at each location familiar with each job and department in each of 11 plant locations after standardized group training for survey completion by one author (L. C.). Psychological demand and decision latitude (control), as defined in the Job Demand-Control Model (48), were measured by items previously used in the Whitehall II study (49). Ratings were available for all participants from scoring of job titles in each department at each location. Ratings were identified on a 12-point scale ranging from often to never. Three questions measured psychological demands (the frequency of working fast, without error, with conflicting demands) and 2 questions measured control (the frequency of having a say in how or when the job is done). The preface to questions instructed raters to answer questions according to what the specific job requires. A single safety and hygiene manager at each location received the complete list of job titles by department, ranging from 24 to 81 jobs per location.

Individual items were added to yield a composite index, and demand ranged from 3 to 36 and control from 2 to 24. Tertiles were used to code demand and control as high, moderate, or low. Interaction terms were constructed likewise by tertiles. Tertiles for categorization were chosen on the basis of prior use in several studies (5, 6, 7, 18, 50–52) and a desire to model effects in a way similar to the Whitehall II studies. The actual distribution of control exposure to outcome had an inverted “U” distribution with moderate levels of control predicting depression in bivariate analysis. Dichotomizing exposure would have resulted in a loss of information.

Data on depression diagnosis claims were available from health insurance claims files based on diagnosis from an individual’s personal physician. Individuals from the depression-free cohort with 2 or more health claims

diagnoses of depression based on face-to-face clinical encounters (*International Classification of Diseases*, Ninth Revision, diagnosis code 296 (major depressive disorder), 309 (adjustment disorder with depression), or 311 (depressive disorder)) during the study period 1998–2003 were considered cases of depression. The 2 diagnoses were required from 2 different claims dates to ensure that the initial diagnosis was definitive.

Human resource databases supplied information on most covariates used in the analysis, including age, gender, race, income, tenure, job grade, and job location. Information from occupational health records included education, smoking history, body mass index, and cholesterol level abstracted in 2003 from plant medical records. The only variables with missing data were education (53.5% available), smoking history (50.8%), body mass index (56.5%), and cholesterol level (40.4%). Data were not available in some sites, while other sites had consistent processes of data collection. Given the large numbers that would have been excluded in the analysis, these variables were coded with a category for missing.

### Ethical approval

Approval for the study was obtained from the corresponding author's institutional review board. Information from the databases used in the analysis was deidentified to protect the privacy of participants.

### Statistical analyses

Covariates were evaluated for bivariate associations with the exposure and outcome variables by using chi-squares and *t* tests. Bivariate and multivariate logistic regression analyses were performed to evaluate the relation between demand and control exposure and depression diagnosis. Models were adjusted for demographic- and work-related factors, as well as for lifestyle factors. Initial models included income and job grade; however, because of evidence of collinearity, income was removed, resolving collinearity issues. Models were evaluated by using the change in  $-2$  log likelihood and *P* values of individual covariates to determine their significance to the model. A final adjustment was completed for plant-based location. Analyses were also completed by using Cox proportional hazards regression. Sensitivity analyses were completed to better understand the effect of location and missing data on the analysis. All statistical tests were 2 sided. All analyses were undertaken using SAS software (SAS Institute, Inc., Cary, North Carolina).

## RESULTS

Characteristics of the “depression-free” cohort (i.e., those without a single claim during their 2-year run-in period) are shown in Table 1. Most of the sample consisted of Caucasian males with at least a high school education; 451 women and 597 African Americans were included. The average age and tenure were high, exemplifying low turnover in this sample.

During the study period between January 1, 1998, and December 31, 2003, 4.6% of the workers ( $n = 349$ ) were diagnosed with depression on the basis of 2 or more face-to-face clinical claims. Expected associations of depression diagnosis were found with gender, race, and age (Table 2). Women had 2.6 times the risk for depression diagnosis versus men (95% confidence interval (CI): 1.9, 3.7). Caucasians had 2.5 times the risk for depression diagnosis versus African Americans (95% CI: 1.4, 4.7). Workers with depression were younger, 42.8 years versus 46.4 years, than those without depression diagnosis ( $P < 0.0001$ ). Mean tenure, income, and job grade were lower in those with depression diagnosis. Although, generally, depression diagnosis was inversely related to tenure, those newest to employment at the study start had the lowest rates of depression diagnosis. The incidence of depression diagnosis by plant location ranged from 3.1% to 4.2% for 7 of the 11 plant locations. There were significant differences in depression diagnosis by plant location, with 1 plant having an incidence of 1% and 3 plants having higher incidence ranging from 6.3% to 11.3%. Current smokers had a higher risk of depression diagnosis (odds ratio = 1.55, 95% CI: 1.13, 2.14), while body mass index and cholesterol did not show significant differences.

Information on regression results for depression diagnosis follows. Increasing demand consistently increased the risk of depression diagnosis in logistic regression models. Control was associated with greater risk of depression diagnosis at moderate levels; low control, contrary to expectation, was not associated with depression (Table 3). When the interaction term for demand and control is entered into the model, high demand and moderate control lose significance, while the combined terms for high demand–moderate control and moderate demand–moderate control are significant in the unadjusted model.

In multivariate logistic regression models, demographic and lifestyle variables had effects similar to those of bivariate models. Demand increased risk, as did moderate control, although moderate control lost significance with adjustment for demographic variables (Table 4). Adjustment for location resulted in loss of significance of high and moderate demand. Use of a mixed-effects model with random intercept by location provides results similar to those of logistic models with location adjusted as a fixed effect. Finally, Cox proportional hazard regression model results were similar to results of logistic regression models.

In models of the 9-level demand and control interaction term, the high demand–moderate control level was associated with greater depression risk (odds ratio = 2.14, 95% CI: 1.24, 3.69); with adjustment for demographic variables, significance was lost. A higher risk of depression in the interaction model appeared to be driven by high demand and moderate demand–moderate control whose estimates indicate elevated risk, although neither is significant.

## DISCUSSION

This study reveals that individuals with higher demand were significantly more depressed with a linear trend across

**Table 1.** Characteristics of a Depression-free US Heavy Industrial Worker Cohort by Demand and Control Exposure ( $n = 7,566$ ), 1998–2003

| Variable                            | Total<br>( $n = 7,566$ ) |      |              | Demand                      |      |              |                        |      |              | P<br>Value | Control                 |              |           |                             |                      |           | P<br>Value |                        |                   |                      |                   |                      |                      |
|-------------------------------------|--------------------------|------|--------------|-----------------------------|------|--------------|------------------------|------|--------------|------------|-------------------------|--------------|-----------|-----------------------------|----------------------|-----------|------------|------------------------|-------------------|----------------------|-------------------|----------------------|----------------------|
|                                     | High<br>( $n = 2,341$ )  |      |              | Moderate<br>( $n = 2,625$ ) |      |              | Low<br>( $n = 2,600$ ) |      |              |            | High<br>( $n = 2,125$ ) |              |           | Moderate<br>( $n = 2,678$ ) |                      |           |            | Low<br>( $n = 2,763$ ) |                   |                      |                   |                      |                      |
|                                     | No.                      | %    | Mean (SD)    | No.                         | %    | Mean (SD)    | No.                    | %    | Mean (SD)    |            | No.                     | %            | Mean (SD) | No.                         | %                    | Mean (SD) |            | No.                    | %                 | Mean (SD)            |                   |                      |                      |
| Gender                              |                          |      |              |                             |      |              |                        |      |              |            |                         |              |           |                             |                      |           |            |                        | 0.66 <sup>a</sup> | <0.0001 <sup>a</sup> |                   |                      |                      |
| Female                              | 451                      | 6.0  |              | 132                         | 5.6  |              | 164                    | 6.2  |              | 155        | 6.0                     |              | 77        | 3.6                         |                      | 176       | 6.6        |                        | 198               | 7.2                  |                   |                      |                      |
| Male                                | 7,115                    | 94.0 |              | 2,209                       | 94.4 |              | 2,461                  | 93.8 |              | 2,445      | 94.0                    |              | 2,048     | 96.4                        |                      | 2,502     | 93.4       |                        | 2,565             | 92.8                 |                   |                      |                      |
| Race                                |                          |      |              |                             |      |              |                        |      |              |            |                         |              |           |                             |                      |           |            |                        |                   | <0.0001 <sup>a</sup> |                   |                      |                      |
| African American                    | 597                      | 7.9  |              | 152                         | 6.5  |              | 213                    | 8.1  |              | 232        | 8.9                     |              | 216       | 10.2                        |                      | 156       | 5.8        |                        | 225               | 8.1                  |                   |                      |                      |
| Caucasian                           | 6,727                    | 88.9 |              | 2,142                       | 91.5 |              | 2,333                  | 88.9 |              | 2,252      | 86.6                    |              | 1,873     | 88.1                        |                      | 2,396     | 89.5       |                        | 2,458             | 89.0                 |                   |                      |                      |
| Hispanic                            | 187                      | 2.5  |              | 36                          | 1.5  |              | 53                     | 2.0  |              | 98         | 3.8                     |              | 26        | 1.2                         |                      | 97        | 3.6        |                        | 64                | 2.3                  |                   |                      |                      |
| Other                               | 55                       | 0.7  |              | 11                          | 0.5  |              | 26                     | 1.0  |              | 18         | 0.7                     |              | 10        | 0.47                        |                      | 29        | 1.1        |                        | 16                | 0.58                 |                   |                      |                      |
| Education <sup>b</sup>              |                          |      |              |                             |      |              |                        |      |              |            |                         |              |           |                             |                      |           |            |                        |                   | 0.05 <sup>a</sup>    | 0.29 <sup>a</sup> |                      |                      |
| College/postgraduate                | 957                      | 23.6 |              | 274                         | 25.3 |              | 333                    | 21.6 |              | 350        | 24.6                    |              | 206       | 22.3                        |                      | 356       | 23.1       |                        | 395               | 24.9                 |                   |                      |                      |
| Elementary/high school              | 3,093                    | 76.4 |              | 809                         | 74.7 |              | 1,210                  | 78.4 |              | 1,074      | 75.4                    |              | 716       | 77.7                        |                      | 1,185     | 76.9       |                        | 1,192             | 75.1                 |                   |                      |                      |
| Smoking <sup>b</sup>                |                          |      |              |                             |      |              |                        |      |              |            |                         |              |           |                             |                      |           |            |                        |                   |                      | 0.04 <sup>a</sup> | <0.0001 <sup>a</sup> |                      |
| Current                             | 1,239                    | 32.2 |              | 382                         | 34.2 |              | 460                    | 31.2 |              | 397        | 31.7                    |              | 293       | 32.6                        |                      | 511       | 33.7       |                        | 435               | 30.4                 |                   |                      |                      |
| Former                              | 1,028                    | 26.7 |              | 267                         | 23.9 |              | 431                    | 29.2 |              | 330        | 26.3                    |              | 282       | 31.4                        |                      | 397       | 26.2       |                        | 349               | 24.4                 |                   |                      |                      |
| Never                               | 1,577                    | 41.0 |              | 467                         | 41.9 |              | 583                    | 39.6 |              | 527        | 42.0                    |              | 324       | 36.0                        |                      | 608       | 40.1       |                        | 645               | 45.1                 |                   |                      |                      |
| Demand <sup>c</sup>                 |                          |      | 22.1 (5.7)   |                             |      |              |                        |      |              |            |                         |              |           |                             | 24.0 (5.5)           |           |            | 21.6 (5.8)             |                   |                      | 21.1 (5.5)        | <0.0001 <sup>d</sup> |                      |
| Control <sup>c</sup>                |                          |      | 10.9 (5.2)   |                             |      | 12.1 (5.4)   |                        |      | 11.1 (5.0)   |            |                         | 9.6 (4.8)    |           |                             | <0.0001 <sup>d</sup> |           |            |                        |                   |                      |                   |                      |                      |
| Age, years                          |                          |      | 46.2 (9.5)   |                             |      | 45.2 (10.1)  |                        |      | 48.2 (8.4)   |            |                         | 45.1 (9.8)   |           |                             | <0.0001 <sup>d</sup> |           |            | 49.0 (8.1)             |                   |                      | 46.8 (9.3)        | 43.6 (10.1)          | <0.0001 <sup>d</sup> |
| Tenure, years                       |                          |      | 17.5 (11.2)  |                             |      | 15.8 (11.7)  |                        |      | 20.7 (9.8)   |            |                         | 15.9 (11.3)  |           |                             | <0.0001 <sup>d</sup> |           |            | 19.8 (10.7)            |                   |                      | 18.2 (11.2)       | 15.2 (11.1)          | <0.0001 <sup>d</sup> |
| Income, dollars                     |                          |      | 30,092       |                             |      | 30,503       |                        |      | 30,136       |            |                         | 29,678       |           |                             | <0.0001 <sup>d</sup> |           |            | 31,079                 |                   |                      | 30,097            | 29,329               | <0.0001 <sup>d</sup> |
| Job grade                           |                          |      | 18.0 (9.0)   |                             |      | 18.7 (10.8)  |                        |      | 19.0 (7.5)   |            |                         | 16.5 (8.3)   |           |                             | <0.0001 <sup>d</sup> |           |            | 21.9 (8.4)             |                   |                      | 18.8 (9.8)        | 14.3 (6.8)           | <0.0001 <sup>d</sup> |
| Body mass index, kg/m <sup>2b</sup> |                          |      | 29.7 (5.2)   |                             |      | 29.2 (5.2)   |                        |      | 29.9 (5.2)   |            |                         | 29.9 (5.2)   |           |                             | 0.0001 <sup>d</sup>  |           |            | 29.8 (5.1)             |                   |                      | 29.5 (5.3)        | 29.8 (5.3)           | 0.19 <sup>d</sup>    |
| Cholesterol, mg/dL <sup>b</sup>     |                          |      | 201.9 (39.5) |                             |      | 200.8 (39.2) |                        |      | 203.1 (39.3) |            |                         | 201.5 (39.8) |           |                             | 0.43 <sup>d</sup>    |           |            | 204.7 (40.5)           |                   |                      | 200.4 (38.7)      | 202.0 (39.6)         | 0.10 <sup>d</sup>    |

Abbreviation: SD, standard deviation.

<sup>a</sup> P value for a chi-square test.<sup>b</sup> Education data ( $n = 4,050$ ); smoking data ( $n = 3,844$ ); body mass index data ( $n = 4,276$ ); cholesterol data ( $n = 3,053$ ).<sup>c</sup> Demand scale range, 3–36 (high); control scale range, 2–24 (high).<sup>d</sup> P value for an F test.

**Table 2.** Demographic, Work, and Lifestyle Covariates by Depression Diagnosis in a US Heavy Industrial Worker Cohort (*n* = 7,566), 1998–2003

| Characteristic                        | Total Sample<br>( <i>n</i> = 7,566) |       |            | Depression Diagnosis<br>( <i>n</i> = 349, 4.6%) |      |            | Odds<br>Ratio | 95%<br>Confidence<br>Interval | <i>P</i><br>Value <sup>a</sup> |
|---------------------------------------|-------------------------------------|-------|------------|---|------|------------|---------------|-------------------------------|--------------------------------|
|                                       | No.                                 | %     | Mean (SD)  | No.   | %    | Mean (SD)  |               |                               |                                |
| Demand                                |                                     |       |            |   |      |            |               |                               | 0.002 <sup>b</sup>             |
| High                                  | 2,341                               | 30.9  |            | 133   | 5.7  |            | 1.62          | 1.23, 2.15                    |                                |
| Moderate                              | 2,625                               | 34.7  |            | 123   | 4.7  |            | 1.33          | 1.00, 1.76                    |                                |
| Low                                   | 2,600                               | 34.4  |            | 93  | 3.6  |            | 1.0           | Referent                      |                                |
| Control                               |                                     |       |            |   |      |            |               |                               | 0.02                           |
| Low                                   | 2,763                               | 36.5  |            | 111   | 4.0  |            | 0.95          | 0.71, 1.27                    |                                |
| Moderate                              | 2,678                               | 35.4  |            | 148   | 5.5  |            | 1.32          | 1.00, 1.75                    |                                |
| High                                  | 2,125                               | 28.1  |            | 90  | 4.2  |            | 1.0           | Referent                      |                                |
| Gender                                |                                     |       |            |   |      |            |               |                               | <0.0001                        |
| Female                                | 451                                 | 6.0   |            | 47  | 10.4 |            | 2.6           | 1.9, 3.7                      |                                |
| Male                                  | 7,115                               | 94.0  |            | 302   | 4.2  |            | 1.0           | Referent                      |                                |
| Race                                  |                                     |       |            |   |      |            |               |                               | 0.01                           |
| African American                      | 597                                 | 7.9   |            | 12  | 2.0  |            | 0.40          | 0.22, 0.72                    |                                |
| Hispanic                              | 187                                 | 2.5   |            | 9   | 4.8  |            | 0.99          | 0.50, 1.95                    |                                |
| Other                                 | 55                                  | 0.73  |            | 1   | 1.8  |            | 0.36          | 0.05, 2.63                    |                                |
| Caucasian                             | 6,727                               | 88.9  |            | 327   | 4.9  |            | 1             | Referent                      |                                |
| Age, years                            |                                     |       |            |   |      |            |               |                               | <0.0001                        |
| 18–24                                 | 159                                 | 2.1   |            | 7   | 4.4  |            | 3.4           | 1.3, 8.6                      |                                |
| 25–34                                 | 963                                 | 12.7  |            | 65  | 6.8  |            | 5.3           | 3.1, 9.1                      |                                |
| 35–44                                 | 1,965                               | 26.0  |            | 125   | 6.4  |            | 5.0           | 3.0, 8.2                      |                                |
| 45–54                                 | 2,998                               | 39.6  |            | 132   | 4.4  |            | 3.4           | 2.1, 5.6                      |                                |
| 55–64                                 | 1,481                               | 19.6  |            | 20  | 1.4  |            | 1.0           | Referent                      |                                |
| Education                             |                                     |       |            |   |      |            |               |                               | 0.10                           |
| College/<br>postgraduate              | 957                                 | 23.6  |            | 61  | 6.4  |            | 1.29          | 0.94, 1.77                    |                                |
| Elementary/<br>high school            | 3,093                               | 76.4  |            | 155   | 5.0  |            | 1             | Referent                      |                                |
| Tenure, years                         |                                     |       |            |   |      |            |               |                               | <0.0001                        |
| New                                   | 861                                 | 11.4  |            | 22  | 2.6  |            | 1.08          | 0.58, 1.99                    |                                |
| 1–9                                   | 1,595                               | 21.1  |            | 122   | 7.7  |            | 3.40          | 2.15, 5.40                    |                                |
| 10–19                                 | 1,339                               | 17.7  |            | 73  | 5.5  |            | 2.37          | 1.46, 3.86                    |                                |
| 20–29                                 | 2,720                               | 36.0  |            | 107   | 3.9  |            | 1.68          | 1.06, 2.68                    |                                |
| ≥30                                   | 1,051                               | 13.9  |            | 25  | 2.4  |            | 1             | Referent                      |                                |
| Smoking data                          |                                     |       |            |   |      |            |               |                               | 0.006                          |
| Current                               | 1,239                               | 32.2  |            | 88  | 7.1  |            | 1.55          | 1.13, 2.14                    |                                |
| Former                                | 1,028                               | 26.7  |            | 46  | 4.5  |            | 0.95          | 0.65, 1.39                    |                                |
| Never                                 | 1,577                               | 41.0  |            | 74  | 4.7  |            | 1             | Referent                      |                                |
| Body mass<br>index, kg/m <sup>2</sup> |                                     |       |            |   |      |            |               |                               | 0.18                           |
| Obese (≥30)                           | 1,760                               | 41.2  |            | 88  | 5.0  |            | 0.72          | 0.50, 1.04                    |                                |
| Overweight<br>(25–29)                 | 1,827                               | 42.7  |            | 109   | 6.0  |            | 0.87          | 0.61, 1.23                    |                                |
| Normal (<25)                          | 689                                 | 16.1  |            | 47  | 6.8  |            | 1             | Referent                      |                                |
| Cholesterol, mg/dL                    |                                     |       |            |   |      |            |               |                               |                                |
| Low/moderate                          | 2,556                               | 83.72 |            | 117   | 4.58 |            | 0.92          | 0.57, 1.48                    | 0.73                           |
| High                                  | 497                                 | 16.28 |            | 21  | 4.23 |            | 1             | Referent                      |                                |
| Income, dollars                       |                                     |       | 30,092     |   |      | 29,591     | 0.90          | 0.86, 0.95                    | 0.0001 <sup>c</sup>            |
| Job grade                             |                                     |       | 18.0 (9.0) |   |      | 16.5 (9.2) | 0.98          | 0.97, 0.99                    | 0.001 <sup>c</sup>             |

Abbreviation: SD, standard deviation.

<sup>a</sup> *P* value for a chi-square test.<sup>b</sup> Chi square (linear trend) = 12.4; *P* = 0.0004.<sup>c</sup> *P* value for a *t* test.



**Table 3.** Unadjusted Logistic Models of Depression Diagnosis Using Demand and Control Exposure, US Heavy Industrial Worker Cohort ( $n = 7,566$ ), 1998–2003

| Variable | Demand or Control Alone |                         | Demand and Control Combined |                         |
|----------|-------------------------|-------------------------|-----------------------------|-------------------------|
|          | Odds Ratio              | 95% Confidence Interval | Odds Ratio                  | 95% Confidence Interval |
| Demand   |                         |                         |                             |                         |
| High     | 1.62                    | 1.24, 2.13              | 1.71                        | 1.29, 2.25              |
| Moderate | 1.33                    | 1.01, 1.75              | 1.33                        | 1.01, 1.76              |
| Low      | 1                       | Referent                | 1                           | Referent                |
| Control  |                         |                         |                             |                         |
| Low      | 0.95                    | 0.71, 1.26              | 1.07                        | 0.80, 1.43              |
| Moderate | 1.32                    | 1.01, 1.73              | 1.47                        | 1.12, 1.93              |
| High     | 1                       | Referent                | 1                           | Referent                |

levels of demand for depression diagnosis. The effect found corresponds with other results in the literature (5, 8, 10). The effect remains significant with adjustment for demographic and lifestyle variables, but it loses significance with adjustment for location.

Contrary to reports in other studies (5, 7, 15), low control jobs were not associated with increased risk of depression diagnosis. Evaluation of tertile interaction terms for demand and control has similar results, with the combination of high demand and moderate control increasing risk for depression diagnosis. Like other models, with adjustment, the result lost significance.

The effects of demand on depression risk are expected on the basis of prior research, and reverse causality is unlikely given the exclusion of those with prior depression diagnosis. It is unlikely that depressed individuals would choose higher demand jobs. The possibility that change in exposure over the course of the study had an effect on demand or control exposure was explored; however, it is unlikely as time-to-event models were very similar to the logistic regression results.

The results of control exposure on depression diagnosis may differ because of differences in the kind of job or industry of employment, as little is known about exposure to psychosocial factors in heavy industrial workers. In addition, demand and control were rated externally to workers versus subjectively, and differences in the rating of exposure may explain different results in control from other studies. It is possible that subjective perceptions of control may be different or unrelated to objective, external ratings of control.

It is possible that, with removal of those with prevalent depression in the cohort, the effects of demand or control may differ in the remaining population. This may be due to a healthy worker survival effect; if those in low control jobs were prevalent cases of depression, removal of these cases from the cohort may leave only those in low control jobs who were not as likely to become depressed. However, an evaluation of the prevalent cases of depression removed from the cohort showed a similar distribution of demand

**Table 4.** Adjusted Logistic Regression Models of Depression Diagnosis Using Tertiles of Demand and Control Exposure, US Heavy Industrial Worker Cohort ( $n = 7,566$ ), 1998–2003

| Effect                             | Demographics Adjusted |                         | Demographics and Lifestyle Adjusted |                         |
|------------------------------------|-----------------------|-------------------------|-------------------------------------|-------------------------|
|                                    | Odds Ratio            | 95% Confidence Interval | Odds Ratio                          | 95% Confidence Interval |
| Demand                             |                       |                         |                                     |                         |
| High                               | 1.53                  | 1.15, 2.03              | 1.39                                | 1.04, 1.86              |
| Moderate                           | 1.42                  | 1.07, 1.89              | 1.33                                | 1.00, 1.77              |
| Low                                | 1                     | Referent                | 1                                   | Referent                |
| Control                            |                       |                         |                                     |                         |
| Low                                | 0.69                  | 0.50, 0.94              | 0.78                                | 0.56, 1.08              |
| Moderate                           | 1.14                  | 0.86, 1.51              | 1.07                                | 0.81, 1.43              |
| High                               | 1                     | Referent                | 1                                   | Referent                |
| Gender                             |                       |                         |                                     |                         |
| Female                             | 2.41                  | 1.71, 3.39              | 2.39                                | 1.70, 3.38              |
| Male                               | 1                     | Referent                | 1                                   | Referent                |
| Age, years                         |                       |                         |                                     |                         |
| 18–24                              | 3.29                  | 1.25, 8.65              | 3.35                                | 1.27, 8.86              |
| 25–34                              | 4.92                  | 2.67, 9.08              | 4.72                                | 2.55, 8.74              |
| 35–44                              | 4.36                  | 2.55, 7.46              | 4.07                                | 2.37, 6.99              |
| 45–54                              | 3.11                  | 1.89, 5.12              | 2.94                                | 1.78, 4.84              |
| 55–64                              | 1                     | Referent                | 1                                   | Referent                |
| Race                               |                       |                         |                                     |                         |
| African American                   | 0.44                  | 0.24, 0.78              | 0.44                                | 0.24, 0.79              |
| Hispanic American                  | 1.08                  | 0.54, 2.15              | 1.12                                | 0.56, 2.24              |
| Other                              | 0.34                  | 0.05, 2.52              | 0.35                                | 0.05, 2.56              |
| Caucasian                          | 1                     | Referent                | 1                                   | Referent                |
| Education                          |                       |                         |                                     |                         |
| > High school                      | 1.24                  | 0.90, 1.70              | 1.23                                | 0.89, 1.68              |
| Unknown                            | 0.91                  | 0.71, 1.17              | 1.1                                 | 0.68, 1.76              |
| ≤ High school                      | 1                     | Referent                | 1                                   | Referent                |
| Job grade                          |                       |                         |                                     |                         |
|                                    | 0.98                  | 0.97, 0.99              | 0.99                                | 0.97, 1.00              |
| Tenure, years                      |                       |                         |                                     |                         |
| 30–39                              | 2.51                  | 1.29, 4.90              | 2.44                                | 1.25, 4.77              |
| 20–29                              | 2.58                  | 1.52, 4.37              | 2.56                                | 1.51, 4.35              |
| 10–19                              | 2.74                  | 1.63, 4.62              | 2.67                                | 1.58, 4.50              |
| 1–9                                | 3.31                  | 2.07, 5.30              | 3.21                                | 2.00, 5.14              |
| New                                | 1                     | Referent                | 1                                   | Referent                |
| Smoking status                     |                       |                         |                                     |                         |
| Current                            |                       |                         | 1.5                                 | 1.08, 2.09              |
| Ever                               |                       |                         | 1.15                                | 0.78, 1.70              |
| Unknown                            |                       |                         | 1.43                                | 0.93, 2.19              |
| Never                              |                       |                         | 1                                   | Referent                |
| Body mass index, kg/m <sup>2</sup> |                       |                         |                                     |                         |
| Obese (≥30)                        |                       |                         | 0.95                                | 0.65, 1.40              |
| Overweight (25–29)                 |                       |                         | 1.1                                 | 0.76, 1.59              |
| Missing                            |                       |                         | 0.48                                | 0.27, 0.84              |
| Normal                             |                       |                         | 1                                   | Referent                |
| Cholesterol level                  |                       |                         |                                     |                         |
| High                               |                       |                         | 0.92                                | 0.57, 1.49              |
| Missing                            |                       |                         | 1.53                                | 1.11, 2.11              |
| Low/moderate                       |                       |                         | 1                                   | Referent                |

and control exposure. Other effects due to use of a healthy worker population include the possibility that those able to tolerate a job would be less likely to be vulnerable to exposure. It is possible that employees unable to manage the psychosocial exposures in this setting changed jobs or left employment, leaving more resistant employees and thus weakening associations between exposure and disease. In this analysis, tenure is used in models as one way to control for the effect of length of employment on risk of depression diagnosis. Sensitivity analysis of the effect of exposure on risk of depression in an inception cohort was evaluated, and results show that this group had lower rates of depression versus the rates of the entire cohort, suggesting that a healthy worker survival effect, if present, was not strong. Unadjusted models of the inception cohort were similar to models of the full sample. With adjustment, those with moderate-demand jobs had significantly higher risk of depression diagnosis, and both low and moderate control increased estimates of depression risk, although neither was significant.

There are several strengths to the current study. This was a retrospective cohort study, allowing evaluation of large groups of workers over time. The availability of many years of administrative health-care data and work-related exposure data allows for removal of prevalent cases and follow-up to diagnosis of depression. Administrative diagnosis of depression from the health claims data used in this study reflects the worker's face-to-face visits with practitioners. This is an improvement over methods using single questions related to mood and removes potential subjectivity related to personality characteristics and negative affect on measurement of the outcome. The use of objective external ratings of psychosocial factors is an objective method more specific to individual jobs and locations than externally assigned ratings that use a job exposure matrix based on broad classifications of workers. The workers in this study all had equal insurance coverage including full mental health benefits and a similar income range, suggesting that at least financial access to health care was equivalent across workers and locations. Potentially, the greater homogeneity of worker type, health-care access, and income provides better control for confounding by socioeconomic status. Finally, this study evaluates the risk of depression in heavy industrial workers, for whom little is known about psychosocial risk factors at work.

The current study has some limitations. Variability by plant location may have affected the results. For example, potential explanations for the loss of significance with adjustment for location may include that demand and control exposure are inseparable from location, given that they are aspects of the workplace context. If adjustment for location is a proxy for unmeasured covariates, then adjustment for location may represent an overadjustment, as plants with higher demand and higher depression will have the effect of demand removed from depression risk. The ability to evaluate the effect of location on analyses was limited because of small location-specific sample size. Collection of additional location-specific information would help to clarify these results including other characteristics of the workplace context.

In this study, there was only 1 rater per location to identify exposure to demand and control. Thus, the effect of rater cannot be separated from the effect of location. Reliability of exposure measures could not be calculated given that only 1 rater per location was used and that ratings were not repeated. Analysis of the amount of variance explained by location was conducted, and most locations did not have significant differences in exposure ratings, while jobs had highly significant differences ( $P < 0.0056$ ) compared with location differences ( $P < 0.05$ ), suggesting a weaker effect of location in the analysis. In future work, exposure ratings could be obtained by additional raters at each location, so that reliability measures are available. However, until inter-rater reliability is specified, the exposure measures cannot be assumed to be consistent across locations.

In addition to the limitations already discussed, a weakness in the current study is the use of health claims diagnosis for identification of depression. There are difficulties in using the concept of prevalence and incidence of depression based on health claims data. First, it is unclear what the proper time period for identification of prevalent cases would be. Further, it is possible that cases of depression were not ascertained in the cohort because of the stigma associated with mental health treatment. Differences in the diagnosis of depression by location may be an issue, including the likelihood of being given a diagnosis of depression, the availability and quality of health care, the differences in regional perceptions of mental health stigma, or differences in the identification of depression by health-care providers and reimbursement of mental health claims. Despite these considerations, it is expected that this is a better method of ascertainment of depression than subjective questions related to mood that are not tied to the diagnosis of depression according to the *Diagnostic and Statistical Manual of Mental Disorders*.

Unmeasured confounding may be an issue as substance use, marital status, and work-family stressors were not available for adjustment and may relate to depression risk. Four covariates (education, smoking history, body mass index, and cholesterol level) had missing data, and a category for the missing data was included to adjust without losing sample size. A sensitivity analysis comparing those with complete data was similar to the results for the sample, suggesting that missing data did not have significant effects on the analysis.

Generalizability of results is limited to hourly heavy industrial employees similar to those in this sample. Given that some jobs are specific to the aluminum industry, generalizing beyond this industry to all heavy industrial jobs or all hourly workers may be unwarranted. In addition, these workers were very stable, having long tenure with potentially a more secure, stable employer.

Overall, this study finds that heavy industrial workers in jobs of high demand and moderate control have greater risk of depression diagnosis claims, but with full adjustment including location, these effects lose significance. Further research is needed to more fully understand location-specific effects on both differences in exposure (work culture) and in factors influencing depression diagnosis. Multilevel methods of analysis might also be used to better

understand the effects of location and work life on the worker's health, including the relation between objective and subjective ratings of psychosocial factors. Further study of the cycle of depression across time in workers is important to offer information on how depressive illness affects an individual's working lives, the mechanism of how acute and chronic psychosocial stressors result in depression, and the relation between mental and physical health problems in workers.

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