

Combining fixed effects and instrumental variable approaches for estimating the effect of psychosocial job quality on mental health: evidence from 13 waves of a nationally representative cohort study

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ABSTRACT

Background Previous studies suggest that poor psychosocial job quality is a risk factor for mental health problems, but they use conventional regression analytic methods that cannot rule out reverse causation, unmeasured time-invariant confounding and reporting bias.

Methods This study combines two quasi-experimental approaches to improve causal inference by better accounting for these biases: (i) linear fixed effects regression analysis and (ii) linear instrumental variable analysis. We extract 13 annual waves of national cohort data including 13 260 working-age (18–64 years) employees. The exposure variable is self-reported level of psychosocial job quality. The instruments used are two common workplace entitlements. The outcome variable is the Mental Health Inventory (MHI-5). We adjust for measured time-varying confounders.

Results In the fixed effects regression analysis adjusted for time-varying confounders, a 1-point increase in psychosocial job quality is associated with a 1.28-point improvement in mental health on the MHI-5 scale (95% CI: 1.17, 1.40; $P < 0.001$). When the fixed effects was combined with the instrumental variable analysis, a 1-point increase psychosocial job quality is related to 1.62-point improvement on the MHI-5 scale (95% CI: –0.24, 3.48; $P = 0.088$).

Conclusions Our quasi-experimental results provide evidence to confirm job stressors as risk factors for mental ill health using methods that improve causal inference.

Keywords cohort, fixed effect regression, instrumental variable analysis, job stress, mental health, work

What is already known on this subject?

- Previous studies on job stress and mental health are subject to a range of biases and methodological problems.

of subjectively reported job stressors and unmeasured time-invariant confounding

What does this study add?

- This article provides an instrumental variable fixed effect regression model to correct for three of these problems: reverse causation, dependent and independent misclassification

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- Results suggest that job stressors have an influence on mental health and highlight the need to address these as modifiable determinants of health.

Introduction

The association between psychosocial job stressors (e.g. low control over work, high psychological demands and job insecurity) and poor mental health has repeatedly been demonstrated in observational studies.^{1–4} One of the most famous models in this area is the demand-control model, which argues that the experience of both high psychological demands (e.g. excessive workload, very hard or overly fast work and conflicting demands) and low job control (a limited ability to learn new things or develop skills, lack of decision making ability) are likely to be detrimental for health.⁵ Another prominent model in the area is the effort-reward imbalance model,⁶ which argues that poor health arises from an imbalance between high extrinsic effort by workers (e.g. pressure to work overtime, increasingly demanding work, constant time pressure and repeated interruptions) and the perception of low rewards financially (income), socially (respect, esteem) and organizationally (job security, promotion prospects). Another prominent model—particularly relevant to the current study—is job insecurity, defined as perceived threat of job loss and the worries related to that threat.⁷

While there has been an extensive amount of research on the relationships between psychosocial job stressors and health, these associations may be influenced by reverse causation (i.e. poorer health status leads to accepting jobs with more stressors), unmeasured or poorly measured confounders, dependent misclassification (i.e. those with poor mental health are more likely to report job stressors) and independent misclassification (i.e. while self-reported job stressors provide a strong signal of underlying job quality, it may be subject to random misclassification that biases the estimated relationship with mental health towards zero). Thus, despite consistent findings across numerous countries, time periods, and research designs, these conventional regression studies have been limited in their ability to provide causal evidence of the relationship between psychosocial job quality and mental health.⁸

The ideal scenario for determining the causal role of social environmental factors—including job stress—on mental health would be a randomized controlled trial (RCT). As this is infeasible in many scenarios, researchers relying on observational data have developed quasi-experimental techniques for causal inference, such as instrumental variable analytic methods.⁹ An instrumental variable (or instrument)

is an exogenous variable (i.e. determined by factors outside the analytic model) that is potentially able to provide an unbiased estimate of treatment effect (e.g. exposure).¹⁰ Thus instrumental variables are able to address many of the problems plaguing observational studies, including reverse causality, unobserved variables or measurement error.

To the best of our knowledge, only two studies have previously looked at the relationship between job stressors and mental health using an instrumental variable approach.^{8,9} Both studies support the argument that adverse working environments cause poorer mental health. However, as these were based on specific occupational cohorts, their conclusions cannot be generalized to the wider labour market. Furthermore, the instruments used were not randomly allocated and may have been associated with uncontrolled between-person differences that may have biased the results.

This article aims to show that individual fixed effects regression can be combined with an instrumental variable approach to estimate the causal effect of psychosocial job quality on mental health, analysing 13 annual waves of Australian cohort data. In doing so, we aim to address possible bias from reverse causation, dependent and independent misclassification of subjectively reported job stressors (instrumental variable approach), and unmeasured time-invariant confounding (through the fixed-effects approach).

Method

Data source

The Household, Income and Labour Dynamics in Australia (HILDA) survey is a longitudinal study of Australian households established in 2001. It collects detailed information annually from over 13 000 individuals within over 7000 households.¹¹ The response rate to wave one was 66%.¹¹ The survey covers a range of dimensions including social, demographic, health and economic conditions combining face-to-face interviews and a self-completion questionnaire. The survey began with a large national sample of Australian households occupying private dwellings. Interviews were with all persons in sample households aged 15 years or older. Additional persons have been added as a result of changes in household composition. For example, household members leaving their original household (e.g. children leaving home or couples separating) formed an entirely new household with all persons then living with the original sample member. Inclusion of these new households is the main way in which the HILDA survey maintains sample representativeness. A top-up sample of 2000 people was added to the cohort in 2011 to allow better representation of the Australian population using the same methodology as the

original sample. The response rates for the HILDA survey are above 90% for respondents who have continued in the survey and above 70% for new respondents entering the study. The main variables examined in this study were available in waves from 2002 to 2014.

Outcome variable

Mental health was assessed using the five-item Mental Health Inventory (MHI-5), a subscale from the Short Form-36 (SF-36) general health measure. The MHI-5 assesses symptoms of depression and anxiety (nervousness, depressed affect) and positive aspects of mental health (feeling calm, happy) in the past 4 weeks. The MHI-5 has reasonable validity and is an effective screening instrument for mood disorders or severe depressive symptomatology in the general population,^{12–16} and it has also been validated as a measure for depression against clinical interviews.^{12,15,16} The current analyses use the continuous MHI-5 score (scale 0–100), with higher scores representing better mental health.

Exposure variable

Our exposure represented a previously developed multidimensional measure of psychosocial job quality assessing four main perceived job stressors: control, demands and complexity, job insecurity and unfair pay.^{17–19} Full details of the construction and validation of the job quality measure are presented elsewhere.^{17–19} In brief, factor analysis and structural equation modelling identified three separate factors, which were labelled: job demands and complexity (three items), job control (three items) and perceived job security (three items). An additional single item assessing whether respondents considered that they were paid fairly for their efforts at work was included as a fourth factor measuring an important aspect of the effort-reward imbalance model.^{17–19} The individual scales were associated with more widely used measures of job demands and control, and other employment conditions such as casual status, hours worked and shift work. Each factor was dichotomized to identify the quartile experiencing the greatest adversity and the composite measure constructed by summing the number of adverse psychosocial job conditions (high job demands and complexity, low job control, high job insecurity and unfair pay). Because of the small number of respondents reporting all four job adversities in a single year/wave, this composite scale was top-coded at three, and, thus, produced four categories ranging from optimal jobs to three or more psychosocial adversities (poorest quality jobs). This measure has been used in other studies on mental health, physical health and sickness absence.^{17–19}

Instrumental variable

We identified two workplace entitlements as possible instrumental variables for psychosocial job quality: (i) flexible start and finish times and (ii) the ability to work from home. Respondents were asked in waves 2002–2014 if these entitlements had the potential to be provided to either them, or other employees working at a similar level in their workplace. We consider these variables as organizational attributes, rather than measuring individual worker behaviours or feelings about the organization or work. We excluded self-employed workers as this group would not have access to organizational-level workplace entitlements.

We argue that these variables meet the three assumptions needed for an instrumental variable, which are:

- (1) The instrument (Z) and the exposure (X) are associated either because Z has a causal effect on X , or because X and Z have a common cause.

Both workplace entitlements (instruments) and psychosocial job quality (exposure) are likely to be related to how a person rates their psychosocial job quality (common cause). For example, as suggested in past research, the ability for a person to have access to flexible working conditions should predict their overall perception of the quality of their employment.²⁰

- (2) Z affects the outcome Y only through X (holding other control variables constant).

It is unlikely that the presence of entitlements in a workplace alone affects a person's mental health (while it has been hypothesized that some social interventions may have a direct health-promoting effect, this has to be further validated empirically to present an issue for this study).²¹ Instead, we would argue that entitlements act primarily through psychosocial job quality, as found in past research.²⁰ We acknowledge that work-family balance (e.g. time working is less enjoyable or more pressured because of family commitments, and vice versa) may be another pathway through which entitlements influence mental health, and thus adjust for this measured confounding in the analysis (see below).

- (3) Z is not associated with uncontrolled factors that cause Y

In addition to controlling for between-person time-invariant differences by using a within-person fixed effects analysis, we also control for an extensive set of time-varying confounders. A Directed Acyclical Graph representing our assumed relationships can be seen in Supplementary File 2.

Other covariates

The model also included several likely confounders of the instrumental variables–exposure–outcome relationship. These account for time-varying variables through which the instrument could impact the outcome other than through the exposure (Supplementary File 2). These included employment arrangement (permanent, casual or labour hire or fixed term), long-term health condition (yes or no), time working less enjoyable/more pressured due to family commitment (1-strongly disagree to 7-strongly agree, or not asked 0), family time less enjoyable/more pressured due to work commitments (1-strongly disagree to 7-strongly agree, or not asked 0), age measured continuously (18–64 years), quintiles of equivalised household disposable income (coded from 1-lowest to 5-highest), occupational skill level (low [sales, machinery workers and labourers], medium [technical and trade workers, community and personal service workers and clerical and admin workers] and high [managers and professionals] according to the Australian and New Zealand Standard Classification of Occupations occupational groupings²²), highest level of education (postgraduate, bachelor, certificate or diploma, Year 12, less than Year 12) and household structure (couple or lone adult residing with dependents, couple without dependents, lone person without dependents and a group or multiple person household).

Data analysis

Individual fixed effects models

We used individual fixed-effects regression models to estimate the change in mental health associated with an increase in psychosocial job quality. These models only use within-person effects, where each individual acts as their own control, and they therefore control for all time-invariant confounding²³ (e.g. personality traits such as negative affect that could cause dependent misclassification bias). We also include time-varying variables to adjust for the time-varying confounding.

Instrumental variable models with fixed effects

From an econometric perspective, instrumental variables regression analyses represent a general way to obtain an unbiased estimate of the relationship between psychosocial job quality and mental health, when it is suspected that the main exposure (psychosocial job quality or ‘X’ above) is correlated with the error term of the model (u_{it})²⁴ (equation 1—fixed effects and other confounding factors not shown). For example, when factors in u_{it} represent omitted factors that determine Y_{it} and Y_{it} influences X_{it} (reverse causation).

$$Y_{it} = \beta_0 + \beta_1 X_{it} + u_{it} \quad (1)$$

Instrumental variables (Z) can help in this situation by isolating a part of the variation in X that is uncorrelated with u_{it} . If the assumptions described above are met, then the unbiased instrumental variable analysis can be conducted using two-stage least squares regression. In the first stage, a population level regression linking X and Z (equation 2) is used to decompose X into two components: a problematic component v_i that is correlated with the error term u_{it} , and a problem-free component $\pi_0 + \pi_1 Z_i$ that is uncorrelated with u_{it} .

$$X_i = \pi_0 + \pi_1 Z_i + v_i \quad (2)$$

where π_0 is the intercept, π_1 is the impact of Z and v_i is the error term.

The second stage uses only the problem-free variation in X to estimate the coefficient β_1 .²⁴ The instrumental variable analysis implemented in this article also used a fixed-effects regression approach, as described above. So, in addition to the instrumental variable for job quality, the analysis also controls for time-invariant confounding.

We fitted four fixed-effect models, progressively adjusting for confounding through the use of instruments and / or addition of potential time-varying confounding variables. Model one tested a fixed effect model without the inclusion of the instrumental variable and without possible time-varying confounders. Model two tested the influence of using workplace entitlements as instrumental variables for psychosocial job quality using two-stage least-squares fixed effect regression. Model 3 was the same as Model 1, but also included possible time-varying confounders. Our preferred Model 4 represented the instrumental variables analysis with fixed effects and adjustment for measured time-varying confounders. The analysis included the period from 2002 to 2014. All analyses were conducted using the `xtivreg2` user-written command in Stata 14.1.²⁵

We conducted the following tests for the instrumental variable analysis:

- (1) Underidentification (i.e. that the two workplace entitlement instruments are ‘relevant’ in that they are correlated with the job quality variable), with the null hypothesis being that the equation is underidentified.²⁵
- (2) Related to this, ‘weak identification’ arises when the excluded instruments are only weakly correlated with the endogenous regressors (job quality), and this can cause bias, especially in small samples. To test for weak

instruments we assessed our Cragg-Donald F statistic against the Stock and Yogo (2005) critical values.^{26,27}

- (3) The Sargan-Hansen test of overidentifying restrictions assess whether the instruments are correlated with the estimated residuals in the second stage regression. If either of the instruments are correlated with the second stage residuals this suggests that at least one of the instruments is invalid from a statistical perspective.²⁶ This does not prove that instruments are valid from a conceptual basis, which, as suggested above needs to be justified on a theoretical basis.

Analytic sample

The sample selection can be seen in Fig. 1. The analytic sample represented those persons aged 18–64 years who were employed. We excluded those persons who reported that they were self-employed, as they may be unlikely to have access to workplace level entitlements ($n = 3608$).

Results

Table 1 shows the characteristics of the analytic sample. The sample size for the analysis was 13 260 persons (81 681 observations), with on average 6.2 waves included per person in the analysis.

Tests on the validity of the instrumental variable approach (including all confounders) led us to reject the null hypothesis that the equation is underidentified (Kleibergen-Paap rk LM statistic = 214.410, $\chi^2 P < 0.001$) and we also found a Cragg-Donald Wald F statistic (130.004) larger than Stock-Yogo (2005) critical values, suggesting that our instruments were not weak and thus relevant.²⁶ Last, the validity of both instruments was assessed using the Sargan-Hansen statistic test (2.883, $\chi^2 P = 0.09$). This suggested that the instruments were uncorrelated with the error term, thus that the instruments themselves are not predictive of mental health other than through their association with job stressors.

Our first analysis represented unadjusted models for both the fixed-effect (Model 1) and instrumental variable fixed-effect (Model 2) analyses. Results are not shown in a Table but are presented in text below. Before adjustment, the simple fixed effect estimate for job quality (where three was the highest job quality and 0 was the lowest) on MHI-5 (on a scale of 0–100) was 1.32 (Model 1; 1.32, 95% 1.21, 1.44, $P < 0.001$). The instrumental variable analysis (Model 2) indicated a larger effect estimate of psychosocial job quality on mental health (1.77, 95% CI: $-0.02, 3.55$, $P < 0.053$), but with larger confidence intervals than the simple fixed effect estimate.

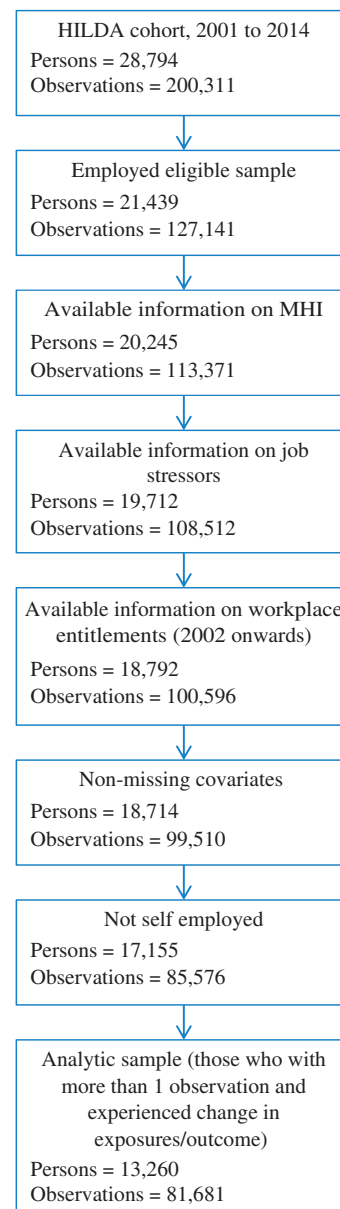


Fig. 1 Selection of analytic sample.

As can be seen in Table 2, results from the multivariate analysis showed that the effect estimate for exposure to psychosocial job quality from the fixed effect analysis (Model 3; 1.28, 95% CI: 1.17, 1.40, $P < 0.001$) was lower than that of the fixed-effect and instrumental variable analysis (Model 4; 1.62, 95% CI: $-0.24, 3.48$, $P = 0.088$). The influence of psychosocial job quality is no longer statistically significant, and the confidence intervals are wider in the instrumental variable fixed-effect analysis than the fixed effect analysis. The wider confidence intervals are due to the fact that only part of the variation in exposure (only that variation related to the instruments) is utilized in instrumental variable analyses.

Table 1 Description of the sample, across all observations

	Sample
MHI (mean, std. dev.)	75.42, 15.64
Psychosocial job stressors %	
Poorest	20.06
2 Adversity	33.60
1 Adversity	35.24
Highest	11.1
Age (mean, std. dev.)	38.10, 13.5
Time working less enjoyable (mean, std. dev.)	1.16, 1.80
Family time less enjoyable (mean, std. dev.)	1.18, 1.86
Long-term health cond. %	
No	87.56
Yes	12.44
Employment arrangement %	
Permanent	68.22
Casual/labour hire	22.72
Fixed-term	9.06
Education %	
Post grad	4.93
Bachelor/diploma	33.02
Certificate or Year 12	39.12
Year 11 or below	22.9
Income (disposable, in quintiles) %	
Lowest	9.9
2	21.2
3	26.04
4	24.14
Highest	18.72
Occupational skill level %	
Low skill	34.84
Low/med	23.62
Med/high	26.41
High	15.12
Household structure %	
Couple without children	26.05
Couple with children	47.56
Lone parent with children	8.56
Lone person	13.03
Other	4.81
Flexible start and finish times %	
No	44.9
Yes	55.1
Home-based work %	
No	77.8
Yes	22.12

to estimate the impact of the exposure. So while this reduces the potential bias of the estimated effect side it also tends to reduce the statistical power of the regression.

Discussion

Main finding of this study

Our fixed-effects results regarding job quality and mental health are consistent with other studies using similar approaches.^{18,28} This further supports the argument that poor psychosocial working conditions are a pertinent risk factor for mental ill health, as described in the theoretical models of job stress explained in the introduction of the article. While we acknowledge that the results of the fixed effects and instrumental variable fixed effects analysis may not be completely comparable, the latter suggested a slightly greater impact of job quality on mental health than the former. There are a number of possible reasons for this. First and foremost, it is possible that the instruments are correlated with mental health (the outcome) in ways other than through psychosocial job quality (exposure) or the potential confounders included in the model, leading to residual time-varying confounding and therefore biased estimates in the instrumental variable analyses. In saying this, we would argue that we have been fairly exhaustive in the range of factors that we have controlled for in the model and our assumed pathways were based on past research. Another possibility for the larger coefficient is that there is random measurement error in the reporting of psychosocial job quality within an individual over time which attenuates the observed impact of changes in job quality on mental health, and that this form of bias is also corrected for in the instrumental variable analysis. Our results overall support the hypothesis that psychosocial job quality represents a risk factor for mental health. Our results suggest further that the magnitude of association is meaningful. Generally speaking, a difference of three points on the norm based scale T-score has been suggested to reflect a minimally important difference.²⁹ Our 4-point job quality index indicates a 4–5 point difference between the lowest and highest psychosocial job quality.

What this study adds

This article responds to criticisms noted in job stress research regarding the subjective nature of both exposures (perceived job quality) and outcomes (mental health).^{30–32} Some of this criticism has focused on the role of confounding by negative affect in the observed relationship between self-reported job quality and outcomes.^{30,31} Fixed-effect regression models can be used to address this problem if the cause is time-invariant (e.g. to the extent that personality or negative affect is time-invariant). However, these models cannot solve the problem of time-varying omitted variables when an individual might be more likely to suffer or report

Table 2 The effect of psychosocial job stressors on mental health, fixed effect and instrumental variable analysis, multivariate associations

	<i>Fixed effect model (Model 3)</i>			<i>Instrumental variable fixed effect model (Model 4)</i>		
	<i>Coef</i>	<i>95% CI</i>	<i>P value</i>	<i>Coef</i>	<i>95% CI</i>	<i>P value</i>
Psychosocial job stressors	1.28	1.17, 1.40	<0.001	1.62	−0.24, 3.48	0.088
Age	0.04	0.01, 0.08	0.014	0.04	0.01, 0.08	0.018
Time working less enjoyable	−0.22	−0.33, −0.11	<0.001	−0.22	−0.33, −0.11	<0.001
Family time less enjoyable	−0.49	−0.60, −1.39	<0.001	−0.48	−0.61, −0.36	<0.001
Long-term health cond. (Ref. no.)						
No	0			0		
Yes	−1.73	−2.07, −1.39	<0.001	−1.73	−2.02, −1.38	<0.001
Employment arrangements						
Permanent	0			0		
Casual/labour hire	−0.35	−0.67, −0.03	0.03	−0.37	−0.72, −0.03	0.032
Fixed-term	0.15	−0.19, 0.49	0.382	0.17	−0.19, 0.52	0.352
Education						
Post grad	0			0		
Bachelor/diploma	−0.17	−1.25, 0.91	0.763	−0.15	−1.23, 0.93	0.786
Certificate or Year 12	−0.87	−2.15, 0.40	0.18	−0.91	−2.20, 0.37	0.165
Year 11 or below	−1.23	−2.62, 0.16	0.083	−1.29	−2.71, 0.13	0.075
Income (disposable in deciles)						
Lowest	0			0		
2	−0.17	−0.55, 0.21	0.383	−0.17	−0.55, 0.21	0.391
3	−0.15	−0.57, 0.26	0.465	−0.15	−0.57, 0.26	0.476
4	−0.27	−0.72, 0.18	0.245	−0.26	−0.71, 0.19	0.259
Highest	−0.15	−0.66, 0.36	0.568	−0.14	−0.65, 0.37	0.588
Occupational skill level						
Low skill	0			0		
Low/med	0.31	−0.08, 0.71	0.119	0.31	−0.08, 0.71	0.122
Med/high	−0.20	−0.57, 0.17	0.284	−0.23	−0.63, 0.17	0.262
High	−0.15	−0.67, 0.37	0.57	−0.17	−0.71, 0.36	0.528
Household structure						
Couple without children	0			0		
Couple with children	0.32	−0.05, 0.70	0.093	0.30	−0.10, 0.70	0.138
Lone parent with children	−1.32	−2.02, −0.63	<0.001	−1.32	−2.02, −0.63	<0.001
Lone person	−1.51	−2.05, −0.97	<0.001	−1.52	−2.07, −0.98	<0.001
Other	−0.61	−1.22, −0.01	0.049	−0.61	−1.22, −0.01	0.048

Notes: The MHI-5 runs from 0 (low) to 100 (high). Coef = model coefficient; 95% CI = 95% confidence intervals, significance value at 95%.

poor job quality when they have worse mental health. In this case, instrumental variable analyses attempts to use a suitable exogenous variable (workplace entitlements) to proxy for an exogenous part of the otherwise endogenous variable. In other words, instrumental variables can be used to account for reverse causation (i.e. poorer health status leads to accepting jobs with more stressors), unmeasured or poorly measured confounders, dependent misclassification (i.e. those with poor mental health are more likely to report job stressors) and other types of misclassification. Either or both of these types of analytic models are appropriate if

researchers are interested in examining causality, acknowledging that in both cases reducing potential bias and improving casual inference comes at a cost of lower power and wider confidence intervals than traditional random effects models.³³

What is already known on this topic

The two other studies that have attempted to implement an instrumental variable approach to assess the relationship between psychosocial working conditions and mental health^{8,9} also noted that estimates obtained from instrumental variable

analyses were slightly higher than those obtained using other methods. Although, these were both based in hospital settings, rather than in a general population cohort as our study was. The authors of these previous studies also acknowledged the challenges in identifying suitable instrumental variables in job stress studies. Even if we find data on potential instruments, it is difficult to ensure that there are no other uncontrolled pathways through which these variables affect mental health other than through psychosocial job factors.

Limitations of this study

In terms of limitations of this study we note that HILDA tends to under-represent those in lower socio-economic groups and migrant workers, which affects the generalizability of our results. There were a number of strengths in this study. These included the ability to examine the relationships between psychosocial working conditions and mental health using a large representative national sample. We were able to use a previously validated measure of psychosocial job quality. Given multiple observations on each individual the fixed effects analytical approach allowed us to examine within-individual associations thus controlling for time-invariant confounders that may have otherwise biased results.

In conclusion, we find that a combined fixed-effects and instrumental variable analysis is consistent with a causal association between psychosocial job quality and mental ill health. Additional research is necessary to further investigate the suitability of instrumental variables in correcting for subjective reporting bias in job stress research. Further, we would suggest that an instrumental variable approaches may be a useful addition to many areas in public health where RCTs are infeasible or difficult, particularly when researchers are concerned about problems connected to the direction of associations and related bias.

Authors' contributions

A.M. designed the study, conducted analysis, and wrote the article. D.P. and Z.A. contributed to data analysis. A.D.L., A.K. and F.P. contributed to interpretation of results. All authors contributed to drafts and the final article.

Ethical standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required.

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Supplementary data

Supplementary data are available at *Journal of Public Health* online.

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Conflict of interest

The authors declare that they have no conflict of interest.

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