The role of job strain in understanding midlife common mental disorder: a national birth cohort study

Samuel B Harvey, Dilan A Sellahewa, Min-Jung Wang, Josie Milligan-Saville, Bridget T Bryan, Max Henderson, Stephani L Hatch, Arnstein Mykletun

Summary

Background **Long-standing concerns exist about reverse causation and residual confounding in the prospective association between job strain and risk of future common mental disorders. We aimed to address these concerns through analysis of data collected in the UK National Child Development Study, a large British cohort study.**

Methods **Data from the National Child Development Study (n=6870) were analysed by use of multivariate logistic regression to investigate the prospective association between job strain variables at age 45 years and risk of future common mental disorders at age 50 years, controlling for lifetime psychiatric history and a range of other possible confounding variables across the lifecourse. Population attributable fractions were calculated to estimate the public health effect of job strain on midlife mental health.**

Findings **In the final model, adjusted for all measured confounders, high job demands (odds ratio 1·70, 95% CI 1·25–2·32; p=0·0008), low job control (1·89, 1·29–2·77; p=0·0010), and high job strain (2·22, 1·59–3·09; p<0·0001) remained significant independent predictors of future onset of common mental disorder. If causality is assumed, our findings suggest that 14% of new cases of common mental disorder could have been prevented through elimination of high job strain (population attributable fraction 0·14, 0·06–0·20).**

Interpretation **High job strain appears to independently affect the risk of future common mental disorders in midlife. These findings suggest that modifiable work-related risk factors might be an important target in efforts to reduce the prevalence of common mental disorders.**

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Black Dog Institute, Prince of Wales Hospital, Sydney, NSW, Australia (S B Harvey PhD); **School of Psychiatry** (S B Harvey, D A Sellahewa BSc, M-J Wang MSc, J Milligan-Saville BSc, B T Bryan BA, A Mykletun PhD), **and School of Psychology** (D A Sellahewa), **University of New South Wales, Sydney, NSW, Australia; Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK** (S B Harvey, M Henderson PhD, S L Hatch PhD); **Department of Epidemiology, Harvard T H Chan School of Public Health, Boston, MA, USA** (M-J Wang); **Leeds and York Partnership, NHS Foundation Trust, Leeds, UK** (M Henderson); **Norwegian Institute of Public Health, Division of Mental Health, Bergen, Norway** (A Mykletun); **The Centre for Work and Mental Health, Nordland Hospital Trust, Bodø, Norway** (A Mykletun); **and Arctic University of Norway, Tromsø, Norway** (A Mykletun)

Correspondence to:
Dr Samuel B Harvey, School of Psychiatry, University of New South Wales, Sydney, NSW 2031, Australia
s.harvey@unsw.edu.au

Introduction

Mental ill-health has become the leading cause of sickness absence and long-term incapacity in most high-income countries,[1] which has led to increased academic, policy, and public attention on the association between job characteristics and mental health.[1–5] The most widely studied and influential theoretical model in this field is Karasek's job demands–control model.[6] This model holds that high job demands (including work pace, intensity, and conflicting demands) and low job control or decision latitude (including workers' ability to make decisions about their work) engender a state of high job strain, which places workers at high risk of health problems.[6] Demonstration of this theorised causal association in relation to common mental disorders would provide a strong basis for the targeting of job strain in work-based mental health prevention programmes.[7,8] However, previous attempts to establish this association have been severely challenged by the possibility of reverse causation and residual confounding.

Associations between high job demands, low job control, and high job strain with symptoms of common mental disorder have been uncovered in decades of cross-sectional research, most notably in large population studies such as the British Whitehall study,[9] the Belgian BELSTRESS study,[10] the Dutch NEMESIS-2 study,[11] the Norwegian HUSK study,[12] and the Australian PATH 40+ study.[13] Although longitudinal studies in this field are less common, they have generally produced similar results to the cross-sectional research, even across a range of follow-up periods. In the French GAZEL study,[14] job demands and control predicted subsequent depressive symptoms over a 1-year period, and in the British Whitehall II study,[15] job demands and job control predicted subsequent psychiatric morbidity over a 5-year period. The prospective results, over a 7-year period, of the Belgian BELSTRESS study indicate[16] job demands (among men), job control (among women), and job strain (for both sexes) showed unadjusted associations with subsequent depressive symptoms. Consistent with these results, major meta-analyses and systematic reviews of the longitudinal evidence have found evidence of effects of job demands, control, and strain on risk of subsequent depression[17] and on risk of common mental disorders more generally.[4,18] Prospective studies have shown that these associations are similar in nature, regardless of whether depression is measured via self-report symptom inventories or diagnostic interviews.[19]

Despite the well established association between job strain and common mental disorders, several major barriers to causal interpretations remain. The first concern is that of reverse causation. Although the job demands–control model implies that adverse job characteristics

Research in context

Evidence before this study

Mental illness has become the leading cause of sickness absence and long-term incapacity in most high-income countries, which has led to increased academic, policy, and public attention on the association between job characteristics and mental health. Karasek's job demands–control model is the most widely studied and influential theory in this field, and the association between high job strain and common mental disorders has been well established in decades of cross-sectional and longitudinal research. However, serious barriers remain to casual interpretations—namely, those of reverse causation and residual confounding. We searched MEDLINE, PsycINFO, Embase, the Cochrane Collaboration, and grey literature databases until April 4, 2016, for publications in English using search terms including "mental health", "work", and "review". This search identified six systematic reviews or meta-analyses that assessed the association between job strain and common mental disorder. These reviews found that few published studies controlled for lifetime psychiatric symptoms or multiple confounding variables across different domains and age periods.

Added value of this study

Our findings show that high job demands, low job control, and high job strain have a prospective effect on risk of future onset of common mental disorder, independent of lifetime psychiatric history and other potential confounding variables across the lifespan. Moreover, 14% of common mental disorder cases are potentially preventable with the elimination of high job strain situations.

Implications of all the available evidence

The models produced in this study are, to the best of our knowledge, the most complete, in terms of taking account of potential confounding, to be published and suggest that job strain is of substantial importance to public health. These findings have important implications for the development of workplace interventions, because targeting of modifiable work-related risk factors, such as high job strain, might help to reduce prevalence of common mental disorders in the general population.

cause deterioration in mental health,[6] individuals with emerging poor mental health might be disadvantaged in the labour market and consequently over-represented in undesirable jobs.[1] Individuals who have a history of common mental disorder might also be more likely to perceive equivalent jobs more negatively than those without these disorders, which is consistent with the negative cognitive biases associated with depression and anxiety disorders. Although cross-sectional studies have provided no information about the order in which job strain and common mental disorders emerge, longitudinal studies in this field have attempted to address the possibility of reverse causation by excluding psychiatric cases or controlling for psychiatric symptoms at baseline. However, psychiatric symptoms earlier in life might be in remission and hence go undetected (and uncontrolled) at baseline, while affecting education, career trajectories, and job ratings.

A second concern is that of residual confounding: a third variable acting as a common cause of actual or perceived job characteristics and common mental disorder. A wide range of non-workplace mental health risk factors might be associated with self-reported job characteristics, such as sociodemographic variables, childhood intelligence, temperament, and stressful life events. Indirect evidence for such confounding comes from Henderson and colleagues'[20] finding that the apparent prospective association between job control and subsequent sickness absence was eliminated after controlling for childhood intelligence quotient (IQ) and education. Some longitudinal studies, such as the BELSTRESS study,[16] have found that prediction of depression symptoms by job strain was reduced to marginal significance once adjustment was made for age, education level, social network, satisfaction with private life, and locus of control. Despite these isolated findings, Bonde's[21] review of the literature on job strain and depression found that few published studies controlled for multiple confounding variables across different age periods.

Our study aimed to address concerns about reverse causation and residual confounding through analysis of data collected in the UK National Child Development Study (NCDS), a large British cohort study.[22] This dataset provides a unique opportunity to address these issues through assessment of the prospective association between job strain and onset of common mental disorder while controlling simultaneously for psychiatric symptoms measured at multiple timepoints, as well as a comprehensive set of other potential confounding variables recorded across the lifespan. The existence of job strain as a potentially modifiable causal factor of common mental disorders would have substantial public health implications, and substantial economic consequences for employers.

Methods

Participants

The 1958 Birth Cohort (NCDS) includes 17 416 (99%) of 17 634 births in the UK during the week of March 3–9, 1958. Data were obtained from cohort members, as well as their parents, schools, and medical officers, at ages 7, 11, 16, 23, 33, 42, 45, and 50 years.[22]

The overall study design and flow of participants through the various assessments is shown in figure 1. The base population for this study included participants who participated in the survey at age 45 years. Participants

were required to have completed the self-completion questionnaires for inclusion in this study. To obtain a cohort of working individuals free of depressive symptoms at baseline (aged 45 years), we excluded participants who reached the threshold for common mental disorder caseness, as defined by a Clinical Interview Schedule Revised score of 12 or higher[23] at age 45 years. The Clinical Interview Schedule Revised is a structured interview that enquires about symptoms of depression and anxiety disorders over the previous month and has been validated against more rigorous clinical diagnostic scales.[24] Participants aged 45 years were also asked, "Are you in paid work either full or part time?" and could respond yes or no. Those who indicated that they were not in paid employment at age 45 years were also excluded. We further removed individuals who changed employers between age 45 and 50 years. Previous analyses have shown that the 45-year-old sample is largely representative of the original birth cohort, although some disadvantaged groups have had a disproportionate loss to follow-up, in particular non-white participants, those from manual class backgrounds, those whose mothers did not remain in school, or those who lived in rented housing.[25]

Ethics approval for the study was granted by the South East Multi-Centre Research Ethics Committee, and participants provided written informed consent after receiving a complete description of the study.

Measures

At age 45 years, job strain variables were measured by use of items derived from the Whitehall II study questionnaire,[15] and on the basis of Karasek's Job Content Questionnaire.[6] The job control subscale comprised of three items measuring decision authority (ability to make decisions about work) and three items measuring skill discretion (opportunity to use skills during work). The job demands subscale comprised of four items that inquired about work pace, intensity, and conflicting demands. These ten items were selected because they had the strongest correlations with the corresponding total subscale scores in previous research.[15] Such research has shown similar associations between self-reported and objective measures of job demand and control.[26] Participants responded to each job strain item on a four-point Likert scale. Particular responses were reverse-scored so that high summed subscale scores indicated high job demands or control. In the present study, reliability was acceptable for the job demands (Cronbach's α=0·69) and job control (Cronbach's α=0·79) subscales. In line with previously published studies that have used the same questions to assess job demand and control,[15,27,28] the scores for these subscales were divided into tertiles (low, medium, and high scores). A job strain measure was computed by the combination of the job demands and control subscales as shown in figure 2, producing nine exposure categories that were further classified into three levels of job strain: low, intermediate, and high.[2]

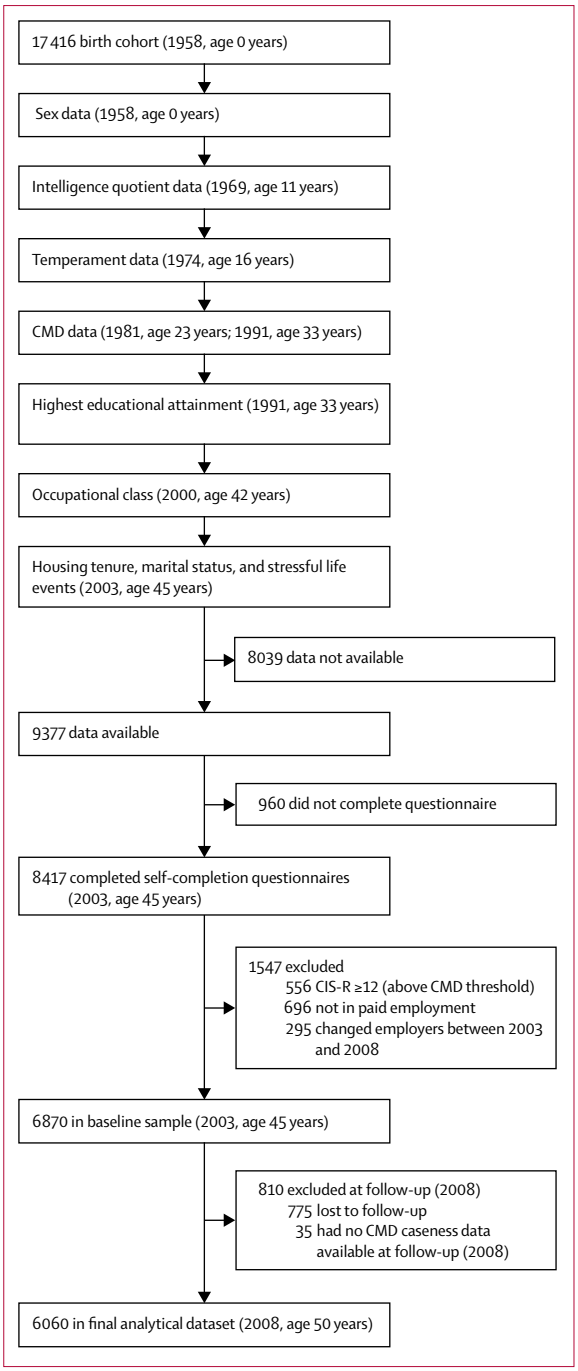

Figure 1: **Study profile**
CMD=common mental disorder. CIS-R=Clinical Interview Schedule Revised.

The nine-item psychological subscale of the Malaise Inventory[29] was used to detect case-level common mental disorders at age 50 years. The psychological subscales of the Malaise Inventory are commonly used in health surveys and have previously been shown to be validated methods of discriminating those with psychiatric morbidity.[30] Each question enquires about symptoms of

	Job demands tertiles		
Job control tertiles	Tertile 1: Low	Tertile 2: Medium	Tertile 3: High
Tertile 1: Low	Intermediate job strain	High job strain	High job strain
Tertile 2: Medium	Low job strain	Intermediate job strain	High job strain
Tertile 3: High	Low job strain	Low job strain	Intermediate job strain

Figure 2: **Division of the job strain variable into low (lilac), intermediate (white), and high (red) job strain**

depression or anxiety, for example, "Do you often feel depressed?" and "Do you often get worried about things?" For each question, a score of 1 was assigned to a yes response and 0 otherwise, and from this a total score ranging between 0 and 9 was generated. Following previous use of this subscale,[31] a score of 4 or higher was considered indicative of case-level symptoms of common mental disorder. In the case of missing data in some but not all items, individuals were only excluded where sufficient missing values could potentially move them into the caseness category.

Covariates

A range of potential confounding variables were analysed as covariates. Each of these has been previously shown to be associated with future common mental disorder and impaired occupational trajectories and, therefore, a high chance of adverse work characteristics and job strain situations.[28,32–34] Marital status at age 45 years was grouped into five categories: single and never married, married or remarried, legally separated, divorced, and widowed. Highest educational attainment at age 33 years was grouped into three hierarchical categories: no formal educational qualifications, O level (lower secondary education), and A level or higher (higher secondary education). Adult social position was represented by housing tenure at age 45 years and occupational class at age 42 years. Housing tenure is indicative of material circumstances[35] and is classified according to whether the housing is owner-occupied (outright or with mortgage) or other living arrangements such as renting, social landlord, or living with family. Occupational class was categorised by use of the British Registrar General classification (1 professional, 2 managerial or technical, 3 skilled, 4 partly skilled, or 5 unskilled).[36]

See Online for appendix

Psychiatric history was represented by case-level symptoms of common mental disorder at ages 23 and 33 years. The full 24-item Malaise Inventory was completed by participants at both ages, but was deemed appropriate to construct the malaise variables by use of the same nine items included in the follow-up at age 50 years. Consequently, a malaise score of 4 or higher out of a maximum score of 9 was considered indicative of case-level symptoms of common mental disorder at ages 23 and 33 years.

Stressful life events at age 45 years were measured as a comparison non-workplace predictor of mental health by use of an extended version of the List of Threatening Experiences Questionnaire,[37] which includes 16 items concerning adverse life events that occurred 6 months before the survey. This questionnaire has shown good validity and reliability, and has been recommended for use in psychiatric studies.[37] As we aimed to assess non-workplace stressful life events, the four items pertaining to employment were excluded from the summary score. Three other questions that were only applicable to cohort members with partners were also excluded. The remaining nine items comprised of questions on illness, separation from or serious problems within close relationships, death of a close family member or friend, financial problems, and experiences of assault. The number of life events was summed and divided into three categories (none, one, or two or more events).

Childhood IQ was derived from General Ability test scores[38] obtained at age 11 years for the measurement of early life covariates. Adolescent temperament was reflected in school teacher ratings on a scale of 1–5 of participants' cautiousness, moodiness, timidity, flexibility, sociability, and laziness at age 16 years.

Statistical analysis

We analysed all data with Stata version 12.0. We included analysis weighting to control for disproportionate loss to follow-up in some groups. As in previous analyses of NCDS data,[39] we calculated inverse probability weights from predicted response probabilities, derived from a logistic regression model for follow-up. The prediction equation included the significant predictors of response at age 50 years, and the effects of sex, social class, education, childhood IQ, and marital status. Because no extreme weights were assigned to any individual, we deemed trimming of weights to be unnecessary.[40] We also completed case analysis to ensure that results were not substantially altered by the application of inverse probability weighting (appendix).

We explored the univariate associations between adulthood covariates (sociodemographic factors and psychiatric history), early life covariates (childhood IQ and adolescent temperament), and job strain variables by use of logistic regression (cumulative logit function) with the three-level job strain variable as the dependent variable in all models. We also applied univariate logistic regression models to investigate the association between the covariates and case-level symptoms of common mental disorder at age 50 years. The common mental disorder caseness variable was binary and defined as a score of 4 or higher on the Malaise Inventory, which had possible scores ranging from 0 to 9. We did multivariate logistic regression to test the prediction of common mental disorder caseness by the job strain variables, accounting for covariates, and non-workplace stressful life events, adjusting for each other and for the covariates entered into the models in a sequence identified a priori. The order in which the covariates were entered followed the sequence of events

within this lifecourse data, such that after socioeconomic factors, early life factors were entered first, followed by young adult events and then midlife factors. Model 1 comprised the unadjusted univariate analysis. For model 2, we entered sociodemographic (sex and marital status) and socioeconomic (housing tenure, occupational class, and highest education) data, followed by early life factors (IQ at age 11 years, temperament at age 16 years) in model 3. We included past psychiatric problems (common mental disorder at ages 23 and 33 years) in model 4, and we controlled for adult non-work stressful life events in the final model (model 5) along with all the other potential confounders. Because some previously published data[16] have suggested differing associations between work and mental health depending on sex or social class, for all analyses we did two-way interactions between sex and occupational class and job strain and common mental disorder with the inclusion of a multiplicative two-way interaction term in the regression models. We only did stratified analysis if significant two-way interactions were detected. We computed population attributable fractions by use of the punaf command in Stata, which uses the normalising and variance-stabilising transformation statistical method.

Role of the funding source

The funders of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the study data and had final responsibility for the decision to submit for publication.

Results

The base population for this study included 9377 individuals who participated in the survey at age 45 years (figure 1). Of these participants, 8417 (90%) completed the self-completion questionnaires required for inclusion in this study: 556 individuals who reached the threshold for common mental disorder caseness, 696 who indicated that they were not in paid employment at age 45 years, and 295 who changed employers between age 45 and 50 years were excluded, leaving a final analytical sample of 6870 participants in the baseline sample. Between ages 45 and 50 years, 775 (11%) of 6870 participants in the analytical sample were lost to follow-up, and 35 had no data on common mental disorder caseness; thus, 6060 (99%) respondents had data on common mental disorder caseness, yielding a follow-up rate of 88·2% (figure 1).

Baseline characteristics of the analytical sample are shown in table 1. Missing data regarding job strain was present in 207 (3·4%) of 6060 participants, whereas 115 (1·9%) of 6060 participants had missing data on non-workplace stressful life events. Loss to follow-up was disproportionate at age 50 years among men, unmarried individuals, and those with low social class, education, and childhood IQ.

As expected, significant associations were found between job strain and the potential confounding variables of sex (p<0·0001), occupational class (p=0·029), psychiatric morbidity at ages 23 and 33 years (p<0·0001 for both), non-workplace stressful live events (p<0·0001), and the adolescent temperaments of being more timid and hardworking (p=0·03 for both; data not shown). Common mental disorder caseness at age 50 years was also associated in the expected direction with the potential confounding variables of sex (p<0·0001), housing tenure (p=0·0001), occupational class (p<0·0001), education (p=0·0002), IQ (p=0·003), psychiatric morbidity at ages 23 and 33 years (p<0·0001 for both), and higher moodiness ratings at age 16 years (p=0·0012). All variables were therefore included as covariates in the multivariate analyses, as planned a priori.

The odds ratios (ORs) and 95% CIs for common mental disorder caseness at age 50 years, as predicted by the job strain variables at age 45 years, are presented in table 2. The weighted rate of common mental disorder caseness at follow-up was 10·2%. In the unadjusted model—ie, model 1—greater odds of displaying case-level symptoms of common mental disorder at follow-up were associated with lower job control (OR 2·58, 95% CI 1·95–3·42; p<0·0001), higher job demands (1·69, 1·35–2·12; p<0·0001), and higher job strain (3·04, 2·35–3·92; p<0·0001). Confounding effects of socioeconomic characteristics (model 2) and early life factors (model 3) explained a substantial amount of the overall effects: inclusion of past psychiatric problems (model 4) in the regression model further attenuated the associations. The final model (model 5) controlled for the potential confounders listed above and mutually adjusted for work-related factors and life events. Although the effect sizes were attenuated, the significant positive associations between the odds of common mental disorder caseness and low job control (OR 1·89, 95% CI 1·29–2·77; p=0·0010), high job demands (1·70, 1·25–2·32; p=0·0008) and high job strain, (2·22, 1·59–3·09; p<0·0001) remained significant. Two-way interactions between job strain and sex (p=0·51) or occupational class (p=0·34) on common mental disorder were not significant. On the basis of the final multivariate model, we calculated the population attributable fractions for job strain. To calculate the population attributable fractions for high job strain situations, the low and medium job strain categories were combined. This allowed a calculation of how many new cases of common mental disorder could have been avoided if all the individuals reporting high job strain (1768 [weighted percentage 26%] of 6060) could have been moved into the combined low and medium job strain group. Assuming causality and an absence of residual confounding, 14% of new cases of common mental disorder could have been prevented through elimination of high job strain (population attributable fractions 0·14, 95% CI 0·06–0·20).

	All participants (n=6060)
Sex	
Male	3534 (52%)
Female	3336 (48%)
IQ at age 11 years (general ability test score)	
Quartile 1 (0–36)	1564 (27%)
Quartile 2 (37–48)	1548 (26%)
Quartile 3 (49–58)	1436 (23%)
Quartile 4 (59–79)	1442 (24%)
Temperament at age 16 years*	
Cautious versus impulsive	2·73 (0·88)
Moody versus even-tempered	3·64 (1·16)
Timid versus aggressive	2·92 (0·71)
Flexible versus rigid	2·74 (0·78)
Sociable versus withdrawn	2·31 (1·02)
Lazy versus hardworking	3·40 (1·18)
CMD at age 23 years	
No	5567 (93%)
Yes	396 (7%)
CMD at 33 years	
No	5926 (96%)
Yes	272 (4%)
Highest educational level at age 33 years	
No formal educational qualifications	1170 (20%)
O level	2085 (34%)
A level or higher	2837 (46%)
Occupational class at age 42 years	
1 (professional)	392 (5%)
2 (managerial or technical)	2592 (38%)
3 (skilled)	2730 (42%)
4 (partly skilled)	816 (12%)
5 (unskilled)	195 (3%)
Housing tenure at age 45 years	
Own outright or mortgage	6048 (88%)
Rent or other arrangements	785 (12%)
Marital status at age 45 years	
Single, never married	675 (10%)
Married or remarried	5069 (74%)
Legally separated	172 (3%)
Divorced or widowed	905 (13%)
Adult life events	
0	4008 (59%)
1	1758 (26%)
2 or more	969 (15%)

Data are n (%) or mean (SD). Data are weighted percentages or weighted means (and unweighted standard deviations). IQ=intelligence quotient. CMD=common mental disorder. *High scores represent inclination towards the second temperament listed in each line.

Table 1: **Baseline characteristics**

All analyses were repeated on the original, unweighted data (not shown), but the results did not substantially differ from the weighted estimates. We also repeated our analyses post hoc with log-binomial regression to compare the effect size estimates when presented as risk ratios rather than ORs. Although the multivariate models were unable to converge, the univariate models provided similar effect sizes to logistic regression (risk ratio [RR] for low job control *vs* high job control 2·36, 95% CI 1·82–3·06, p<0·0001; RR for high job demand *vs* low job demand 1·60, 1·31–1·97, p=0·0003; RR for high job strain *vs* low job strain 2·72, 2·16–3·44, p<0·0001).

Discussion

Although the presence of a prospective association between job strain and common mental disorders has been well established,[18,21,41] substantial doubts remain about the true nature of this association because of the concerns about possible reverse causation and residual confounding.[4] The present study has analysed lifecourse data to show that job demands, control, and strain have a prospective effect on risk of future onset of common mental disorder independent of lifetime psychiatric history and other potential confounding variables across the lifespan. The models produced in this study are the most complete, in terms of taking account of potential confounding, to ever be published and allowed us to determine an accurate estimate of the mental health effect of job strain at a population level. Our models suggest that up to 14% of common mental disorder cases in this cohort were potentially preventable with the elimination of job strain situations. Such estimates have important caveats, most notably an assumption of causation and an absence of any residual confounding. However, given the complexity of the models presented in this paper, this population attributable fraction suggests that job strain is an important modifiable risk factor for public mental health interventions to address.

The finding that lower job control, higher job demands, and higher job strain each predicted increased risk of future common mental disorders at 5-year follow-up corroborates reports that the job strain variables were associated with common mental disorders cross-sectionally in large population studies,[41] as well as prospectively in longitudinal studies.[18,21] The use of lifecourse data has enabled us to extend beyond previous research by rigorously controlling for lifetime psychiatric history and other early life factors. Previous studies typically only controlled for psychiatric symptoms at baseline, such that earlier psychiatric symptoms in remission might have gone undetected and uncontrolled. By contrast, the present study not only excluded participants meeting the threshold for psychiatric caseness at baseline, but also controlled for psychiatric morbidity as measured at two earlier points in the individual's life (ie, at ages 23 and 33 years). Furthermore, our use of lifecourse data enabled simultaneous control for an extensive set of other variables that could act as a common cause of self-reported job characteristics and risk of common mental disorders, including childhood, adolescence, and adulthood variables. The childhood and adolescence

	n (%)*	Model 1		Model 2		Model 3		Model 4		Model 5	
		OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
Job control											
Low	2212 (33%)	2·58 (1·95–3·42)	<0·0001	2·14 (1·58–2·92)	<0·0001	2·18 (1·54–3·08)	<0·0001	1·93 (1·32–2·81)	0·0006	1·89 (1·29–2·77)	0·0010
Medium	2991 (44%)	1·61 (1·22–2·13)	0·001	1·44 (1·07–1·93)	0·016	1·31 (0·93–1·83)	0·12	1·20 (0·84–1·72)	0·31	1·21 (0·84–1·74)	0·31
High	1526 (23%)	1·00	..	1·00	..	1·00	..	1·00	..	1·00	..
Job demand											
Low	2893 (43%)	1·00	..	1·00	..	1·00	..	1·00	..	1·00	..
Medium	2056 (31%)	1·52 (1·21–1·89)	0·0003	1·72 (1·36–2·18)	<0·0001	1·40 (1·07–1·84)	0·015	1·25 (0·93–1·69)	0·14	1·25 (0·92–1·70)	0·15
High	1737 (26%)	1·69 (1·35–2·12)	<0·0001	2·03 (1·58–2·60)	<0·0001	1·76 (1·33–2·33)	<0·0001	1·69 (1·25–2·29)	0·0007	1·70 (1·25–2·32)	0·0008
Job strain											
Low	2153 (33%)	1·00	..	1·00	..	1·00	..	1·00	..	1·00	..
Medium	2698 (41%)	1·81 (1·40–2·34)	<0·0001	1·67 (1·28–2·18)	0·0002	1·64 (1·21–2·22)	0·0014	1·49 (1·08–2·05)	0·014	1·54 (1·11–2·13)	0·0095
High	1768 (26%)	3·04 (2·35–3·92)	<0·0001	2·80 (2·14–3·66)	<0·0001	2·59 (1·91–3·52)	<0·0001	2·29 (1·65–3·17)	<0·0001	2·22 (1·59–3·09)	<0·0001

Model 1 is crude. Model 2 is adjusted for sex, housing tenure, occupational class, marital status, and highest education at age 33 years. Model 3 is adjusted for sex, housing tenure, occupational class, marital status, highest education at age 33 years, IQ at age 11 years, and temperament at age 16 years. Model 4 is adjusted for sex, housing tenure, occupational class, marital status, highest education at age 33 years, IQ at age 11 years, temperament at age 16 years, CMD at age 23 years, and CMD at age 33 years. Model 5 is adjusted for sex, housing tenure, occupational class, marital status, highest education at age 33 years, CMD at age 23 years, CMD at age 33 years, IQ at age 11 years, temperament at age 16 years, and adult non-work life events. CMD=common mental disorder. OR=odds ratio. IQ=intelligence quotient. *Data are weighted percentages.

Table 2: **Associations between job strain variables at age 45 years and new onset CMD caseness at age 50 years by use of logistic regression**

covariates have rarely been controlled for in previous studies. Through these innovations, the present study constitutes the most rigorous attempt to date to address concerns about reverse causation and residual confounding. Consequently, the present results permit several new conclusions to be drawn.

First, although reverse causation and residual confounding might contribute to the observed association between the job strain variable and common mental disorder, these issues do not entirely account for the association. The present findings strengthen the evidence that job strain has an independent causal effect on common mental disorder onset, as postulated in Karasek's[6] demands–control model. Second, comparison of effect sizes from our models suggests that low job control might exert a stronger independent influence on common mental disorder onset than on high job demands. The particular importance of job control as a causal factor is consistent with evidence of reduced common mental disorders following workplace interventions that improve employee control.[42] This importance might reflect the conceptual link between low job control and perceived low job control. Low perceived control is an important transdiagnostic vulnerability factor for several common mental disorders.

Our study also has important limitations. The chosen method of analysis for our nested-case control study was logistic regression. Although appropriate for this study design, logistic regression can inflate effect sizes compared with other types of analysis that produce risk ratios. To explore this possibility, we re-ran our analyses post hoc with log-binomial regression. Even though the multivariate models were unable to converge, the univariate models provided similar effect sizes to those reported with logistic regression. Failed conversion of multivariate log-binomial regression models is common and results from the maximisation process not being able to find the maximum likelihood estimate, which does not imply any absence of significance of the underlying association of interest, but rather the mathematical complexities of working with probabilities within a log-link function. As with many studies in this field, self-reported measures were used to assess job strain and common mental disorders. Consequently, common method factors might have inflated the associations between these variables. However, the adjustment for several potentially relevant variables (eg, childhood temperament) might have gone some way to mitigating this risk. Although an extensive set of covariates were controlled for to restrict overestimated associations, some residual confounding remains possible, particularly from variables such as physical health, substance misuse, and family psychiatric history. Residual confounding is also a possibility because of misclassification of the measured confounders. For example, the personality measures obtained might not have adequately captured all the personality traits, which could be relevant for the associations under investigation. We also note that this study only assessed job strain and suggested that other work-related risk factors for common mental disorders, such as effort-reward imbalance and job insecurity, might have a role as residual confounders. The pattern of exposure to job strain over time, particularly the chronicity of any exposure, might also be important. A related limitation is that our sample was selected to be in employment and without any evidence of mental illness at baseline (age 45 years). As a result, some individuals who were more prone to mental disorders were likely to

have been excluded on the basis of their symptoms or the fact that their previous illness might have contributed to them leaving the workforce. This exclusion might have made our sample more resilient, an issue often termed the healthy worker effect, which could have resulted in an underestimation of the effect of job strain on mental health. Additionally, regardless of our attempts to define a sample without mental health symptoms at baseline and to control for previous mental health problems, some of our sample population might have had a previous mental disorder that was well controlled at each assessment. This possibility means that an element of reverse causation could remain in our final models.

Other factors might have contributed to the underestimation of the true effect of job strain. Since the outcome was future common mental disorders at a single 5-year follow-up, the analyses were insensitive to psychiatric consequences of job strain that emerged after the baseline measure but subsided before follow-up. Limitations to the study's external validity also exist. Although the base sample was large and generally representative of the UK population, evidence of differential attrition existed, with only 8417 (48%) of the original sample recruited at birth providing valid responses at age 45 years. Despite this limitation, previous analyses have shown that the 45-year-old sample remains largely representative of the original birth cohort, although some disadvantaged groups have had a disproportionate loss to follow-up, in particular non-white participants, those from manual class backgrounds, whose mothers did not remain in school, or who lived in rented housing.[25] Even though weighting was used in the analysis to address this concern, such weighting can only consider predictors of attrition measured at baseline. This limitation means that factors that might have affected attrition but occurred after baseline—eg, emerging mental health problems— could not be accounted for. As in all birth cohort studies, these results are also subject to cohort effects and might be age specific. For example, job control appeared to be a particularly important influence on mental health in this cohort; however, this might not generalise to younger workers for whom relatively low job control could be more acceptable given their early career status. Moreover, since the cohort members were all British and were surveyed during the 2008 global financial crisis, the present results might not generalise to workers of other nationalities or to time periods of differing job security. Our study focused on common mental disorders occurring between the ages of 45 and 50 years, which is not the peak age of onset of mental health problems. As such, the overall effect of job strain might be underestimated.

Since data were not collected concerning temporal patterns of exposure to job strain (eg, gradual *vs* sudden onset or acute *vs* chronic exposure), it is unclear from these results whether some patterns of exposure have particularly deleterious effects on mental health. For example, the BELSTRESS study indicated that repeated job strain has a strong adverse effect on mental health compared with less chronic strain.[16] However, the present study has highlighted the potential public health effect of addressing job strain factors in the workplace. Previous research on interventions aimed at increasing employee control[42,43] or improving job design[44,45] has shown some promise in the promotion of mental health and reduction of stress in the workplace. To capitalise on this potential, more methodologically rigorous evaluation of workplace interventions should be focused on these modifiable risk factors.

Contributors

SBH, MH, SLH, and AM had the original idea for the study and formulated the analysis plan. SBH and M-JW acquired the data. SBH, DAS, and M-JW did the statistical analysis. SBH, DAS, and M-JW drafted the manuscript, which was revised for additional interpretation by all authors.

Declaration of interests

We declare no competing interests.

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