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**Psychosocial factors and hospitalisations for Covid-19: Prospective cohort study of the general population**

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*Conflict of interest:* Ian Deary was responsible for the design of some of the cognitive function tests in the revised battery used in the imaging sessions in UK Biobank; he is also a study participant.

*Transparency*: GDB affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

*Contributions:* The authors collectively generated the idea for the present paper and formulated an analytical plan; ML built the dataset; CRG carried out the data analyses; DA prepared the figures; and GDB wrote the first draft of manuscript. All authors commented on an earlier version of the manuscript. GDB, CRG, ML and IJD will act as guarantors for this work. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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*Ethical approval*: In UK Biobank, ethical approval for data collection was received from the North-West Multi-centre Research Ethics Committee and the research was carried out in accordance with the Declaration of Helsinki of the World Medical Association.

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**Abstract**

*Objective:* To examine the association of a range of psychosocial factors with hospitalisation for Covid-19.

*Design:* Prospective cohort study

*Setting:* England.

*Participants:* UK Biobank comprises around half a million people who were aged 40 to 69 years at study induction between 2006 and 2010 (response rate 5.5%) when information on psychosocial factors and covariates were captured.

*Main outcome measure:* Hospitalisation for Covid-19 in England between 16th March and XXXXXX 2020 as provided by Public Health England.

*Results:* There were 908 hospitalisations for Covid-19 in an analytical sample of XXXXXX. In age- and sex-adjusted analyses, an elevated risk of Covid-19 was related to disadvantaged levels of education (odds ratio; 95% confidence interval: 2.05; 1.70, 2.47), income (2.00; 1.63, 2,47), area deprivation (2.20; 1.86, 2.59), occupation (1.39; 1.14, 1.69), psychological distress (1.58; 1.32, 1.89), mental health (1.50; 1.25, 1.79), neuroticism (1.19; 1.00, 1.42), and performance on two tests of cognitive function – verbal reasoning (2.66; 2.06, 3.34) and processing speed (1.27; 1.08, 1.51). All associaitions were graded (p-value for trend ≤0.038). After mutual adjustment for these characteristics plus ethnicity, comorbidity, and lifestyle, only the relationship between lower cognitive function as measured using the verbal reasoning test and a doubling in the risk of the infection remained (1.98; 1.38, 2.85).

*Conclusion:* A range of psychosocial factors revealed associations with hospitalisations for Covid-19 of which the relation with cognitive function was most robust.

Key words: risk factors, Covid-19, hospitalisation, cohort study, UK

**Box**

*What is already known on this subject*

* Given the recent discovery of Covid-19, its aetiology is not well understood.
* The little evidence that is available has been gleaned from prognostic studies of disease progression and death.
* We are not aware of any studies of the role of psychosocial factors in the primary prevention of the infection.

*What this study adds*

* A higher risk of hospitalisation for Covid-19 was evident at disadvantaged levels of education, income, area deprivation, occupation, psychological distress, mental health, neuroticism, and cognitive function.
* After taking into account multiple confounding factors, the most robust of these associations was for cognitive function.

**Introduction**

With outbreaks reported across 114 countries, the novel coronavirus referred to as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared pandemic by the World Health Organization on 11th March 2020.1 By 11th May, in the absence of widespread testing in most countries, there has been global notification of 4 million cases of coronavirus disease 2019 (COVID-19) – the disease caused by SARS-CoV-2 – with it being implicated in more than 270,000 deaths.2 Equivalent data releases for the UK indicate 223,060 cases and 32,065 deaths.3

Prior pandemics – Spanish influenza in 1918 and Swine influenza in 2009 – were notable for marked inequalities in their occurrence, whereby more socioeconomically disadvantaged countries,4,5 cities,6 neighbourhoods,7,8 and individuals9 experienced the highest mortality rates from the infection. Recent findings from analyses of data for Covid-19 hospitalisations across the five boroughs of New York City10 and deaths involving the infection in the UK11 reveal higher rates in more deprived areas. The mechanisms that underlie these gradients may involve overcrowded living and working conditions, comorbidity, and a lack of understanding of prevention advice among socially disadvantaged individuals. Indirect pathways may include the higher prevalence of unfavourable health behaviours – cigarette smoking, alcohol intake, and suboptimal nutrition – in lower social groups which in themselves have been linked to selected lower respiratory tract infections.12

While correlated with socioeconomic status,13,14 mental health and cognitive function may have independent utility in understanding the burden of respiratory disease. Although described as a potential consequence of Covid-19 based studies of survivors of the severe acute respiratory syndrome (SARS) pandemic,15,16 poor psychological health may also influence the risk of contracting the respiratory infection by impairing innate and adaptive immunity.17 In a cross-sectional study, mental health problems were correlated with a higher likelihood of reporting the common cold,18 a coronavirus species. In cohort studies generated using linked electronic registries, people with a history of depression,19 psychosis,20 and stress disorders21 serious enough to warrant treatment in a psychiatric care facility subsequently experienced elevated rates of an array of respiratory infections. Additionally, in the general population, even moderate levels of self-reported symptoms of psychological distress (depression and anxiety) have been prospectively linked to an elevated risk of death from pneumonia despite adjustment for confounding factors which include socioeconomic position.22

In the current pandemic, the public has been saturated with preventative advice and guidelines which span the simple and practical to the complex, contradictory and false.23-25 In order to diminish their risk of the infection, the population has to acquire, synthesis, and deploy this information – described by some commentators as an ‘infodemic’ – but the ability to do so seems to vary by levels of health literacy26 just as it may for its close correlate, cognitive function. Although traditionally studied in the context of non-communicable disease,27-29 higher levels of cognitive ability – a psychological trait that involves the storage, selection, manipulation, and organisation of information – appear to be related to markedly lower rates of mortality from infectious disease after taking into account social circumstances.30,31

With this evidence base giving us reason to anticipate links between these psychosocial characteristics and incident Covid-19 infection, we explored these relationships using data from UK Biobank, a prospective cohort study. To the best of our knowledge, this is the first examination of the role of individual-level psychosocial characteristics in the primary prevention of Covid-19.

**Methods**

We used data from both UK Biobank,32 a prospective cohort study, the sampling and procedures of which have been well described.13,33 In brief, baseline data collection took place between 2006 and 2010 in twenty-two research assessment centres across t­­­he UK, resulting in a sample of 502,655 people aged 40 to 69 years (response rate 5.5%).32 In UK Biobank, ethical approval was received from the North-West Multi-centre Research Ethics Committee, and the research was carried out in accordance with the Declaration of Helsinki of the World Medical Association, and participants gave informed consent. No additional ethical approval was required for present analyses of anonymised data.

*Assessment of socioeconomic factors*

We used four indicators of socioeconomic status. Total annual household income before tax was self-reported and classified into three groups (<18,000, -30,999, -51,999, ≥£52,000 GBP). For educational qualifications, we used a three category variable (degree, other qualifications, no qualifications). Using current job title, or most recent if participants were not working at baseline assessment or data on current job were missing, we produced three categories with managerial positions having the highest prestige (managers & senior officials, professional, associate professional & technical; administrative & secretarial, & skilled; and personal service, sales & customer service, process, plant & machine operatives, elementary). Lastly, we used the Townsend deprivation index as our indicator of neighbourhood socioeconomic circumstances. Based on a composite of four characteristics (home and car ownership, employment, and number of households resident), participants’ postcodes at recruitment were matched to output areas from the most recent national census. A continuously scored variable, higher values denote greater deprivation.

CG: the result for occupation and Covid-19 looks odd. What is the relationship between occupation and CVD death– an outcome that illustrates inequalities *par excellence* and one we used in the BMJ UKBB paper? Is it also non-linear?

*Assessment of psychological factors*

We captured five psychological factors. Study members were asked if they had ever been under the care of a psychiatrist for any mental health problem; in the UK, such a referral would ordinarily have been triaged via a general practitioner. Symptoms of psychological distress were measured using the four item version of the Patient Health Questionnaire (PHQ-4)6 in which individual items are rated on a 4 point Likert scale from 0 (“not at all”) to 3 (“nearly every day”) such that total scores range from 0 to 12 (higher scores denote greater distress). Scores on the PHQ-4 show good agreement with longer scales, and reveal known correlations with demographic risk factors for depression and anxiety.7 Neuroticism was measured with the 12-item Eysenck Personality Questionnaire-Revised Short Form;8 higher scores denote higher levels.

Two tests of cognitive functioning were administered. Verbal and numerical reasoning was measured using a computerized 13-item multiple-choice test with a two-minute time limit. The score was the number of correct answers. This test was introduced after the beginning of the baseline assessment period so data are available for a subset of study members only (N=180,914). Reaction time was measured using a computerized Go/No-Go “Snap” game. Participants were presented with electronic images of two cards. If symbols on the cards were identical, participants were instructed to immediately push the button-box using their dominant hand. The first five pairs were used as a practice with the remaining seven pairs, containing four identical cards, forming the assessment. Reaction time score was the mean time (milliseconds) to press the button when each of these four pairs was presented. Choice reaction time correlates strongly with single mental tests that involve complex reasoning and knowledge.34

*Assessment of confounding factors*

Ethnicity was self-reported and categorised as White, Asian, Black, Chinese, Mixed, or other ethnic group. A social isolation scale was derived from enquiries concerning number of people in household, visiting friends/family, and social activities.35 One point was allocated for living alone, one for friends/family visits less than once/month, and one for no weekly participation in social activities. Social isolation was denoted by a score of 3. Self-reported physician diagnosis was collected for vascular or heart problems, diabetes, chronic lung disease, asthma, and cancer. Cigarette smoking, physical activity, and alcohol consumption was measured using standard enquiries. Height and weight were measured directly during a medical examination from which body mass index was calculated using the usual formulae (weight, kg/height,2 m2). Forced expiratory volume in one second, a measure of pulmonary function, was quantified using spirometry with the best of three technically satisfactory exhalations used in our analyses. Handgrip strength was measured using a hydraulic hand dynamometer (Jamar J00105) with the participant maximally squeezing the handle of the dynamometer while seated for 3 seconds; an average of the readings from the right and left hand was used. Seated systolic and diastolic blood pressure measurements were made twice using the Omron HEM-7015IT digital blood pressure monitor (Omron Healthcare)20 or, exceptionally, a manual sphygmomanometer; an average of the two readings was used herein. We defined hypertension according to existing guidelines as systolic/diastolic blood pressure ≥140/90 mmHg and/or self-reported use of antihypertensive medication.36 Non-fasting venous blood was drawn with assaying conducted at dedicated central laboratory for C-reactive protein, glycated haemoglobin, and high-density lipoprotein cholesterol.37

*Ascertainment of hospitalisation for Covid-19*

Provided by Public Health England, data on Covid-19 status downloaded on 1st May 2020 covered the period 16th March 2020 until XXX 2020.38 Samples were taken from in- patients and can therefore be regarded as a proxy for hospitalisations for severe cases of the disease. With coverage being for England only, study members from Scotland and Wales were omitted from our analytical sample.

In preliminary analyses, we used three different Covid-19 case definitions based on these data: all apparent cases of the disease (N=908); cases based on samples from in-patients only (N=751); and cases based on two or more samples from in-patients (N=445) – the notion being that those people tested more frequently were most likely to be in hospital at the time of testing. Evidence from prognostic studies of hospitalised patients in the USA39 and China40 suggest that men, older individuals, ethnic minorities, and those with existing disease experience greater rates of progression to intensive care and death. Preliminary analyses of the present data on incidence of severe disease revealed similar associations irrespective of case definition (supplemental table 1), although the association with older age was U-shaped. On the basis of this predictive validity, we proceeded with our main analyses in which we used all Covid-19 cases.

*Statistical analyses*

We omitted from our analyses men and women who had died before 5th March 2020 – the latest date to which vital status data were available – as they could not contribute to the risk set for Covid-19. Odds ratios and accompanying 95% confidence intervals were computed using logistic regression models to summarise the relationship between psychosocial factors and Covid-19 hospitalisations. In the main analyses, we initially adjusted odds ratios for age and sex, followed by ethnicity, then covariates organised into comorbidities (vascular disease, diabetes etc), lifestyle factors (cigarette smoking etc), and, depending on the psychosocial exposure of interest, socioeconomic or psychological factors. In preliminary analyses, the addition of biomarkers to the final model had no appreciable impact on the effects estimates relative to the final model in which they did not feature (supplemental tables 4 and 5 versus tables 2 and 3); these covariates therefore did not feature in the main analyses. Analyses were conducted using Stata version 13.

**Results**

In XXXXXX study members (XXXX women) there were 908 hospitalisations for Covid-19 between 16 March 2020 and YYY in England (XX in women). Of the 28 baseline characteristics featured in table 1, only four – extant cancer, grip strength, neuroticism, and social isolation – did not reveal relationships with Covid-19 at conventional levels of statistical significance in bivariate analyses. These were therefore excluded as covariates from subsequent multiple regression analyses.

In table 2 and figure 1 we depict the association between various socio-economic characteristics and the risk of hospitalisation for Covid-19 infection. After adjustment for age and sex, those study members who were most disadvantaged educationally, financially, and geographically experienced around a doubling in the risk of infection. Effects in these analyses were apparent across the full socioeconomic continuum (p for trend <0.0001). While controlling for ethnicity had little impact on these gradients, partial attenuation was apparent after taking into account comorbidities and lifestyle factors.

However, adjusting for psychological characteristics had the most explanatory power relative to the minimally-adjusted odds ratios, whereby the risk of hospitalisation remained somewhat elevated at both lower levels of education and income but statistical significance at conventional levels was lost. Given the known correlation between education and cognitive reasoning (herein, r=XX, p-value XXx), in sensitivity analyses we removed reasoning from the model containing the 5 psychological factors. This resulted in the magnitude of low education–Covid-19 relationship being restored (odds ratio; 95% confidence interval for no qualifications: 2.08; 1.69, 2.56) and suggested most of the marked attention seen for this relationship after taking into account psychological factors were ascribed to differences in cognition. The association between area deprivation and risk of infection was more robust to these various statistical adjustment.

Of the socioeconomic variables, occupational classification of the study member revealed the weakest associations overall with hospitalisation for Covid-19 and, in all analyses, study members in the administrative/secretarial in fact experienced protection against the infection. Lastly, after including up to seventeen covariates in the most complex multivariable models, there was evidence of some weak residual associations for income and deprivation but not for education.

In table 2 and figure 2 we illustrate the associations between psychological traits and the risk of Covid-19. In minimally-adjusted analyses, all psychological factors were related to the risk of hospitalisation with the infection. Effects for neuroticism and reaction time – weak initially – were essentially eliminated after control for comorbidities and any subsequent group of covariates. Adjustment for comorbidities also had a partial impact on the relation of distress, psychiatric consultation, and verbal reasoning with the infection, but associations largely remained, most obviously for reasoning. After multiple control for all covariates, however, the only relationship that remained with Covid-19 was that for verbal reasoning such that the most disadvantaged group experienced around a doubling of hospitalisation risk.

We also carried out some planned sensitivity analyses. With the reasoning test having been introduced part way through baseline data collection, as indicated, analyses featuring this variable were based on a subgroup of study members. To ensure direct comparison across statistical models, for each exposure we therefore recomputed our analyses based on a non-missing dataset (supplemental table 2 for socioeconomic characteristics, and supplemental table 3 for psychological characteristics). The same pattern of association was apparent in these new analyses.

**Discussion**

*Principal findings*

Our main findings were that disadvantaged levels of a series of psychosocial characteristics – education, income, area deprivation, mental health, and cognitive function – were related to an elevated risk of hospitalisations with Covid-19 in most of the analyses conducted. Net of mutual control for these factors, and after taking into account other potentially covariates, however, only the relationship between lower cognitive function based on a test of numerical reasoning and a higher risk of this infection remained. That we were able to replicate findings for apparently known risk factors for Covid-19 from prognostic studies – being male, having an ethnic minority background, carrying a comorbidity – gives us some trust in our more novel findings for these psychosocial factors.

*Comparison with results from other studies*

We are unaware of any published studies exploring the impact of individual-level psychosocial factors on the occurrence of risk of Covid-19. Prognostic studies using area-based statistics have recently been published, however. In New York City, Manhattan, the most socioeconomically advantaged borough based on routinely collected education and poverty statistics, had the lowest rates of hospitalisations for Covid-19 relative to the four remaining areas.10 While, by contrast, the Bronx, the least favourable socioeconomically, had the highest level of hospitalisations, rates were graded across the boroughs for education but not poverty. In a recent report from the Office for National statistics in the UK, rates of death in which Covid-19 was implicated were directly related to neighbourhood deprivation in a step-wise manner.11 Outside the eras of pandemics, other respiratory diseases such as tuberculosis,41,42 pneumonia,43 influenza,44 and, importantly, the common cold45 – also appear to be similarly socioeconomically patterned, although these are not universal observations.46,47 We are unaware of any studies exploring the relation of indicators of cognitive function and mental health with Covid-19, though up to a doubling in rates of death from respiratory disease has been reported in people with lower cognition test scores,30,31 individuals with a serious mental illness,20 and those with lower levels of psychological distress.22

*Mechanisms of effect*

Specific and non-specific mechanisms may link these psychosocial variables to the risk of Covid-19.

A plausible explanations for the association between cognition and respiratory infection is that people with higher ability, and indeed the educationally advantaged,48 are more likely to take-up influenza and pneumococcal inoculation, however, in absence of any effective vaccination for Covid-19 this is implausible. In our analyses we took into account unfavourable health behaviours which are more common in lower cognition scoring groups49-53 and have also been implicated in the incidence of pneumonia54 but the effect for cognition remained. It may be that the deluge of health advice in the current pandemic during a period when news outlets and social media platforms have never been more ubiquitous, has highlighted that lower cognition and therefore poor health literacy in the population is a public health concern. In a small-scale cross-sectional study, people with low health literacy reported being less concerned about the current pandemic and to believe they were at lower risk.26

Mental health problems may influence the risk of acquiring a respiratory infection by negatively impacting cognitive function,55 potentially compromising the ability to adequately recognise a deterioration in health, actively seek medical attention, and communicate effectively with health care professionals. An unhealthy lifestyle and sub-optimal circumstances including poor housing and lower income are also more common in people with mental health problems13,56 but we were careful to covary on these factors in our analyses. It may also be the case that people experiencing levels of psychological distress may have diminished learned resistance to infection owing to fewer social interactions, although a pre-pandemic measure of social isolation in our analyses did not confer the expected protection against the infection.

*Study strengths and limitations*

The strengths of our study include it being very well characterised for exposures and covariates despite its scale, allowing us to attempt to identify independent effects. That the study is prospective means assessment of these baseline data preceded that of disease onset; as such, reverse causality is not a concern such that the infection could not, for instance, influence mental health and job loss leading to downward social mobility. Our work is of course not without its weaknesses. Samples were taken from hospitalised patients but it is unclear if all cases had been exclusively hospitalised because of Covid-19-type symptoms, or, as seem likely given mass testing within hospitals, some patients were found to be positive for the infection while an inpatient for other reasons. We excluded study members who had died prior to 5th March 2020 because they could not contribute to the risk set, however, ascertainment of Covid-19 hospitalisation did not reliably begin until 16th March. It is unlikely, however, that the absence of vital status data for this 11 day period would have impacted on our effect estimates in a large dataset.

The Biobank study sample is recruited from only 5.5% of the target population agreeing to participate.32 As has been demonstrated,57,58 the data material is therefore inappropriate for estimation of risk factor or disease prevalence and this includes the Covid-19 infection and any data simulations of its dissemination. As we have demonstrated, however, these observations do not seem to influence reproducibility of the association of established risk factors for non-communicable disease such as vascular disease and selected cancers, and other health endpoints such as suicide.58 We think the same reasoning can be applied to communicable disease.

*Conclusions*

In conclusion, in this aetiological-orientated study, a range of psychosocial factors showed associations with hospitalisations for Covid-19, among which cognitive function was most robustly related. Replications in other cohorts is required before policy recommendations can be advanced.

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**Table 1. Psychosocial factors and covariates at baseline according to hospitalisations for Covid-19**

(CG: please add new p-value to accompany new point estimate which is from analyses of current vs. never smokers as I understand it. Also, what’s our new term for manual social class?)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristic** | **Covid-19 hospitalisation** | | **P value** | **Unadjusted OR**  **(95% CI)a** |
|  | **Yes**  **(n=908)** | **No**  **(n=430,143)** |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| *Demographic factors* |  |  |  |  |
| Age (yrs), mean (SD) | 57.27 (8.99) | 56.36 (8.10) | 0.0007 | 1.12 (1.05, 1.20) |
| Female, no. (%) | 402 (44.27) | 236,323 (54.94) | <0.0001 | 0.65 (0.57, 0.74) |
| Non-white ethnicity | 128 (14.22) | 25,170 (5.89) | <0.0001 | 2.65 (2.20, 3.20) |
| Socially isolated, no (%) | 90 (9.91) | 38,353 (8.92) | 0.293 | 1.12 (0.90, 1.40) |
|  |  |  |  |  |
| *Comorbidities* |  |  |  |  |
| Vascular or heart disease, no. (%) | 383 (42.7) | 124,306 (29.03) | <0.0001 | 1.82 (1.60, 2.08) |
| Hypertension, no (%) | 566 (64.61) | 238,111 (56.35) | <0.0001 | 1.44 (1.22, 1.69) |
| Diabetes, no. (%) | 90 (10.03) | 21,316 (4.98) | <0.0001 | 2.13 (1.71, 2.64) |
| Chronic bronchitis or emphysema, no. (%) | 28 (3.08) | 6,311 (1.47) | <0.0001 | 2.14 (1.47, 3.11) |
| Asthma, no. (%) | 126 (13.88) | 49,600 (11.53) | 0.027 | 1.24 (1.02, 1.49) |
| Cancer, no. (%) | 75 (8.42) | 31,051 (7.26) | 0.183 | 1.17 (0.93, 1.49) |
|  |  |  |  |  |
| *Lifestyle factors* |  |  |  |  |
| Current smoker, no (%) | 102 (11.37) | 42,636 (9.97) | 0.162 | 1.35 (1.09, 1.68) |
| No physical activity, no (%) | 117 (13.31) | 26,096 (6.16) | <0.0001 | 2.34 (1.93, 2.84) |
| Drinks alcohol daily/almost daily, no (%) | 148 (16.41) | 87,754 (20.46) | 0.003 | 0.76 (0.64, 0.91) |
| Body mass index, mean (SD) | 29.2 (5.45) | 27.4 (4.77) | <0.0001 | 1.37 (1.30, 1.44) |
|  |  |  |  |  |
| *Biomarkers* |  |  |  |  |
| Lung function, mean (SD) | 2.69 (0.82) | 2.82 (0.80) | <0.0001 | 0.84 (0.78, 0.90) |
| Hand grip strength, mean (SD) | 32.5 (11.0) | 32.5 (11.3) | 0.970 | 1.00 (0.94, 1.07) |
| C-reactive protein, median (IQR) | 1.63 (0.84-3.04) | 1.24 (0.63-2.44) | 0.0001 | 1.29 (1.20, 1.39) |
| High-density lipoprotein, median (IQR) | 1.33 (1.11-1.56) | 1.43 (1.20-1.71) | 0.0009 | 0.69 (0.63, 0.76) |
| HbA1C, median (IQR) | 35.6 (33.3-38.2) | 35.0 (32.6-37.4) | 0.0001 | 1.29 (1.20, 1.40) |
|  |  |  |  |  |
| *Psychological factors* |  |  |  |  |
| Psychological distress score ≥3, no (%) | 224 (28.64) | 90,981 (23.69) | 0.001 | 1.29 (1.11, 1.51) |
| Psychiatric consultation, no (%) | 140 (15.71) | 48,599 (11.38) | <0.0001 | 1.45 (1.21, 1.74) |
| Neuroticism, mean (SD) | 4.37 (3.39) | 4.27 (3.28) | 0.371 | 1.03 (0.96, 1.10) |
| Reasoning, mean (SD) | 5.24 (2.08) | 6.03 (2.16) | <0.0001 | 1.47 (1.32, 1.63) |
| Reaction time, mean (SD) | 574.91 (134.88) | 558.83 (117.73) | <0.0001 | 1.13 (1.06, 1.20) |
|  |  |  |  |  |
| *Socioeconomic factors* |  |  |  |  |
| No university education | 647 (73.86) | 283,693 (67.36) | <0.0001 | 1.37 (1.18, 1.59) |
| Annual household income<£18,000 | 241 (33.1) | 80,966 (22.27) | <0.0001 | 1.73 (1.48, 2.01) |
| Neighbourhood deprivation score | -0.08 (3.53) | -1.32 (3.06) | <0.0001 | 1.43 (1.35, 1.51) |
| Manual social class | 149 (26.28) | 58,766 (19.07) | <0.0001 | 1.51 (1.25, 1.82) |
|  |  |  |  |  |

1Odds ratios are expressed per category, or per SD increase for continuous variables except for reasoning which is expressed per SD decrease. The maximum analytical sample of 431051 people was lower in selected analyses owing to missing data.

**Table 2. Odds ratios (95% CI) for the relation of socioeconomic factors with Covid-19 hospitalisation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Case no./Risk no.1** | **Adjustments** | | | | | |
|  |  | **Age & sex** | **Age, sex & ethnicity** | **Age, sex, ethnicity & comorbidity2** | **Age, sex, ethnicity & lifestyle factors3** | **Age, sex, ethnicity & psychological factors4** | **All covariates** |
| **Educational attainment** |  | N=422057 | N=420502 | N=415945 | N=415367 | N=155244 | N=152739 |
| University degree | 229/137717 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Other qualifications | 406/214337 | 1.16 (0.98, 1.36) | 1.19 (1.01, 1.41) | 1.16 (0.98, 1.37) | 1.03 (0.87, 1.22) | 1.06 (0.81, 1.39) | 0.94 (0.71, 1.24) |
| No qualifications | 241/70003 | 2.05 (1.70, 2.47) | 2.07 (1.71, 2.50) | 1.85 (1.53, 2.25) | 1.47 (1.20, 1.80) | 1.35 (0.93, 1.95) | 1.01 (0.68, 1.49) |
| P for trend |  | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.151 | 0.945 |
|  |  |  |  |  |  |  |  |
| **Annual household income** |  | N=364219 | N=363175 | N=359853 | N=359491 | N=137808 | N=135773 |
| <£18,000 | 241/81207 | 2.00 (1.63, 2,47) | 1.89 (1.51, 2.35) | 1.74 (1.39, 2.17) | 1.39 (1.10, 1.75) | 1.34 (0.91, 1.97) | 1.15 (0.77, 1.73) |
| £18,000-£30,999 | 179/92461 | 1.31 (1.05, 1.63) | 1.27 (1.01, 1.60) | 1.22 (0.97, 1.54) | 1.05 (0.83, 1.32) | 1.29 (0.90, 1.85) | 1.15 (0.79, 1.68) |
| £31,000-£51,999 | 167/95454 | 1.18 (0.94, 1.48) | 1.17 (0.94, 1.47) | 1.16 (0.92, 1.45) | 1.07 (0.85, 1.34) | 1.03 (0.72, 1.49) | 1.02 (0.70, 1.48) |
| ≥£52,000 | 141/95097 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| P for trend |  | <0.0001 | <0.0001 | <0.0001 | 0.006 | 0.077 | 0.401 |
|  |  |  |  |  |  |  |  |
| **Neighbourhood deprivation** |  | N=430538 | N=427986 | N=419593 | N=418942 | N=156360 | N=153384 |
| 1 (low) | 205/143483 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 267/143548 | 1.32 (1.10, 1.58) | 1.29 (1.07, 1.55) | 1.25 (1.04, 1.50) | 1.20 (1.00, 1.45) | 1.32 (0.97, 1.79) | 1.22 (0.89, 1.65) |
| 3 | 436/143517 | 2.20 (1.86, 2.59) | 1.97 (1.66, 2.34) | 1.79 (1.51, 2.13) | 1.57 (1.31, 1.88) | 1.52 (1.12, 2.05) | 1.20 (0.87, 1.63) |
| P for trend |  | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.007 | 0.297 |
|  |  |  |  |  |  |  |  |
| **Occupational classification** |  | N=308689 | N=307262 | N=302239 | N=302495 | N=130238 | N=128079 |
| Managers, senior officials, etc | 324/175637 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Administrative, secretarial, etc | 94/74137 | 0.70 (0.55, 0.88) | 0.69 (0.55, 0.87) | 0.68 (0.54, 0.86) | 0.63 (0.50, 0.80) | 0.65 (0.46, 0.92) | 0.59 (0.42,0.84) |
| Personal service, sales, etc | 149/58915 | 1.39 (1.14, 1.69) | 1.30 (1.07, 1.59) | 1.22 (1.00, 1.49) | 1.06 (0.86, 1.30) | 0.90 (0.65, 1.26) | 0.75 (0.53, 1.06) |
| P for trend |  | 0.024 | 0.091 | 0.314 | 0.780 | 0.242 | 0.027 |
|  |  |  |  |  |  |  |  |

1 Numbers based on unadjusted model. 2 Comorbidity includes diagnoses of vascular or heart disease, diabetes, chronic bronchitis or emphysema, asthma, and hypertension defined according to measured blood pressure and/or use of anti-hypertensive medication. 3 Lifestyle factors includes body mass index, smoking status, alcohol intake frequency & number of types of physical activity taken in last four weeks. 4 Psychological factors include psychological distress, psychiatric consultation, neuroticism, verbal and numerical reasoning, & reaction time.

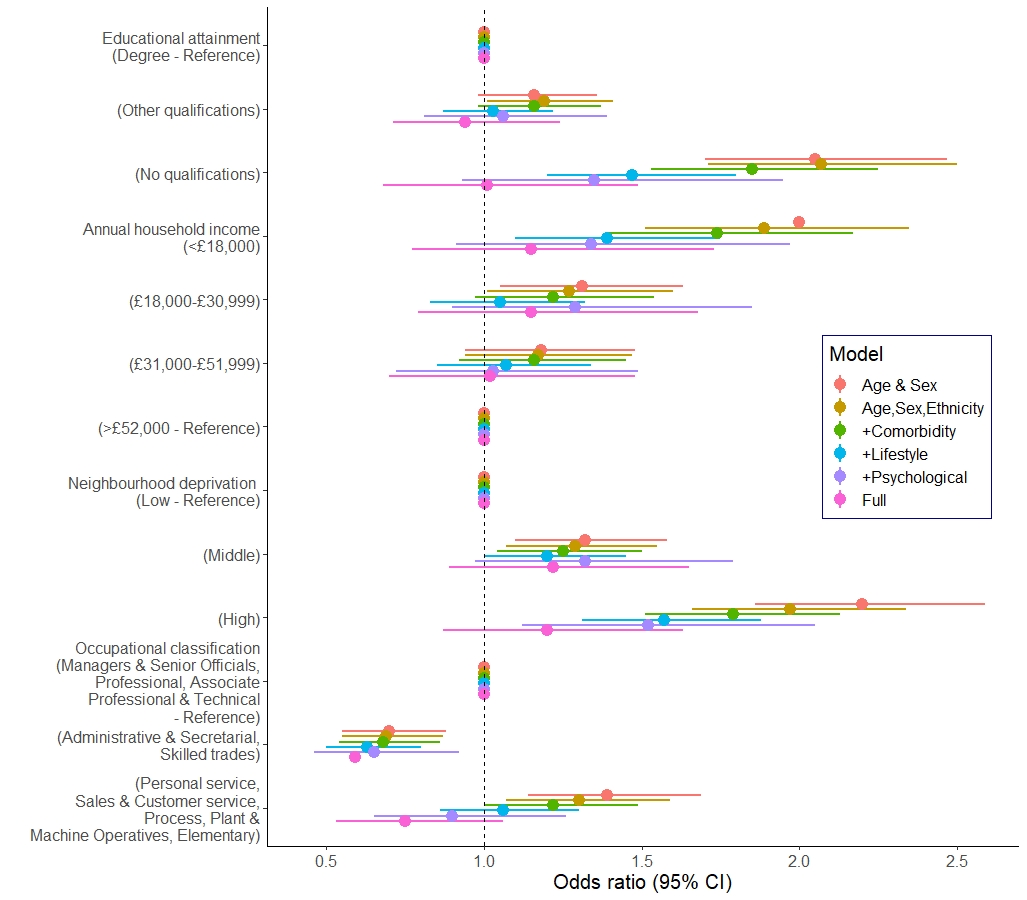
**Table 3. Odds ratios (95% CI) for the relation of psychological factors with Covid-19 hospitalisation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Case no./**  **Risk no.1** | **Adjustments** | | | | | |
|  |  | **Age & sex** | **Age, sex & ethnicity** | **Age, sex, ethnicity & comorbidity2** | **Age, sex, ethnicity & lifestyle factors3** | **Age, sex, ethnicity & socioeconomic factors4** | **All covariates** |
| **Psychological distress** |  | N=384909 | N=383655 | N=377290 | N=376562 | N=248162 | N=245119 |
| 1 (low) | 267/153504 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 291/140200 | 1.28 (1.08, 1.51) | 1.29 (1.09, 1.53) | 1.22 (1.03, 1.45) | 1.16 (0.98, 1.38) | 1.16 (0.93, 1.45) | 1.07 (0.86, 1.35) |
| 3 | 224/91205 | 1.58 (1.32, 1.89) | 1.51 (1.26, 1.81) | 1.37 (1.14, 1.65) | 1.18 (0.98, 1.43) | 1.26 (0.98, 1.61) | 1.09 (0.84, 1.41) |
| P for trend |  | <0.0001 | <0.0001 | 0.001 | 0.068 | 0.064 | 0.487 |
| Per SD increase |  | 1.22 (1.14, 1.29) | 1.19 (1.12, 1.26) | 1.15 (1.08, 1.23) | 1.09 (1.02, 1.17) | 1.12 (1.02, 1.22) | 1.07 (0.97, 1.17) |
|  |  |  |  |  |  |  |  |
| **Psychiatric consultation** |  | N=427819 | N=426823 | N=418218 | N=417481 | N=269373) | N=265566 |
| No | 751/379080 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Yes | 140/487739 | 1.50 (1.25, 1.79) | 1.51 (1.26, 1.81) | 1.45 (1.21, 1.75) | 1.32 (1.09, 1.59) | 1.23 (0.94, 1.62) | 1.15 (0.87, 1.52) |
|  |  |  |  |  |  |  |  |
| **Neuroticism** |  | N=425707 | N=424212 | N=416378 | N=415622 | N=265538 | N=264784 |
| 1 (low) | 224/106910 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 345/174705 | 1.01 (0.85, 1.19) | 1.03 (0.87, 1.22) | 0.99 (0.83, 1.17) | 0.99 (0.83, 1.18) | 1.03 (0.82, 1.30) | 1.01 (0.80, 1.27) |
| 3 | 319/144092 | 1.19 (1.00, 1.42) | 1.21 (1.02, 1.44) | 1.10 (0.92, 1.31) | 1.08 (0.90, 1.29) | 1.06 (0.84, 1.35) | 1.00 (0.78, 1.28) |
| P for trend |  | 0.038 | 0.023 | 0.277 | 0.382 | 0.621 | 0.985 |
| Per SD increase |  | 1.08 (1.01, 1.15) | 1.08 (1.01, 1.16) | 1.05 (0.98, 1.12) | 1.03 (0.96, 1.10) | 1.00 (0.92, 1.10) | 0.99 (0.90, 1.09) |
|  |  |  |  |  |  |  |  |
| **Verbal numerical reasoning** |  | N=175267 | N=174581 | N=172530 | N=415777 | N=126721 | N=124890 |
| 1 (low) | 152/43988 | 2.66 (2.06, 3.34) | 2.31 (1.77, 3.02) | 2.17 (1.65, 2.86) | 1.92 (1.45, 2.53) | 2.14 (1.50, 3.05) | 1.98 (1.38, 2.85) |
| 2 | 115/58446 | 1.52 (1.16, 1.99) | 1.45 (1.10, 1.90) | 1.46 (1.10, 1.92) | 1.36 (1.03, 1.80) | 1.57 (1.14, 2.17) | 1.58 (1.14, 2.18) |
| 3 | 96/72833 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| P for trend |  | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Per SD decrease |  | 1.47 (1.32, 1.64) | 1.37 (1.23, 1.53) | 1.33 (1.19, 1.49) | 1.27 (1.13, 1.42) | 1.35 (1.17, 1.57) | 1.31 (1.13, 1.52) |
|  |  |  |  |  |  |  |  |
| **Reaction time** |  | N=426147 | N=424432 | N=416366 | N=415777 | N=268826 | N=265002 |
| 1 (low) | 262/140934 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 274/141575 | 1.04 (0.87, 1.23) | 1.00 (0.84, 1.19) | 0.97 (0.82, 1.16) | 0.95 (0.79, 1.13) | 1.02 (0.82, 1.27) | 1.02 (0.81, 1.27) |
| 3 | 345/143368 | 1.27 (1.08, 1.51) | 1.16 (0.98, 1.37) | 1.11 (0.93, 1.32) | 1.04 (0.88, 1.24) | 1.06 (0.84, 1.34) | 1.02 (0.80, 1.29) |
| P for trend |  | 0.004 | 0.078 | 0.205 | 0.572 | 0.608 | 0.876 |
| Per SD increase |  | 1.12 (1.06, 1.19) | 1.07(1.01, 1.14) | 1.06 (0.99, 1.13) | 1.03 (0.97, 1.10) | 1.08 (0.98, 1.18) | 1.07 (0.97, 1.17) |
|  |  |  |  |  |  |  |  |

1 Numbers based on age & sex adjusted model. 2 Comorbidity includes diagnoses of vascular or heart disease, diabetes, chronic bronchitis or emphysema, asthma, and hypertension defined according to measured blood pressure and/or use of anti-hypertensive drugs. 3Lifestyle factors included body mass index, smoking status, alcohol intake frequency & number of types of physical activity taken in last four weeks. 4Socioeconomic factors included occupational classification, educational attainment, Townsend deprivation index, & household income before tax

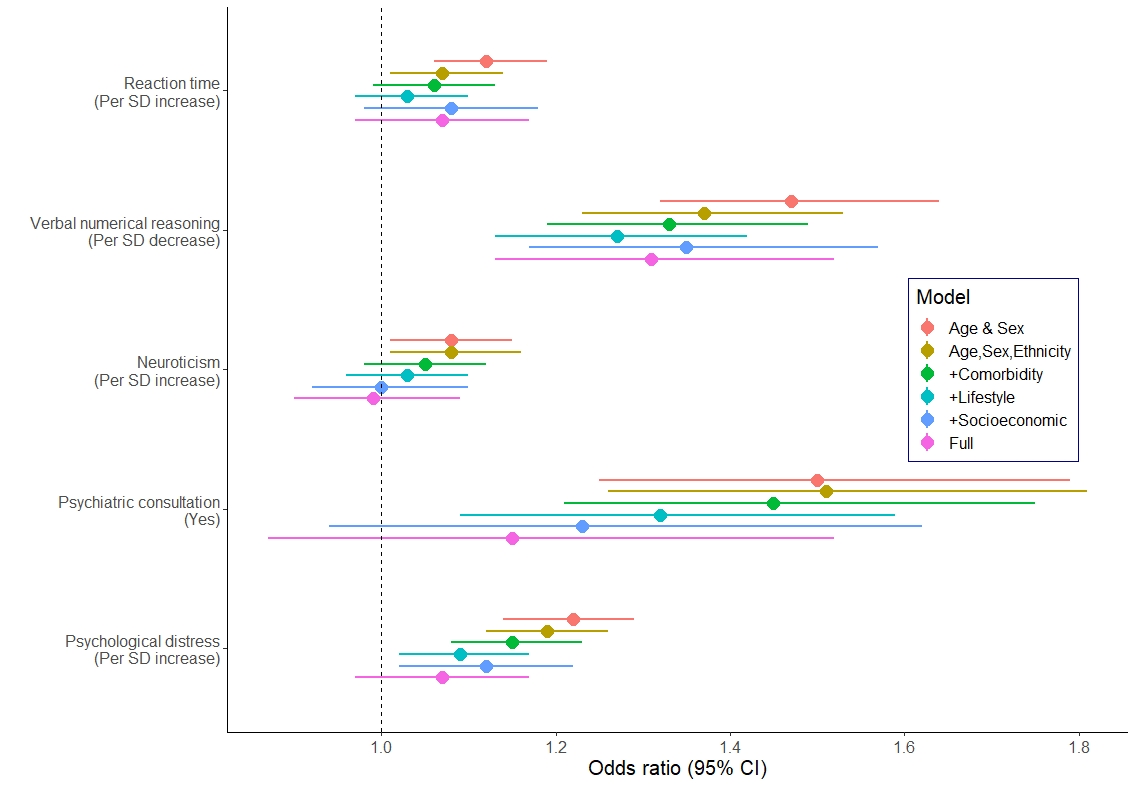
**Figure 1. Odds ratios (95% CI) for the relation of socioeconomic factors with Covid-19 hospitalisation**

(Drew: see shorthand for job classification in tables. Please use here to minimise crowding. Can we have any separation between exposure variables? )

****

Adjustments are as per table 2.

**Figure 2. Odds ratios (95% CI) for the relation of psychological factors with Covid-19 hospitalisation**



Adjustments are as per table 2.

**Supplemental Table 1. Preliminary analyses of covid-19 data in UK Biobank (N=431,052) – odds ratios for apparent risk factors for disease progression in covid-19 (based on clinical studies)**

**(note from CG: ‘Still to revise 6may 6.42’)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Covid-19 cases**  **(N=908)** | **Covid-19 cases known to have been hospitalised (‘origin’=1) (N=751)** | **Covid-19 cases known to have been hospitalised (‘origin’=1) \*and\* with >=2 tests conducted (N=445)** |
|  |  |  |  |
| *Age* |  |  |  |
| 40-49 | Ref (1.0) | Ref (1.0) | Ref (1.0) |
| 50-59 | 0.69 (0.57, 0.83) | 0.77 (0.63, 0.95) | 0.81 (0.62, 1.05) |
| 60+ | 1.09 (0.93, 1.27) | 1.16 (0.97, 1.38) | 1.17 (0.83, 1.48) |
| Per decade increase | 1.15 (1.06, 1.25) | 1.18 (1.08, 1.29) | 1.17 (1.04, 1.32) |
|  |  |  |  |
| *Sex* |  |  |  |
| Female | Ref (1.0) | Ref (1.0) | Ref (1.0) |
| Male | 1.53 (1.35, 1.75) | 1.56 (1.35, 1.81) | 1.55 (1.28, 1.87) |
|  |  |  |  |
| *Ethnicity* |  |  |  |
| White | Ref (1.0) | Ref (1.0) | Ref (1.0) |
| Non-white | 2.65 (2.20, 3.20) | 2.45 (1.98, 3.03) | 3.12 (2.42, 4.01) |
|  |  |  |  |
| *Long-standing illness* |  |  |  |
| No | Ref (1.0) |  |  |
| Yes | 2.06 (1.80, 2.35) | 2.03 (1.75, 2.04) | 2.26 (1.87, 2.73) |
|  |  |  |  |

**Supplemental Table 2. Odds ratios (95% CI) for the relation of socioeconomic factors with Covid-19 hospitalisation *– based on complete data***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Case no./**  **Risk no.1** | **Adjustments** | | | | | |
|  |  | **None CG: please replace with age + sex adjustment** | **Age, sex & ethnicity** | **Age, sex, ethnicity & comorbidity1** | **Age, sex, ethnicity & lifestyle factors2** | **Age, sex, ethnicity & psychological factors3** | **Adjusted for all covariates** |
| **Educational attainment** |  |  |  |  |  |  |  |
| University Degree | 90/55905 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Other qualifications | 144/77597 | 1.17 (0.89, 1.52) | 1.19 (0.91, 1.55) | 1.15 (0.88, 1.49) | 1.03 (0.79, 1.34) | 1.06 (0.81, 1.39) | 0.94 (0.71, 1.24) |
| No qualifications | 54/19237 | 1.70 (1.20, 2.41) | 1.75 (1.23, 2.48) | 1.60 (1.12, 2.27) | 1.28 (0.89, 1.84) | 1.30 (0.89, 1.90) | 1.01 (0.68, 1.49) |
| P for trend |  | 0.005 | 0.003 | 0.015 | 0.245 | 0.214 | 0.945 |
|  |  |  |  |  |  |  |  |
| **Annual household income** |  |  |  |  |  |  |  |
| <£18,000 | 68/26578 | 1.82 (1.27, 2.60) | 1.79 (1.23, 2.60) | 1.63 (1.12, 2.38) | 1.41 (0.96, 2.08) | 1.41 (0.95, 2.09) | 1.15 (0.77, 1.73) |
| £18,000-£30,999 | 71/34301 | 1.47 (1.03, 2.10) | 1.47 (1.02, 2.11) | 1.41 (0.98, 2.03) | 1.28 (0.89, 1.85) | 1.28 (0.88, 1.86) | 1.15 (0.79, 1.68) |
| £31,000-£51,999 | 60/36526 | 1.17 (0.81, 1.69) | 1.16 (0.80, 1.68) | 1.14 (0.79, 1.65) | 1.07 (0.74, 1.56) | 1.09 (0.75, 1.57) | 1.02 (0.70, 1.48) |
| ≥£52,000 | 54/38368 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| P for trend |  | <0.0001 | 0.001 | 0.006 | 0.053 | 0.060 | 0.401 |
|  |  |  |  |  |  |  |  |
| **Townsend Deprivation Index** | |  |  |  |  |  |  |
| 1 (low) | 69/48529 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 102/53718 | 1.34 (0.99, 1.82) | 1.31 (0.97, 1.78) | 1.29 (0.95, 1.75) | 1.24 (0.91, 1.68) | 1.28 (0.94, 1.74) | 1.22 (0.89, 1.65) |
| 3 | 121/51407 | 1.70 (1.26, 2.29) | 1.55 (1.14, 2.09) | 1.46 (1.08, 1.97) | 1.28 (0.94, 1.75) | 1.41 (1.04, 1.92) | 1.20 (0.87, 1.63) |
| P for trend |  | <0.0001 | 0.005 | 0.016 | 0.130 | 0.030 | 0.297 |
|  |  |  |  |  |  |  |  |
| **Occupational classification** |  |  |  |  |  |  |  |
| Managers, senior officials, etc | 154/76773 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Administrative, secretarial, etc | 42/29676 | 0.71 (0.51, 1.01) | 0.71 (0.51, 1.01) | 0.70 (0.50, 0.99) | 0.65 (0.46, 0.91) | 0.64 (0.45, 0.90) | 0.59 (0.42, 0.84) |
| Personal service, sales, etc | 48/21630 | 1.12 (0.81, 1.55) | 1.08 (0.78, 1.50) | 1.04 (0.75, 1.45) | 0.90 (0.65, 1.25) | 0.86 (0.61, 1.21) | 0.75 (0.53, 1.06) |
| P for trend |  | 0.993 | 0.887 | 0.713 | 0.219 | 0.145 | 0.027 |

1Comorbidity includes diagnoses of vascular or heart disease, diabetes, chronic bronchitis or emphysema, asthma, and hypertension defined according to measured blood pressure and/or use of anti-hypertensive medication. 2 Lifestyle factors includes body mass index, smoking status, alcohol intake frequency & number of types of physical activity taken in last four weeks. 2 Psychological factors include psychological distress, psychiatric consultation, neuroticism, verbal and numerical reasoning, & reaction time.

**Supplemental Table 3. Odds ratios (95% CI) for the relation of psychological factors with Covid-19 hospitalisation *– based on complete data***

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Case no./**  **Risk no.1** | **Adjustments** | | | | | |
|  |  | **None CG: please replace with age + sex adjustment** | **Age, sex & ethnicity** | **Age, sex, ethnicity & comorbidity1** | **Age, sex, ethnicity & lifestyle factors2** | **Age, sex, ethnicity & socioeconomic factors3** | **Adjusted for all covariates** |
| **Psychological distress** |  |  |  |  |  |  |  |
| 1 (low) | 149/96723 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref.) | 1.0 (ref.) | 1.0 (ref) |
| 2 | 161/93337 | 1.14 (0.91, 1.42) | 1.15 (0.92, 1.44) | 1.12 (0.89, 1.40) | 1.09 (0.87, 1.36) | 1.13 (0.91, 1.42) | 1.07 (0.86, 1.34) |
| 3 | 113/555059 | 1.36 (1.06, 1.75) | 1.32 (1.03, 1.70) | 1.25 (0.97, 1.61) | 1.15 (0.89, 1.48) | 1.22 (0.95, 1.57) | 1.09 (0.84, 1.40) |
| P for trend |  | 0.016 | 0.028 | 0.080 | 0.272 | 0.107 | 0.501 |
| Per SD increase |  | 1.18 (1.08, 1.29) | 1.16 (1.06, 1.27) | 1.13 (1.03, 1.24) | 1.09 (1.00, 1.20) | 1.12 (1.02, 1.22) | 1.07 (0.97, 1.17) |
|  |  |  |  |  |  |  |  |
| **Psychiatric consultation** |  |  |  |  |  |  |  |
| No | 412/238768 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Yes | 58/26798 | 1.26 (0.96, 1.67) | 1.29 (0.98, 1.70) | 1.26 (0.95, 1.66) | 1.19 (0.90, 1.57) | 1.22 (0.92, 1.61) | 1.15 (0.87, 1.52) |
|  |  |  |  |  |  |  |  |
| **Neuroticism** |  |  |  |  |  |  |  |
| 1 (low) | 119/69458 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 191/109358 | 1.03 (0.82, 1.30) | 1.05 (0.83, 1.32) | 1.03 (0.81, 1.29) | 1.02 (0.81, 1.28) | 1.03 (0.82, 1.29) | 1.01 (0.80, 1.27) |
| 3 | 157/85968 | 1.09 (0.85, 1.39) | 1.11 (0.87, 1.41) | 1.06 (0.83, 1.36) | 1.03 (0.81, 1.32) | 1.06 (0.83, 1.35) | 1.00 (0.79, 1.28) |
| P for trend |  | 0.491 | 0.395 | 0.612 | 0.804 | 0.660 | 0.982 |
| Per SD increase |  | 1.03 (0.94, 1.13) | 1.04 (0.94, 1.14) | 1.02 0.93, 1.12) | 1.00 (0.91, 1.10) | 1.01 (0.92, 1.11) | 0.99 (0.90 1.09) |
|  |  |  |  |  |  |  |  |
| **Verbal numerical reasoning** |  |  |  |  |  |  |  |
| 1 (low) | 81/26374 | 2.51 (1.83, 3.47) | 2.09 (1.50, 2.93) | 2.03 (1.45, 2.84) | 1.86 (1.33, 2.62) | 2.06 (1.44, 2.96) | 1.98 (1.38, 2.84) |
| 2 | 86/41404 | 1.70 (1.24, 2.34) | 1.61 (1.17, 2.21) | 1.59 (1.16, 2.18) | 1.53 (1.11, 2.11) | 1.60 (1.16, 2.21) | 1.58 (1.14, 2.18) |
| 3 | 70/57112 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| P for trend |  | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.001 | <0.0001 |
| Per SD decrease |  | 1.46 (1.27, 1.66) | 1.34 (1.17, 1.54) | 1.32 (1.15, 1.52) | 1.27 (1.10, 1.46) | 1.33 (1.15, 1.55) | 1.31 (1.12, 1.52) |
|  |  |  |  |  |  |  |  |
| **Reaction time** |  |  |  |  |  |  |  |
| 1 (low) | 164/99395 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 155/88713 | 1.09 (0.87 1.36) | 1.05 (0.84, 1.31) | 1.04 (0.84, 1.31) | 1.03 (0.82, 1.29) | 1.03 (0.82, 1.29) | 1.02 (0.81, 1.28) |
| 3 | 148/76914 | 1.21 (0.96, 1.53) | 1.10 (0.87, 1.39) | 1.09 (0.86, 1.37) | 1.05 (0.83, 1.33) | 1.04 (0.82, 1.31) | 1.02 (0.80, 1.29) |
| P for trend |  | 0.104 | 0.424 | 0.496 | 0.659 | 0.759 | 0.869 |
| Per SD increase |  | 1.16 (1.06, 1.27) | 1.10 (1.01, 1.21) | 1.09 (1.00, 1.20) | 1.08 (0.99, 1.19) | 1.07 (0.98, 1.17) | 1.06 (0.97, 1.17) |
|  |  |  |  |  |  |  |  |

1 Comorbidity includes diagnoses of vascular or heart disease, diabetes, chronic bronchitis or emphysema, asthma, and hypertension defined according to measured blood pressure and/or use of anti-hypertensive drugs. 2 Lifestyle factors included body mass index, smoking status, alcohol intake frequency & number of types of physical activity taken in last four weeks. 3 Socioeconomic factors included occupational classification, highest educational attainment, Townsend deprivation index, & household income before tax

**Supplementary Table 4. Odds ratios (95% CI) for the relation of socioeconomic factors with Covid-19 hospitalisation *– impact of adjusting for biomarkers***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Adjustments** | | |
|  | **Case no./Risk no.1** | **Age, sex & ethnicity** | **Age, sex, ethnicity & biomarker2** | **All covariates3** |
| **Educational attainment** |  | N=420502 | N=301981 | N=108462 |
| Degree | 229/137717 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Other qualifications | 406/214337 | 1.19 (1.01, 1.41) | 1.15 (0.93, 1.41) | 0.94 (0.66, 1.33) |
| No qualifications | 241/70003 | 2.07 (1.71, 2.50) | 1.82 (1.43, 2.31) | 1.10 (0.68, 1.77) |
| P for trend |  | <0.0001 | <0.0001 | 0.802 |
|  |  |  |  |  |
| **Annual household income** |  | N=363175 | N=261825 | N=96562 |
| <£18,000 | 241/81207 | 1.89 (1.51, 2.35) | 1.47 (1.12, 1.93) | 1.03 (0.62, 1.72) |
| £18,000-£30,999 | 179/92461 | 1.27 (1.01, 1.60) | 1.09 (0.83, 1.44) | 1.04 (0.65, 1.68) |
| £31,000-£51,999 | 167/95454 | 1.17 (0.94, 1.47) | 1.10 (0.84, 1.49) | 1.13 (0.72, 1.78) |
| ≥£52,000 | 141/95097 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| P for trend |  | <0.0001 | 0.007 | 0.988 |
|  |  |  |  |  |
| **Neighbourhood deprivation** |  | N=427986 | N=301418 | N=108898 |
| 1 (low) | 205/143483 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 267/143548 | 1.29 (1.07, 1.55) | 1.14 (0.91, 1.42) | 1.10 (0.76, 1.58) |
| 3 | 436/143517 | 1.97 (1.66, 2.34) | 1.58 (1.28, 1.96) | 0.97 (0.66, 1.42) |
| P for trend |  | <0.0001 | <0.0001 | 0.840 |
|  |  |  |  |  |
| **Occupational classification** |  | N=307262 | N=221854 | N=91388 |
| Managers, senior officials, etc | 324/175637 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Administrative, secretarial, etc | 94/74137 | 0.69 (0.55, 0.87) | 0.65 (0.49, 0.87) | 0.48 (0.30,0.77) |
| Personal service, sales, etc | 149/58915 | 1.30 (1.07, 1.59) | 1.28 (1.01, 1.64) | 0.75 (0.48, 1.15) |
| P for trend |  | 0.091 | 0.223 | 0.054 |

1 Numbers based on unadjusted model. 2Biomarkers included FEV1, and blood concentrations of c-reactive protein, HbA1c, and HDL cholesterol. 3Multivariate model included age, sex, ethnicity, diagnoses of vascular or heart disease, diabetes, chronic bronchitis or emphysema, asthma, hypertension defined according to measured blood pressure and/or use of anti-hypertensive drug, body mass index, smoking status, alcohol intake frequency, number of types of physical activity taken in last four week, psychological distress, psychiatric consultation, reasoning, reaction time, FEV1, and blood concentrations of c-reactive protein, HbA1c and HDL cholesterol.

**Supplementary Table 5. Odds ratios (95% CI) for the relation of psychological factors with Covid-19 hospitalisation – *impact of adjusting for biomarkers***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Case no./Risk no.1** | **Adjustments** | | |
|  |  | **Age, sex & ethnicity** | **Age, sex, ethnicity & biomarkers2** | **All covariates3** |
| **Psychological distress** |  | N=383655 | N=273998 | N=179391 |
| 1 (low) | 267/153504 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 291/140200 | 1.29 (1.09, 1.53) | 1.16 0.94, 1,43) | 1.04 (0.79, 1.36) |
| 3 | 224/91205 | 1.51 (1.26, 1.81) | 1.28 (1.01, 1,61) | 0.98 (0.71, 1.34) |
| P for trend |  | <0.0001 | 0.033 | 0.931 |
| Per SD increase |  | 1.19 (1.12, 1.26) | 1.12 (1.04, 1.22) | 1.04 (0.93, 1.17) |
|  |  |  |  |  |
| **Psychiatric consultation** |  | N=426823 | N=303561 | N=194162 |
| No | 751/379080 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| Yes | 140/487739 | 1.51 (1.26, 1.81) | 1.44 (1.15, 1.82) | 1.27 (0.91, 1.76) |
|  |  |  |  |  |
| **Neuroticism** |  | N=424212 | N=302071 | N=193565 |
| 1 (low) | 224/106910 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 345/174705 | 1.03 (0.87, 1.22) | 0.98 (0.79, 1.22) | 1.03 (0.78, 1.37) |
| 3 | 319/144092 | 1.21 (1.02, 1.44) | 1.19 (0.96, 1.48) | 1.06 (0.78, 1.42) |
| P for trend |  | 0.023 | 0.088 | 0.725 |
| Per SD increase |  | 1.08 (1.01, 1.16) | 1.08 (0.99 1.17) | 0.99 (0.88, 1.11) |
|  |  |  |  |  |
| **Verbal numerical reasoning** |  | N=174581 | N=122752 | N=89129 |
| 1 (low) | 152/43988 | 2.31 (1.77, 3.02) | 2.35 (1.68, 3.30) | 2.08 (1.33, 3.28) |
| 2 | 115/58446 | 1.45 (1.10, 1.90) | 1.51 (1.07, 2.13) | 1.67 (1.12, 2.49) |
| 3 | 96/72833 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| P for trend |  | <0.0001 | <0.0001 | 0.001 |
| Per SD decrease |  | 1.37 (1.23, 1.53) | 1.37 (1.19, 1.58) | 1.33 (1.10, 1.61) |
|  |  |  |  |  |
| **Reaction time** |  | N=424432 | N=302492 | N=193832 |
| 1 (low) | 262/140934 | 1.0 (ref) | 1.0 (ref) | 1.0 (ref) |
| 2 | 274/141575 | 1.00 (0.84, 1.19) | 1.01 (0.81, 1.25) | 1.09 (0.83, 1.42) |
| 3 | 345/143368 | 1.16 (0.98, 1.37) | 1.07 (0.87, 1.33) | 1.05 (0.79, 1.40) |
| P for trend |  | 0.078 | 0.505 | 0.724 |
| Per SD increase |  | 1.07(1.01, 1.14) | 1.06 (0.98, 1.15) | 1.08 (0.96, 1.21) |
|  |  |  |  |  |

1 Numbers based on age & sex adjusted model. 2 Biomarkers included FEV1, and blood concentrations of c-reactive protein, HbA1c, and HDL cholesterol. 3Multivariate model included age, sex, ethnicity, diagnoses of vascular or heart disease, diabetes, chronic bronchitis or emphysema, asthma, hypertension defined according to measured blood pressure and/or use of anti-hypertensive drug, body mass index, smoking status, alcohol intake frequency, number of types of physical activity taken in last four week, occupational classification, educational attainment, Townsend deprivation index, household income before tax, FEV1, and blood concentrations of c-reactive protein, HbA1c and HDL cholesterol.