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DISCUSSION PAPER SERIES

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Nicole Andelic
University of Aberdeen

Julia Allan
University of Aberdeen

Keith A. Bender
University of Aberdeen and IZA

Daniel Powell
University of Aberdeen

Ioannis Theodossiou
University of Aberdeen

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Performance-Related Pay and Objective Measures of Health after Correcting for Sample Selection*

Much of the literature on performance-related pay (PRP) and poor health relies on self-reported data, and the relationship is particularly difficult to examine due to confounding variables. To address these limitations we examine three groups of health measures using data from the UKHLS: blood pressure (n=5667), inflammation markers in blood (n=4025) and self-reported health (n=6120). Physiological markers of health allow us to circumvent some of the issues associated with self-reported measures and by using size of firm and % share of PRP workers in occupation we also statistically control for some of the endogeneity associated with self-selection bias. Regressions correcting for self-selection bias and socio-demographic covariates find that PRP contracts are associated with poorer self-reported mental health, higher systolic blood pressure and higher levels of fibrinogen. These findings have implications for firms that use PRP as they may need to implement policies to mitigate against stress.

JEL Classification: J33, M52, I1

Keywords: performance-related pay, health, sample selection

Corresponding author:
Keith A. Bender
University of Aberdeen
King's College
Aberdeen AB24 3FX
United Kingdom
E-mail: kabender@abdn.ac.uk

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1. Introduction

Basing employees' salaries on their performance (performance-related pay or PRP) is typically perceived as a payment system with a range of positive outcomes. Research papers in economics have repeatedly found that PRP leads to higher productivity (Lazear, 2000) through incentivisation or self-sorting effects, higher wages (Booth & Frank, 1999) and even higher job satisfaction (Green & Heywood, 2008), although there is some evidence suggesting that the link between job satisfaction and PRP may only hold for high-income workers (McCausland *et al*., 2005). Traditionally then, it has been widely accepted that PRP is generally of benefit to all parties involved and leads to an alignment between the goals of employers and employees (Lazear, 2000). However, this view does not account for the unintended consequence that PRP may have on health outcomes.

In his book *The Wealth of Nations*, Scottish economist Adam Smith made the following observation: "*Workmen… when they are liberally paid by the piece, are very apt to overwork themselves and to ruin their health and constitution in a few years.*" (Smith, 1776, p. 83). Despite this early observation, it is only in the past two decades that researchers have begun seriously investigating this claim empirically and subsequently finding a relationship between PRP and various measures of poor health. The majority of this research has been carried out with workforce survey data such as the British Household Panel Survey (Bender & Theodossiou, 2014) or the US National Longitudinal Survey of Youth (Artz & Heywood, 2015), with the exception of a small number of experimental studies (Allan *et al*., 2021; Cadsby *et al*., 2016; Dohmen & Falk, 2011). These studies have to date, almost entirely relied on measuring injuries or health through self-report, either through Likert scale ratings or self-disclosed medical conditions. In contrast, there is little research on PRP and health using biomarkers as physiological indicators of health in survey data. The current paper will address this gap in the literature.

The next section will provide a brief overview of the literature on PRP and health to date, followed by a motivation for the current study and the methods used during analysis. A section discussing the results will follow and the final section will discuss the implications of these findings.

2. Literature review

Although there are several studies that have found a link between PRP and health in survey data, a wide range of observed health outcomes are included in the literature such as injuries, insurance premiums, medication use and self-reported health. Consequently, there is likely more than one causal mechanism through which PRP may impact on health and the literature can broadly be defined into three such pathways.

The first pathway is based on the association between PRP and injuries. It is possible that making earnings dependent on performance incentivises individuals to increase their rate of output, thereby also encouraging risk-taking behaviours which in turn lead to higher rates of injuries and accidents at work. This is typically supported by industry-specific examples. For example, Freeman and Kleiner (2005) find that an American shoe-manufacturing company that switched from PRP to fixed salary contracts saw a decrease in workers' compensation insurance premiums, suggesting that accidents and injuries lessened after the switch. Comparisons between groups demonstrate similar results. For example, a study examining long-haul truckers (Monaco & Williams, 2000) finds that accidents were more frequent among groups of truckers who are paid by percentage of revenue in comparison to those who are paid by the mile (18% vs 13%) and in line with this, Saha *et al*. (2004) show that workers in fertilizer production who are paid by PRP are 1.7 to 4.3 times more likely to have accidents than their counterparts on time-based pay contracts over a five-year period. Finally, beyond these industry-specific findings, several studies have used nationally representative survey data and find that there is a robust link between PRP and injuries/accidents across industries and occupations (Artz & Heywood, 2015; Bender *et al*., 2012).

However, PRP is also associated with health outcomes not directly to injuries. For example, Dahl and Pierce (2020) study Danish firms who switched from fixed to PRP contracts and discover a 4-6 % increase in the use of anti-depressants and anxiety medication by employees, indicating that mental health was poorer after the switch. Bender and Theodossiou (2014) find that PRP workers were more likely than others to report issues with cardiovascular health, stomach/digestive problems and poorer emotional health. This may be due to a second pathway; the consequences of working more hours when employed in a PRP contract. Previous research in the UK has found that PRP workers are likely to work 1.5 hours more per week than those on fixed pay (Bender and Theodossiou, 2014). Therefore there may be a trade-off of earnings versus leisure time that could otherwise be spent on activities that promote physical and mental health. On the other hand, it may be that rather than causing a decrease in healthy activities, the additional hours may lead to an increase in behaviours detrimental to health as a coping mechanism. For example, Artz *et al*. (2021) find that workers paid via PRP are more likely to drink alcohol and use drugs than workers on a fixed salary, even after controlling for individual and firm fixed effects and endogeneity. Similar findings seem to be prevalent in Germany as well (Baktash *et al*., 2021).

Finally, a third pathway suggests that working in a PRP contract is inherently stressful, either because of working additional hours as suggested by Bender and Theodossiou (2014), or due to the financial uncertainty that is associated with a variable income stream and the pressure to keep productivity high. Although humans are generally good at adapting to brief episodes of stress, persistent and chronic stress increases allostatic load over time, i.e. physiological “wear and tear” on the body (McEwen, 1998). Increased allostatic load may eventually reduce the efficacy of the immune system, putting individuals at higher risk of experiencing health issues (Rohleder, 2014). This third pathway is the focus of the current paper and is explored through analysis of large scale survey data. Importantly though, none of these pathways are mutually exclusive, and it is possible that PRP employees are at higher risk of poor health through more than pathway at the same time.

One of the limitations of examining PRP and health using survey data is the possibility of confounding variables causing both self-sorting into PRP and poorer health outcomes. Although not impossible, it is often difficult to statistically control for endogeneity. For example, it is possible that workers who are attracted to variable pay have a higher risk-preference in comparison to their fixed salary counterparts (e.g. Bandiera *et al*., 2015; Cornelissen *et al*., 2011; Grund & Sliwka, 2010). A high level of risk-preference then is likely to correlate with risk behaviour which in turn causes poorer health (Anderson & Mellor, 2008; Dohmen *et al*., 2005), leading workers with a high risk-preference to both be more likely to be found in PRP contracts as well as having poorer health. However, Allan *et al*. (2021) recently address this issue in an incentivised experiment. By randomly allocating participants to either a PRP or a fixed payment condition they circumvent the issue of self-selection. The study finds that even a brief 10-minute work task leads to higher levels of the stress-related hormone, cortisol, in saliva when participants were paid by performance rather than a fixed payment. For survey data then where the random assignment is very rare, it is important to correct for self-selection bias.

A second limitation of the existing literature is the lack of physiological measures of health. Although Allan *et al*. (2021) provide evidence for a causal link between PRP and increased levels of cortisol in a lab setting, the study suffers from common experimental limitations such as a homogeneous sample and perhaps more importantly, only provides evidence for acute physiological stress. In contrast, studies using survey data are able to investigate PRP and health across a range of industries and occupations and with a representative sample of the workforce. Previous studies based on survey data examine a range of health outcomes, including workplace injuries (Bender *et al*., 2012; Artz & Heywood, 2015), subjective overall health, and a range of conditions associated with stress including heart problems, stomach/digestive problems and anxiety/depression (Bender & Theodossiou, 2014). However, to date research has not explored the relationship between PRP and well-known physiological markers of stress, which are arguably more robust than self-report measures and which can give some insight into more chronic effects of stress. The aim of the current study is to address this gap in the literature by examining the association between PRP and physiological health variables whilst correcting for self-selection bias.

3. Methodology

The following basic equation for estimating health is similar to a health production function (Grossman, 1972):

$$H_i = X_i\beta + \delta PRP_i + \varepsilon_i, \quad (1)$$

where for person i, H is a measure of health, X is a set of socio-demographic and other characteristics that affect health though the parameters in β, PRP is a dummy variable capturing performance-related pay and ε is an error term. The parameter, δ, captures the relationship between PRP and health and given the literature and mechanisms explained above is expected to show that PRP leads to lower levels of health.

A key problem with estimating equation (1) using survey data is that it is likely that those choosing a PRP contract are a selected group of workers and this selection process is not independent of health potentially biasing the estimate of δ. As discussed in the literature review, PRP and health are both impacted by the risk tolerance of individuals – the less risk averse individuals are, the more likely they are to be in PRP jobs and to experience adverse health outcomes. Thus, equation (1) needs to be modelled as an endogenous treatment in order to have more confidence that we are picking up causal influences of PRP on health and not just correlational. The endogenous treatment methodology involves two steps. In the first step the PRP choice is specified as follows:

$$PRP_i = X_i\beta + Z_i\gamma + \mu_i. \quad (2)$$

A key element of this regression is the Z matrix which are the instruments used to identify the model with their influence on the choice of a PRP contract given by γ. Although the model could be identified from the nonlinearity of the functional forms, here, we use two instruments to help with identification. The first comes from a question asked of respondents about the size of the firm. Previous research by Conyon *et al*. (2001) and Heywood *et al*. (1997) suggests that there are fixed costs for setting up PRP systems, though it results in lower supervision costs, and therefore, larger firms would be more likely to implement such systems. Our first instrument is a binary variable with two levels: a small firm size of 25 employees or less versus moderate-to-large firm size of more than 25 employees. The relatively low number of 25 employees was chosen as a substantial portion of survey respondents indicated that they did not know the exact number of employees but could confirm that it was above/below 25 employees. A second instrument comes from an aggregation strategy (e.g. Artz & Heywood, 2015; Baktash *et al*., 2021; Cornelissen *et al*., 2011; Lee, 2004; Woessmann & West, 2006 and others). The share of PRP workers are calculated for each of 74 three-digit occupations in Wave 2 of the UKHLS[1]. This will capture the propensity of occupations to employ PRP and can signal the ease by which performance can be monitored, which makes it more likely that firms will employ PRP contracts (Bayo-Moriones *et al*., 2013).

The second step involves the estimation of the equation (1)

$$H_i = X_i\beta + \delta \boldsymbol{PRP_i} + \varepsilon_i,$$

where $\boldsymbol{PRP_i}$ is the predicted values obtained from the first stage equation 2.

With these two equations specified, maximum likelihood methods are used to estimate the two equations jointly.

4. Data

There is a lack of survey data offering information about payment contracts, socio-demographic indicators as well as physical health. One notable exception to this is the UK Household Longitudinal Survey[2] (UKHLS, University of Essex, Institute for Social and Economic Research, 2021), the replacement of the British Household Panel Survey (BHPS). The UKHLS is a household panel study that started in 2009 and includes approximately 40 000 households across all countries in the UK. In contrast to its predecessor, the UKHLS does not only ask for self-reported evaluations of health, but

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[1] As in Baktash *et al*. (2021), we exclude the particular worker in the calculation of the percentage of PRP workers in his or her occupation. Although the dataset has 81 three-digit occupations, we excluded occupations with less than 10 workers, leaving 74 occupations.

[2] More information is available online via https://www.understandingsociety.ac.uk/.

also incorporates a Nurse Assessment module for a subset of the sample in the second and third wave of the UKHLS in 2010-2012 and 2011-2013, respectively[3] (University of Essex, Institute for Social and Economic Research, 2014). In addition to this health data, it records information about PRP in every other wave of the study ('Does your pay include performance-related pay?'), meaning that the second wave of the UKHLS (from 2011-2012) includes both PRP and the nurse assessed health information about the sample[4]. Consequently, the current paper focuses on wave 2 of the UKHLS. The PRP question is only asked of workers who indicate that they are employees. and self-employed workers are therefore excluded from the analysis. Furthermore, although workers in Northern Ireland are included in the main UKHLS survey, the Nurse Assessment module is not offered to this group and so Northern Ireland residents are also excluded from the current analysis.

In addition to the physiological measures from the Nurse Assessment module, the current study includes four measures of self-reported health derived from two scales. The first scale, the GHQ-12, is commonly used when screening for mental health difficulties (Goldberg & Williams, 1988). It consists of twelve items that are rated on a 4-point Likert scale from 0-3 (Better/More than usual, Same as usual, Less than usual, Not at all) and then summed, resulting in a score from 0-36. The second scale is the SF-12, which is commonly used as a medical quality of life measure (Jenkinson & Layte, 1997). The physical and mental health subscales of the SF-12 focus on the extent to which the respondent's physical/mental health impact on their everyday life (Ware *et al*., 1996). Both subscores are transformed into scores ranging 0-100 where higher values indicate better health. The

[3] The Nurse Assessment module was administered to 15,591 respondents during the second wave of the UKHLS. All of the respondents were part of the General Population Sample component of the UKHLS. However, during the second wave of the UKHLS, a subset of the original BHPS sample were invited back to the survey, subsequently identified as the BHPS Sample component. During the third wave, the Nurse Assessment module was administered to 5,053 respondents from the BHPS Sample component. Consequently, the two Nurse Assessment samples do not overlap.

[4] The advantage of focusing our efforts on the second wave of the UKHLS is that there is no "lag" between the PRP measure and the health measures. However, additional analyses were carried out on the BHPS sample component using their PRP response during the second wave and their health measures during the third wave. Despite the one-year lag, we find qualitatively similar results from the sample presented here. However, the BHPS sample is smaller and unsurprisingly the effects are statistically weaker. Results are available from the authors.

UKHLS also provides the individual responses for the first item on the SF-12 scale[5], 'In general, would you say your health is…'. This item is rated on a 5-point Likert scale (Excellent, Very good, Good, Fair, Poor) and is used here as a general measure of health. Both this single health item and the GHQ-12 were coded in the same direction as the physical/mental health subscores for consistency when reporting the self-reported health measures in the next section.

The Nurse Assessment module of the UKHLS provides a range of health measures beyond self-report. These include systolic and diastolic blood pressure, as well as c-reactive protein and fibrinogen markers as extracted from blood samples provided by the respondents. Self-reported stress is associated with increases in both systolic and diastolic blood pressure both in research examining brief episodes of stress in the lab (Hjortskov *et al*., 2004) as well as longitudinal survey data measuring chronic psychosocial stress (Steptoe *et al*., 2005). Furthermore, people with blood pressure above 140/90 mmHg are considered at risk for hypertension (National Institute for Health and Care Excellence [NICE], 2019), suggesting that this is another important outcome to measure. Similarly, c-reactive protein is a marker of inflammation where levels > 3 mg/l is considered a risk factor for cardiovascular disease (Pearson *et al*., 2011). It has been linked with lower socio-economic status (Owen *et al*., 2003) and a systematic review by Johnson *et al*. (2013) suggests that levels of c-reactive protein may mediate the relationship between chronic stress and health outcomes. The UKHLS report that c-reactive protein levels in males and females from their Nurse Assessment sample are on average 2.3 and 3.1 mg/l respectively, similar to the levels found in the Health Survey

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[5] Both scales use a mixture of binary or 5-point Likert ratings. The questions are prefaced with "During the past 4 weeks…". The physical scale consists of the following six items: 1) In general, would you say your health is Excellent-Poor, 2) Does your health now limit you in these activities, a) Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf, b) Climbing several flights of stairs, 3) Have you had any of the following problems with your work or other regular daily activities as a result of your health, a) Accomplished less than you would like, b) Were limited in the kind of work or other activities, 4) How much did pain interfere with your normal work.
The mental scale also consists of six items: 1) Have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems, a) Accomplished less than you would like, b) Didn't do work or other activities as carefully as possible, 2) Have you felt calm and peaceful, 3) Did you have a lot of energy, 4) Have you felt downhearted and blue, 5) How much of the time has your physical health or emotional problems interfered with your social activities.

for England (HSE, University College London, Department for Epidemiology & Public Health, 2009). Although there are no clinical cut-off points, fibrinogen is increased by acute mental stress (Ellins *et al*., 2017; Steptoe *et al*., 2003) and a link has also been found between increased fibrinogen levels and lower education levels and income (Panagiotakos *et al*., 2004), lower socio-economic status (Ramsay *et al*., 2008) and chronic stress (Siegrist *et al*., 1997). Similarly to the HSE 2009, in the full UKHLS Nurse Assessment males and females have average fibrinogen levels of 2.7 and 2.8 g/l respectively.

There are discrepancies in the sample size for each health measure in the UKHLS. Not all survey respondents were invited to take part in the Nurse Assessment, and although the majority of Nurse Assessment participants were invited to provide blood samples, a subset of the blood is frozen for future research and thus there are no inflammation markers for these respondents. In the current study we have aimed to use the larger sample size where possible. In addition, for the blood marker sample, respondents with c-reactive protein levels greater than > 10 mg/l are removed from analysis as recommended by UKHLS (Benzeval *et al*., 2014). Thus, after these restrictions and removing those without valid data for the other variables, the sample sizes for the three regression analyses are 6120 (outcome: self-reported health), 5667 (blood pressure) and 4025 (inflammation markers).

In addition to the key health and PRP data, the UKHLS has a rich array of other variables that would serve as covariates. We have included socio-demographic information such as age, gender, ethnicity, country of residence, education, income and occupation. Furthermore, we have included other factors which may affect health such as ever smoked status, body mass index (BMI), and whether the job is manual or not. Finally, taking prescribed medication is included as a covariate as physiological health may be influenced by medication.

5. Results

5.1 Descriptive statistics

The sociodemographic breakdown of the three samples can be seen in Table 1. Unsurprisingly, the proportion of nonPRP workers (82.97%) is higher than PRP workers (17.03%) in the largest sample and, importantly, the percentage remains comparable across all three samples. The samples also include a higher proportion of respondents who are white, living in England, female, have a higher education and be employed in a non-manual occupation. Furthermore, respondents are more likely to have a BMI > 25, smoke or have smoked but not need medication for illnesses. The age of respondents at the time of the survey ranges from 16-65 years, and the average age is 42.28 years in the largest sample. Finally, the average monthly take-home income is £1,689.97 across all workers, albeit a proportion of these are part-time workers. Visual inspection of the health outcome variables (Figure 1) find a mostly normal distribution for all variables except c-reactive protein which has an expected positive skew, necessitating the transformation of this variable into logs. Simple comparisons of means show significant differences in self-reported general health, physical health, c-reactive protein and fibrinogen when comparing PRP and fixed pay contracts (see Table 2), all of which at a first glance suggest that PRP workers have better health. There are no significant differences in GHQ-12, self-reported mental health or either of the blood pressure measures although PRP respondents were slightly more likely to have blood pressure above the clinical cut-off values of 140/90 mmHg than nonPRP workers (17.21% vs 14.23%).

Table 1. Frequency of sociodemographic variables

	Self-report sample	Blood pressure sample	Inflammation marker sample
	(n=6120)	*(n=5667)*	*(n=4025)*
nonPRP	5078 (82.97%)	4737 (83.59%)	3358 (83.43%)
PRP	1042 (17.03%)	930 (16.41%)	667 (16.57%)
BMI > 25	4051 (66.19%)	3728 (65.78%)	2748 (68.27%)
BMI =< 25	2069 (33.81%)	1939 (34.22%)	1277 (31.73%)
Has never smoked	2643 (43.19%)	2607 (46%)	1725 (42.86%)
Has ever smoked	3477 (56.81%)	3060 (54.00%)	2300 (57.14%)
Female	3454 (56.44%)	3223 (56.87%)	2234 (55.50%)
Male	2666 (43.56%)	2444 (43.13%)	1791 (44.50%)
Married	3479 (56.85%)	3236 (57.10%)	2351 (58.41%)
Not married	2641 (43.15%)	2431 (42.90%)	1674 (41.59%)
Education - high	2753 (44.98%)	2584 (45.60%)	1770 (43.98%)
Education - mid	1324 (21.63%)	1218 (21.49%)	849 (21.09%)
Education - lower	2043 (33.38%)	1865 (32.91%)	1406 (34.93%)
Non-white ethnicity	289 (4.72%)	370 (6.53%)	213 (5.29%)
White ethnicity	5831 (95.28%)	5297 (93.47%)	3812 (94.71%)
Resident in England	5661 (92.50%)	5245 (92.55%)	3702 (91.98%)
Resident in Scotland	305 (4.98%)	286 (5.05%)	218 (5.42%)
Resident in Wales	154 (2.52%)	136 (2.34%)	105 (2.61%)
Manual work	1369 (22.37%)	1269 (22.39%)	972 (24.15%)
Non-manual work	4751 (77.63%)	4398 (77.61%)	3053 (75.85%)
Medication	2371 (38.74%)	2229 (39.33%)	1557 (38.68%)
No medication	3749 (61.26%)	3438 (60.67%)	2468 (61.32%)
Age (years)	42.28	42.43	43.51
Monthly income	£1,689.97	£1,687.28	£1,701.21

Figure 1. Distributions of health outcomes

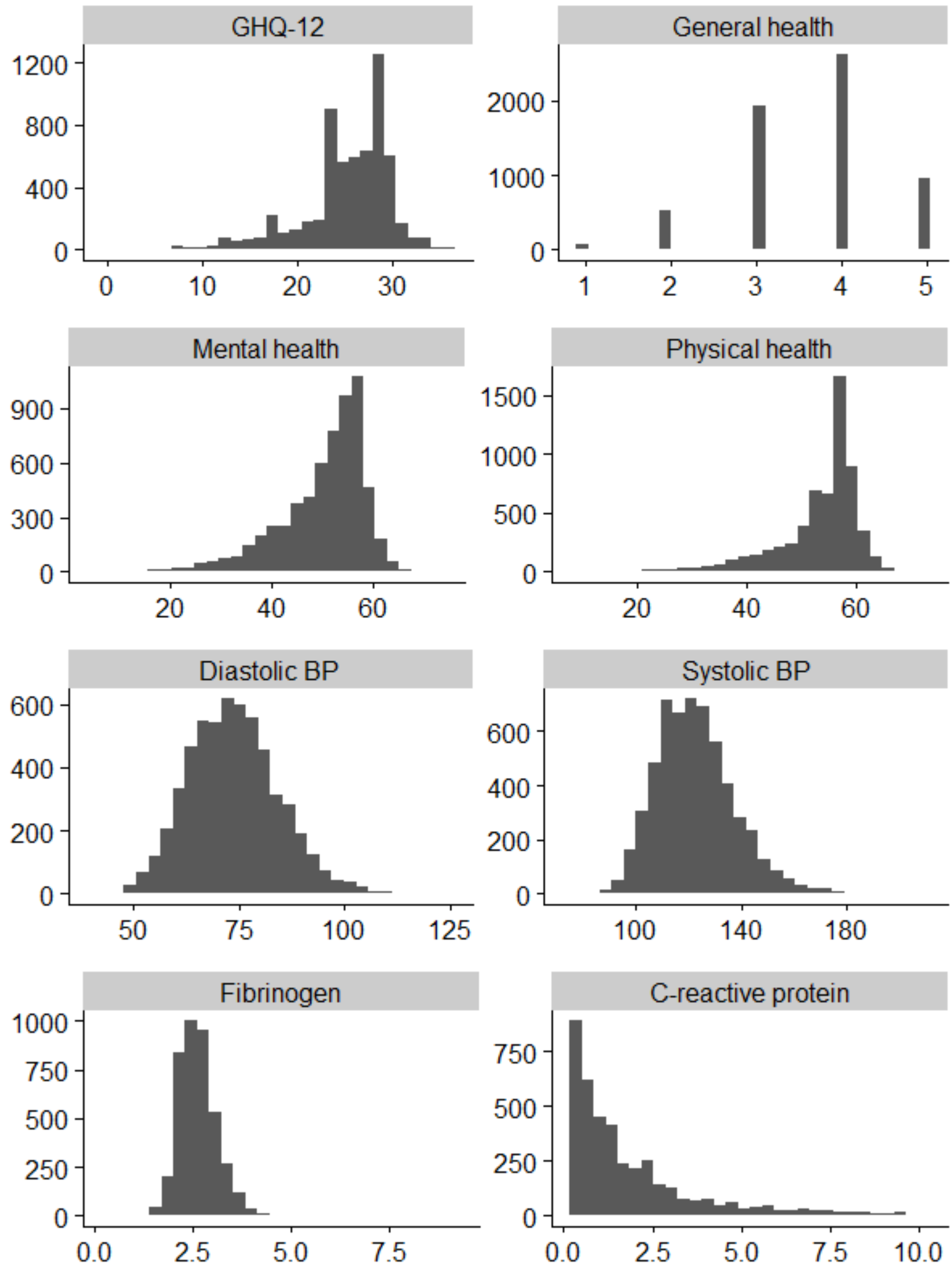

Table 2. Means and standard deviations for dependent variables

	Self-report sample *(n=6120)*				Blood pressure (BP) sample *(n=5667)*			Inflammation marker sample *(n=4025)*	
	Self-rept'd GHQ-12	Self-rept'd general health	Self-rep't physical health	Self-rep't mental health	Systolic BP	Diastolic BP	BP > 140/90 mmHg	C-reactive protein	Fibri-nogen
Fixed pay	25.17 (4.92)	3.62 (0.89)	52.98 (7.99)	50.25 (8.53)	122.67 (15.07)	73.78 (10.73)	14.23%	1.94 (1.93)	2.66 (0.52)
PRP	25.44 (4.68)	3.70 (0.86)	54.05 (6.97)	50.30 (8.52)	123.24 (14.62)	74.29 (10.94)	17.21%	1.74 (1.74)	2.59 (0.47)

Note: Standard deviations in brackets. The GHQ-12 (0-36) and general health (1-5) scores have been reversed so that higher scores indicate better health, in line with the physical and the mental health subscores (0-100).

There are several potential explanations for these results that run contrary to the hypothesis and previous findings that PRP is detrimental to health. The first is that the PRP sample contains participants with more of the characteristics that are strong predictors of better health outcomes, such as younger age (41.36 years for PRP workers vs 42.47 years for nonPRP workers), higher monthly income (£2,126.32 vs £1,600.43) and more likely to have studied in higher education (52.11% vs 43.52%), consequently netting out much of the effect that working in PRP may have on health, suggesting the need to control for such factors in a regression framework. Secondly, as discussed in the previous section there is likely to be a self-selection bias. Individuals who are struggling with their health are more likely to sort out of payment contracts which require a high rate of productivity, meaning that there is a limited time to "catch them" in PRP employment when measuring health. Alternatively, individuals with good health may be willing to undertake more risk and uncertainty so be more willing to opt for a PRP payment scheme. Consequently, to examine this further it is necessary to run an endogenous treatment regression that controls for covariates which may impact on health and corrects for self-selection bias to determine whether this positive association between PRP and health is robust to these issues.

5.2 Regression results

As discussed above, an endogenous treatment model is estimated for each health outcome involving the simultaneous estimation of two equations – one predicting self-selection into PRP while the other is the specific health equation. The former is a reduced form regression, estimated with the variables from the outcome regression as well as the instruments. As the self-reported general health measure is an ordinal variable, it is estimated with an ordered probit regression. Similarly, the likelihood of having blood pressure above the clinical cut-off point is a binary variable and consequently it was estimated with a probit regression. All the remaining health outcomes are estimated with a linear regression model[6]. In addition to PRP, the health regression includes a number of sociodemographic variables such as: monthly net income/1000, manual work, age, gender, education level, marital status, ethnicity and country of residence in the UK as well as variables which are known to affect physiological markers and perceptions of health, including BMI, previous or current smoking and taking prescribed medication, are included in the model. Since the PRP selection equation is a reduced form regression, it includes all the variables from the health equation as well as the two instruments: small firm size and percent PRP in an occupation. The log of c-reactive protein was used to mitigate against the positive skew mentioned previously.

[6] All models were estimated in R and Stata using the commands `etregress, eprobit` and `eoprobit`. Although the GHQ-12 is used with a Likert scale, the 0-36 scoring used here results in a normal distribution which is suitable for parametric testing (Banks *et al*., 1980).

Table 3. Marginal effects for each endogeneity treatment regression

	Self-reported GHQ-12	Self-reported general health	Self-reported physical health	Self-reported mental health	Systolic blood pressure	Diastolic blood pressure	Blood pressure > 140/90 mmHg	C-reactive protein	Fibrinogen
	n=6120	*n=6120*	*n=6120*	*n=6120*	*n=5667*	*n=5667*	*n=5667*	*n=4025*	*n=4025*
Self-selection regression									
Instrument - % PRP across occupation	0.56*** (0.05)	0.77*** (0.05)	0.77*** (0.05)	0.58*** (0.05)	0.62*** (0.05)	0.81*** (0.05)	0.81*** (0.05)	0.76*** (0.07)	0.58*** (0.07)
Instrument - firm size	0.04*** (0.01)	0.05*** (0.01)	0.05*** (0.01)	0.05*** (0.01)	0.04*** (0.01)	0.05*** (0.01)	0.05*** (0.01)	0.04*** (0.01)	0.04** (0.04)
Outcome regression									
PRP	-6.99*** (0.26)	-0.01 (0.04)	2.38*** (0.74)	-11.46*** (0.53)	15.69*** (1.12)	-0.12 (1.38)	-0.01 (0.05)	-0.18 (0.19)	0.58*** (0.05)
Age	-0.03*** (0.01)	-0.002*** (0.0003)	-0.09*** (0.01)	0.03** (0.01)	0.37*** (0.02)	0.19*** (0.01)	-0.01*** (0.0005)	0.004** (0.001)	0.01*** (0.001)
BMI > 25	-0.09 (0.15)	-0.07*** (0.01)	-1.31*** (0.21)	-0.23 (0.26)	5.04*** (0.41)	5.40*** (0.29)	-0.09*** (0.01)	0.56*** (0.03)	0.20*** (0.02)
Smoker	-0.38*** (0.14)	-0.04*** (0.01)	-0.51*** (0.19)	-0.61** (0.25)	-0.35 (0.39)	0.02 (0.27)	0.001 (0.01)	0.07* (0.03)	0.05** (0.02)
Monthly income/1000	0.44*** (0.07)	0.02*** (0.003)	0.46*** (0.10)	0.70*** (0.12)	-1.12*** (0.20)	0.04 (0.15)	0.001 (0.005)	-0.01 (0.02)	-0.03*** (0.01)
Male	1.20*** (0.16)	-0.02** (0.01)	-0.39* (0.22)	2.00*** (0.28)	8.94*** (0.44)	2.08*** (0.31)	-0.08*** (0.01)	-0.16*** (0.03)	-0.18*** (0.02)
Not married	-0.64*** (0.15)	-0.03*** (0.01)	-0.19 (0.20)	-1.63*** (0.26)	1.46*** (0.41)	0.13 (0.29)	-0.01 (0.01)	0.04 (0.03)	0.03 (0.02)
Education - lower	0.22 (0.19)	-0.03*** (0.01)	-0.93*** (0.26)	0.24 (0.33)	0.91 (0.52)	-0.02 (0.36)	-0.004 (0.01)	0.12** (0.04)	0.06** (0.02)

	0.40**	-0.03**	-0.79***	0.77**	0.85	0.18	-0.004	0.07	0.04
Education - mid	(0.20)	(0.01)	(0.27)	(0.34)	(0.54)	(0.38)	(0.01)	(0.04)	(0.02)
	0.07	0.08***	2.22***	1.44***	1.94*	-0.64	0.002	-0.08	-0.09*
White ethnicity	(0.32)	(0.01)	(0.43)	(0.55)	(0.78)	(0.55)	(0.02)	(0.06)	(0.04)
	0.46	0.03	0.48	0.64	1.12	1.14	-0.01	0.02	-0.05
Resident in Scotland	(0.32)	(0.02)	(0.43)	(0.55)	(0.87)	(0.61)	(0.02)	(0.06)	(0.04)
	-0.30	-0.02	-1.33**	-0.67	-0.66	-0.72	0.01	-0.12	-0.04
Resident in Wales	(0.44)	(0.02)	(0.60)	(0.76)	(1.24)	(0.87)	(0.03)	(0.09)	(0.05)
	0.46*	-0.004	0.07	0.44	-0.89***	-0.03	0.004	-0.03	-0.01
Non-manual work	(0.25)	(0.01)	(0.33)	(0.42)	(0.67)	(0.47)	(0.02)	(0.05)	(0.03)
	1.19***	0.13***	3.59***	1.77***	-1.04*	-0.29	0.02*	-0.15***	-0.03
No medication	(0.15)	(0.01)	(0.20)	(0.26)	(0.41)	(0.29)	(0.01)	(0.03)	(0.02)
	25.56***	-	53.51***	47.43***	97.07***	62.13***	3.41***	-0.20	2.10***
Constant	(0.55)		(0.75)	(0.94)	(1.44)	(1.03)	(0.31)	(0.12)	(0.07)

Note: Standard errors in brackets. Reference categories include BMI <= 25, non-smoker, female, married, high education, ethnicity other than white, resident in England, manual work and taking prescribed medications. All covariates from the outcome regression are also included in the self-selection regression. Occupation split into 9 levels is included as a covariate but not reported here for the sake of brevity.

Constants are not provided for the ordered probit regression. Instead, model uses the following cut points: -2.26, -1.20, -0.003, 1.33. The ordered probit predicts highest level of health (5).

** p < .05, ** p < .01, *** p < .001*

As can be seen in Table 3, the self-selection regressions find that both instruments are statistically significant predictors of PRP at a .001 level or lower for each health outcome. In line with research by Conyon *et al*. (2001) and Heywood *et al*. (1997), firms with a smaller number of employees are statistically less likely to utilise PRP contracts with marginal effects ranging from 0.04-0.05. Unsurprisingly, and as demonstrated by Artz *et al*. (2021), we find that share of PRP workers per occupation category is also a statistically significant predictor of all health outcomes (0.56-0.81).

Examining each of the health outcomes after correcting for self-selection bias in the bottom part of Table 3, we find that PRP contracts are associated with poorer self-reported mental health as measured by the GHQ-12 (marginal effect: -6.99) and the mental health component of SF-12 (-11.46), higher systolic blood pressure (15.69) and higher levels of fibrinogen (0.58). Somewhat surprisingly, it also predicts improved levels of self-reported physical health (2.38), even after controlling for covariates and endogenous treatment of PRP. Finally, PRP is not a statistically significant predictor of self-reported general health, diastolic blood pressure, blood pressure above the clinical cut-off point or (the log of) c-reactive protein.

5.3 Group differences

Finally, it is possible that the relationship between PRP and health outcomes may differ depending on the subsample that is studied. In particular, we are interested in how the relationship differs when comparing males and females, who are known to have different physiological makeup (and in the results in Table 3 are always statistically significantly different across the two groups), as well as manual and non-manual workers where the nature of the work tasks differ substantially. Consequently, we estimate regressions for each of the health outcomes across these four subsamples whilst controlling for self-selection and the same covariates as in the full regression.

As can be seen in Table 4, there are some noticeable differences between males and females. Although both groups show a similar significant effect of PRP on worse GHQ-12 scores (marginal effects: -6.84 and -6.90) and poorer mental health as measured by SF-12 (-11.56 and -10.72) as well as no effect of PRP on the self-reported general health item, PRP is only a significant predictor of better self-reported physical health among males (3.39). On the other hand, PRP is a significant predictor of higher systolic blood pressure among males (13.20) but not females (-2.39), indicating higher risk of cardiovascular disease among the former. PRP is not a significant predictor of higher diastolic blood pressure or having blood pressure above the clinical cut-off points in either of the subsamples. Finally, when estimating biomarkers in blood we can see that PRP is a significant predictor of higher c-reactive protein (0.73) as well as higher levels of fibrinogen (0.65) among male workers. However, there is no significant effect of PRP on either biomarker among female workers.

Table 4. Marginal effects for PRP predicting health outcomes for each subsample regression from sample selection regressions

	Self-reported GHQ-12	Self-reported general health	Self-reported physical health	Self-reported mental health	Systolic blood pressure	Diastolic blood pressure	Blood pressure > 140/90 mmHg	(log of) C-reactive protein	Fibrinogen
Full sample (from Table 3)	-6.99*** (0.26)	-0.01 (0.04)	2.34*** (0.74)	-11.49*** (0.53)	15.69*** (1.13)	-0.14 (1.39)	-0.01 (0.05)	-0.18 (0.19)	0.58*** (0.05)
Male	-6.84*** (0.31)	-0.003 (0.06)	3.39*** (0.93)	-11.56*** (0.65)	13.20*** (2.48)	-0.89 (1.99)	0.04 (0.09)	0.73*** (0.28)	0.65*** (0.06)
Female	-6.90*** (0.45)	-0.01 (0.04)	1.28 (1.16)	-10.72*** (0.97)	-2.39 (3.24)	0.36 (2.29)	-0.02 (0.06)	-0.20 (0.23)	-0.13 (0.11)
Manual	2.27* (1.27)	-0.02 (0.06)	1.97 (2.14)	-12.89*** (0.84)	18.47*** (2.08)	0.34 (4.81)	0.02 (0.26)	-1.02*** (0.32)	0.61*** (0.10)
Non-manual	-6.68*** (0.32)	-0.01 (0.04)	2.11*** (0.81)	-10.62*** (0.73)	15.18*** (1.33)	-0.29 (1.44)	-0.01 (0.05)	-0.25 (0.17)	-0.09 (0.06)

Note: Standard errors in brackets. Regressions include all previously mentioned covariates but are omitted here for brevity. Full results are available upon request from author.
** p < .05, ** p < .01, *** p < .001*

Unsurprisingly, there are also some differences when splitting the sample by manual and non-manual workers. For example, manual workers see a positive effect of PRP on GHQ-12 scores (marginal effect: 2.27) indicating better mental health whereas non-manual workers see a negative effect on the same health outcome (-6.68). In line with the full sample regression, neither group finds a significant effect of PRP on self-reported general health. However, PRP predicts slightly better physical health among non-manual workers (2.11) but has no effect on manual workers. PRP is a significant predictor of poorer mental health across both groups (-12.89 and -10.62). In line with the full sample, we find a positive relationship between PRP and higher systolic blood pressure in both groups (18.47 and 15.18) but no relationship between PRP and diastolic blood pressure or risk of being above the clinical cut-off point. On the other hand, PRP is a significant predictor of lower c-reactive protein (-1.02) yet higher levels of fibrinogen (0.61) among manual workers, but has no effect on biomarkers among non-manual workers. We can conclude then that some of the differences seen in the full sample are driven by the stronger effects among males and manual workers, albeit the number of PRP workers in manual occupations is small (n = *82*) and it is unclear how specific PRP structures differ between the two types of occupation. Results should therefore be interpreted with caution.

6. Conclusion

The aim of the current study is to examine the relationship between PRP and poor health using biomarkers of stress and health in workforce survey data. Although there is a growing body of evidence investigating the relationship between PRP and health, our study is able to address two limitations of previous research. Firstly, by measuring blood pressure and inflammation markers in blood it is possible to circumvent some of the issues traditionally associated with self-reported health measures in the literature on PRP. Secondly, by correcting for self-selection bias the study controls for some of the endogeneity that is associated with workers both self-selecting into PRP as well as having poorer health.

The findings from the current study are largely in line with previous research that has found that PRP workers are more likely to have poor health. Like Dahl and Pierce (2019), we find evidence that PRP workers self-report worse mental health and like Bender and Theodossiou (2014), who find that workers spending more time in PRP employment are more likely to suffer from cardiovascular health issues, this study shows higher levels of blood pressure among PRP workers, and particularly if they are also male. For the first time, this study is also able to show that PRP employees have higher levels of fibrinogen which in turn is associated with chronic levels of stress. Chronic stress in PRP employees could be due to the increase in working hours (Bender & Theodossiou, 2014) or due to the stress associated with a variable income stream. Regardless of the pathway, chronic stress may both exacerbate health issues and lead to unhealthy coping mechanisms such as alcohol and drug use (Artz *et al*., 2021) and the use of biomarkers in the current study provides novel evidence for physiological wear and tear in PRP workers. Finally, a main finding is that these differences between nonPRP and PRP workers are only present after statistically correcting for self-selection bias, suggesting that endogeneity is a key issue when studying the effects of PRP on health. Looking at differences in the PRP-health relationship suggests that men may have the largest risk of poor health due to PRP.

Although the UKHLS dataset provided a unique opportunity to look at biomarkers of stress, the paper suffers from some common survey data limitations. For example, the strongest level of income uncertainty may be felt when all of your pay is PRP, such as piece rate jobs. On the other hand, piece rates may offer a greater sense of control and therefore cause less income uncertainty. Regardless of the direction, the UKHLS only ask about PRP in a broad sense. It is therefore not possible to distinguish between participants whose pay is fully based on performance, and those who receive a combination of both PRP and a fixed salary. As different PRP structures may be more prevalent in certain occupations, this may explain some of the differences that we see between manual and non-manual workers. Future research should examine the interaction between manual labour and PRP structures.

Furthermore, the second wave of the UKHLS does not ask about personality traits or risk aversion, both of which may affect sorting into PRP and health outcomes. To some extent, this limitation may be mitigated by including smoking as a covariate in our model, which is often used a proxy for risk-taking, and by using the two stage regression procedure. However, if a dataset including labour information, physiological data and personality traits become available we believe that this would be a fruitful avenue for future research.

In summary, much of the previous literature has focused on the association between injuries or self-reported health and PRP. However, the current study finds evidence of a link between physiological markers of chronic stress and performance related pay once self-selection bias has been corrected for. These findings have implications for public health and employee relations given the established linkages between stress and health outcomes. While it may be that PRP contracts are viewed as the optimal payment contract for a firm, use of PRP in the labour market can have widespread detrimental effects on the employed population, which in turn may affect the long-term productivity of the labour force. If firms continue the use of PRP they may need to implement policies to mitigate against chronic stress.

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