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Unemployment, employment precarity, and inflammation.

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Unemployment has been associated with poorer health, but few studies have examined the biological mechanisms that confer these health decrements. Further, no studies to date have examined differences across employment groups to consider whether employment (in whatever means) is preferential in terms of health. The present study utilised secondary data from Understanding Society: The Household Longitudinal Survey during the aftermath of the recent global recession. Two markers of peripheral inflammation: C-reactive protein (CRP) and fibrinogen were assessed across employment groups (unemployed; permanent, temporary, and self-employed), controlling for individual, socio-demographic and health variables to give greater context to our understanding of how employment status influences health. After controlling for relevant confounds, unemployment was associated with higher levels of fibrinogen but not CRP. Subsequent analyses of employment subgroup revealed the temporary employed have similar levels of fibrinogen to the unemployed, and may therefore be at a similar health disadvantage. The findings confirm that unemployment is associated with increases in one marker of peripheral inflammation, but that this health protection is not conferred to those in precarious employment.

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Introduction

Unemployment is a chronic stressor associated with physical and psychological morbidity including increased mortality (Roelfs et al., 2011), endocrine dysregulation (Sumner and Gallagher, 2017, Gallagher et al., 2016), cardiovascular disease risk (Dupre et al., 2012), and inflammation (Hughes et al., 2017). Population-level studies have shown increased inflammatory markers associated with cardiovascular disease among the unemployed (Hughes et al., 2015, Janicki-Deverts et al., 2008, Hintikka et al., 2009). These studies, however, have focused on examining differences in a binary categorisation of employment versus unemployment, but evidence is emerging that as much as "unemployment" is not one single conceptualisation, neither is "employment".

Atypical employment has grown in recent decades, with many workers employed on fixed-term contracts and experiencing unstable job conditions (Pirani and Salvini, 2015), associated with negative psychological consequences (Gustafsson et al., 2012). Since the recent global recession, both unemployment and temporary employment have expanded. The European Union has a higher temporary employment rate than the OECD average (14.2% versus 11.2% in 2016); and whilst the UK has tracked below this figure (6% in 2017, 4% in 2019), temporary employment has increased since the collapse in 2008 (OECD, 2019). The rate of young people in the UK going into precarious employment (temporary employment) is increasing, resulting in decreases to wellbeing and increases in mental health distress (Thorley and Cook, 2017). If temporary employment is also associated with decrements to health, and increased risk for mortality (Kivimäki et al., 2003) then earlier work using this binary categorisation of unemployment versus employment does not capture the complexities of (un)employment. Further, whilst less abundant, research has suggested that self-employment can be characterised by increased stress and loneliness (Patzelt and Shepherd, 2011), variables associated with health and wellbeing. Our aim was to examine the relationship between unemployment, employment and its subgroups, and inflammation in the UK using national data obtained during a time of peak unemployment (2010-2011), contrasting to similar pre-recession

large scale data (Janicki-Deverts et al., 2008, Hintikka et al., 2009), and extending similar work carried out across economic changes (Hughes et al., 2015).

Methods

Data were obtained from the second wave of *Understanding Society* (University of Essex et al., 2015). Socio-demographic information was obtained at a general survey interview conducted in 2010 or 2011, and blood samples were collected during a nurse visit approximately five months after the survey interview (McFall et al., 2014, University of Essex and Institute for Social and Economic Research, 2014). Respondents were invited to take part in the nurse data collection if they were aged over 16 years, lived in England, Wales, or Scotland, and were not pregnant. Respondents were included in the analyses if they had complete data for the variables of interest. We excluded participants that indicated they were retired, homemakers, not working due to incapacity, or in education. The final analysis included 4540 individuals.

The biomarkers were high-sensitivity C-reactive protein (CRP) and fibrinogen, measured in mg per litre and grams per litre, respectively. Employment status at the time of the Wave 2 interview was used to define employment status and contract type (if employed). This is used as a proxy for employment status at the time of the nurse visit, although it is accepted that some participants may have changed their employment status between the two interviews.

Individual characteristics (age, sex, and partnership status), socio-economic characteristics (highest level of education and subjective financial status), and health characteristics (smoker status, obesity (BMI<25>), presence of chronic medical conditions, use of prescription and non-prescription medications, and alcohol consumption) were used as control variables due to their associations with inflammation (Nabi et al., 2008, Hughes and Kumari, 2017, Kalousova and Burgard, 2014). BMI was calculated by weight and height measurement carried out during the nurse visit; and all other characteristics were captured in self-report during the survey interview.

Chi-squared tests for independence and simple linear regressions were used to test for difference and association in biomarkers and confounds between employment groups. Multiple linear regression was used to assess the association between the biomarkers and employment variables after controlling for different groups of confounds. An adjusted alpha level of .025 was set to adjust for multiple dependent variables (based on two biomarkers being analysed). These analyses were carried out using weights to account for response rates and survey design. Data screening indicated normally distributed errors in the case of the fibrinogen regressions, but moderate deviation from normality for the CRP regressions. The CRP scores were log-transformed to correct for this. Taking prescription medications and being diagnosed with chronic medical conditions can impact inflammation (Ballantyne and Nambi, 2005, van Rijn et al., 2014), therefore, the analyses were repeated excluding participants in these categories but were found to be consistent with the main analyses (not shown).

Results

Overall, 7.6% (weighted percentage) of the sample were unemployed. Amongst the employed, 81.8% were permanently employed, 5.3% were temporarily employed, and 12.9% were self-employed (all weighted percentages). Individual, socio-economic, and health characteristics are presented in Table 1.

The unemployed had significantly higher levels of fibrinogen than the employed group as a whole, as well as each of the employment subgroups. The unemployed also had significantly higher levels of CRP relative to the employed and self-employed subgroup, but not relative to the temporary or permanent employed subgroups. There was a moderate positive correlation between the two biomarkers (Pearson's *r* (unweighted)=0.43).

Tables 2 and 3 present the regressions for CRP (log-transformed) and fibrinogen, including the employment variables and controls. CRP levels (log-transformed) amongst the unemployed group

were significantly different to the whole employed group when controlling for individual characteristics alone; but differences were nullified when controlling for all confounds (Table 2; models 1-4a). In contrast, the unemployed group have significantly higher levels of fibrinogen compared to the employed in each model (Table 2; models 1-4b). When comparing each employment subgroup, CRP was significantly different between the unemployed and self-employed and permanently employed when controlling for individual characteristics alone; but differences were nullified when controlling for all confounds (Table 3; models 1-4a). Fibrinogen differs significantly between the unemployed and permanent and self-employed in all levels of control; but there are no significant differences between the unemployed and the temporary employed (Table 3; models 1-4b). Thus, for fibrinogen the protection of employment is no longer conferred for those that are employed on a temporary contract.

Discussion

This study is the first to evaluate differences in inflammation associated with cardiovascular health across (un)employment subgroups, looking beyond the binary categorisation of unemployed/employed. Our findings indicate that while unemployment is associated with elevated fibrinogen, comparisons to temporary employment reveal no statistically significant association when controlling for confounds. The literature on temporary employment is supportive of it being harmful to psychological health (Virtanen et al., 2005), self-rated health (Pirani and Salvini, 2015), and mortality (Kivimäki et al., 2003); and it would appear here to be similarly associated to elevated fibrinogen as unemployment. Previous work has found the health of self-employed women to be better than unemployed counterparts (Dolinsky and Caputo, 2003), however little research has been carried out comparing the groups in terms of inflammation. Whilst our findings for CRP are not in line with other studies on the topic when controlling for factors beyond individual characteristics (Janicki-Deverts et al., 2008, Hughes et al., 2015), our observations for fibrinogen are. The observation that unemployment is associated with higher fibrinogen but not with CRP is challenging

to explain given relatively few studies examining chronic stressors and both of these markers of

inflammation. Although these markers are often inter-correlated, differential associations have been

noted in areas such as personality traits (Allen and Laborde, 2017). Different expressions of stress

(e.g. burnout, anxiety, depression) have been found to have differential associations with these

markers, where depression and burnout were positively associated with CRP, but not fibrinogen

(Toker et al., 2005).

It is important to acknowledge that the lack of determinable causality, the possibility of reverse

causation, and that the discrepancy between blood sampling and demographic data sampling time

are limitations. However, our approach accounted for several important confounds, and remained

consistent when those with long-term health conditions were excluded in additional analyses (not

shown). In summary, present findings indicate that temporary employment has little inflammatory

difference to unemployment in regard to fibrinogen. Given the continuing rise of precarious modes

of employment across the OECD (OECD, 2019), these findings have public health implications. Policy

should encourage employers to expand the use of permanent contracts.

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Research Highlights

- Unemployed have higher levels of fibrinogen and CRP than employed.

- Controlling for confounds equalises CRP differences in (un)employed groups.

- Higher fibrinogen in unemployed is observed in temporary employed also.

- Supporting health in the unemployed and temporary employed should be prioritised.

Tables

Table 1. Individual, socio-economic and health behaviours and conditions characteristics by employment group

Variable		Unemployed (N=305) Weighted column %	Employed (N=4235) Weighted column %		Permanent Employed (N=3500) Weighted column %		Temporary Employed (N=197) Weighted column %		Self-Employed (N=538) Weighted column %	
Age category (years)	16-24	23.4	8.4		7.6		32.9		3.8	
	25-35	17.9	21.0		21.6		18.2		18.4	
	35-44	17.3	24.3	***	25.5	***	13.6		21.4	***
	45-54	24.0	28.7		29.0		19.9		30.5	
	55-64	17.5	17.6		16.4		15.4		25.9	
Sex	Male	55.5	54.0		51.8		46.6		70.8	***
	Female	44.5	46.0		48.2		53.4		29.2	
Partnership status	Partnered	37.3	72.6	***	72.4	***	61.3	***	79.2	***
	Not Partnered	62.7	27.4		27.6		38.7		20.9	
Level of Education	Degree	10.1	28.3		27.6		34.6		30.4	
	Other higher degree	7.3	14.3		14.3		14.6		13.9	
	Secondary 18 or other	35.2	30.6	***	30.1	***	33.7	***	32.7	***
	Secondary 16	28.8	21.2		22.7		10.7		15.9	
	No qualifications	18.8	5.6		5.3		6.5		7.2	
Subjective Financial Status	Finding it quite or very difficult	37.7	9.3		9.0		11.6		10.3	
	Just about getting by	41.6	26.3	***	26.3	***	22.4	***	27.9	***
	Doing alright	14.4	36.5		36.5		37.1		36.2	
	Living comfortably	6.3	27.9		27.2		28.9		25.7	
Smoker status	Non-smoker	49.5	77.9	***	77.6	***	79.7	***	79.0	***
	Smoker	50.1	22.1		22.4		20.3		21.0	
Obesity (BMI)	<25	35.3	30.9		30.6		40.4		29.1	
	25+	64.7	69.1		69.4		59.6		70.9	
Long-standing illness or disability	None	66.7	75.6	**	75.5	**	79.0	**	75.1	*
	1+	33.3	24.4		24.6		21.0		24.9	
Prescription medicines	None	54.8	59.7		58.8		65.7	*	63.0	*
	1+	45.2	40.3		41.2		34.3		37.0	

Days consumed alcohol in previous week	<5	89.0		86.2		87.2		87.1		79.7	
	5+	11.0		13.8		12.8		12.9		20.3	*
CRP: mean (SE)		3.8 (0.56)		2.6 (0.09)	*	2.7(0.10)		2.4(0.40)		2.2 (0.17)	**
CRP (log-transformed): mean (SE)		0.48 (0.08)		0.30 (0.02)	*	0.31 (0.02)		0.24 (0.10)		0.23 (0.05)	*
Fibrinogen: mean (SE)		2.8 (0.04)		2.6(0.01)	***	2.7(0.01)	***	2.6(0.05)	**	2.7(0.03)	**

***p<0.001, **p<0.01, *p<0.05. All comparisons made to unemployed group

Table 2: Multiple linear regressions for the association between binary measure of employment status and CRP and Fibrinogen after controlling individual, socio-economic and health behaviours and conditions characteristics

	C-Reactive Protein (log transformed)												Fibrinogen											
	Model 1a: Individual characteristics			Model 2a: Individual & SES characteristics			Model 3a: Individual & health behaviour and conditions characteristics			Model 4a: Individual, SES & health behaviour & conditions characteristics			Model 1b: Individual characteristics			Model 2b: Individual & SES characteristics			Model 3b: Individual & health behaviour and conditions characteristics			Model 4b: Individual, SES & health behaviour & conditions characteristics		
	β	SE	p	β	SE	p	β	SE	P	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Employment status (Unemployed)																								
Employed	-0.22	0.08	**0.008**	-0.08	0.08	0.347	-0.11	0.08	0.148	-0.05	0.08	0.580	-0.20	0.04	**<0.001**	-0.14	0.04	**0.001**	-0.14	0.04	**0.001**	-0.119	0.043	**0.006**
Sex (Male)																								
Female	0.19	0.04	**<0.001**	0.20	0.04	**<0.001**	0.20	0.04	**<0.001**	0.21	0.04	<0.001	0.13	0.02	**<0.001**	0.13	0.02	**<0.001**	0.14	0.02	**<0.001**	0.141	0.018	**<0.001**
Age category (years) (16-24)																								
25-34	0.12	0.11	0.268	0.13	0.11	0.244	0.02	0.11	0.852	0.03	0.11	0.811	0.13	0.05	**0.009**	0.14	0.05	**0.007**	0.09	0.05	0.056	0.098	0.049	0.046
35-44	0.20	0.10	0.047	0.20	0.10	0.053	0.03	0.10	0.794	0.03	0.10	0.797	0.29	0.05	**<0.001**	0.28	0.05	**<0.001**	0.23	0.05	**<0.001**	0.230	0.048	**0.000**
45-54	0.28	0.10	**0.007**	0.25	0.10	**0.011**	0.06	0.10	0.557	0.05	0.10	0.616	0.35	0.05	**<0.001**	0.34	0.05	**<0.001**	0.28	0.05	**<0.001**	0.278	0.047	**0.000**
55-64	0.38	0.10	**<0.001**	0.36	0.10	**<0.001**	0.13	0.10	0.220	0.11	0.10	0.269	0.45	0.05	**<0.001**	0.44	0.05	**<0.001**	0.38	0.05	**<0.001**	0.376	0.050	**0.000**
Partnership Status (Unpartnered)																								
Partnered	0.02	0.05	0.722	0.04	0.05	0.402	0.00	0.05	0.957	0.01	0.05	0.909	-0.01	0.02	0.678	0.00	0.02	0.989	-0.01	0.02	0.636	-0.008	0.023	0.717
Education Level (Degree)																								
Other higher degree				0.10	0.06	0.074				0.03	0.05	0.533				0.06	0.04	0.107				0.026	0.034	0.443
Secondary 18 or other				0.14	0.05	**0.004**				0.07	0.05	0.145				0.08	0.02	**0.002**				0.043	0.024	0.079
Secondary 16				0.16	0.06	**0.004**				0.09	0.06	0.116				0.08	0.03	**0.003**				0.041	0.027	0.132
No qualifications				0.40	0.08	**<0.001**				0.30	0.07	**<0.001**				0.19	0.04	**<0.001**				0.131	0.041	**0.001**
Subjective financial status (Finding it quite or very difficult)																								
Just about getting by				-0.10	0.07	0.173				-0.04	0.07	0.571				-0.02	0.03	0.576				0.007	0.033	0.836
Doing alright				-0.15	0.07	0.039				-0.06	0.07	0.388				-0.06	0.03	0.082				-0.014	0.033	0.675
Living comfortably				-0.29	0.07	**<0.001**				-0.15	0.07	0.030				-0.10	0.03	**0.004**				-0.036	0.034	0.282
Smoker status (Non-smoker)																			0.18	0.02	**<0.001**	0.157	0.025	**<0.001**

	B	SE	p	B	SE	p	B	SE	p	B	SE	p	B	SE	p	B	SE	p	B	SE	p	B	SE	p
Smoker							0.26	0.05	**<0.001**	0.21	0.05	**<0.001**												
Obesity																								
(<25)																								
25+							0.57	0.04	**<0.001**	0.56	0.04	**<0.001**							0.23	0.02	**<0.001**	0.222	0.019	**<0.001**
Prescription Medications																								
(None)																								
1+							0.28	0.04	**<0.001**	0.27	0.04	**<0.001**							0.06	0.02	**0.004**	0.059	0.022	**0.007**
Long-standing impairment, illness or disability																								
(None)																								
1+							0.05	0.04	0.238	0.04	0.04	0.340							0.00	0.02	0.943	-0.002	0.023	0.930
Days consumed alcohol in previous week																								
(<5)																								
5+							-0.08	0.05	0.109	-0.05	0.05	0.255							-0.10	0.03	**0.000**	-0.094	0.028	**0.001**
Constant	0.20	0.11	0.079	0.10	0.13	0.447	-0.29	0.11	**0.011**	-0.33	0.12	**0.008**	2.52	0.05	**<0.001**	2.46	0.06	**<0.001**	2.31	0.05	**<0.001**	2.272	0.058	**<0.001**
R-Squared		0.02			0.04			0.11			0.12			0.07			0.08			0.12			0.13	

Significant associations are highlighted in bold (p<0.025). Reference categories shown in brackets.

Table 3: Multiple linear regressions for the association between employment subtypes and CRP and Fibrinogen after controlling individual, socio-economic and health behaviours and conditions characteristics

	C-Reactive Protein (log transformed)												Fibrinogen											
	Model 1a: Individual characteristics			Model 2a: Individual & SES characteristics			Model 3a: Individual & health behaviour and conditions characteristics			Model 4a: Individual, SES & health behaviour & conditions characteristics			Model 1b: Individual characteristics			Model 2b: Individual & SES characteristics			Model 3b: Individual & health behaviour and conditions characteristics			Model 4b: Individual, SES & health behaviour & conditions characteristics		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Employment status (Unemployed)																								
Permanent employed	-0.21	0.08	0.013	-0.07	0.08	0.419	-0.11	0.08	0.166	-0.04	0.08	0.625	-0.20	0.04	**<0.001**	-0.14	0.04	**0.001**	-0.15	0.04	**<0.001**	-0.13	0.04	**0.004**
Temporary employed	-0.23	0.13	0.074	-0.09	0.14	0.516	-0.10	0.12	0.398	-0.03	0.13	0.796	-0.14	0.06	0.030	-0.07	0.06	0.254	-0.07	0.06	0.244	-0.04	0.06	0.476
Self-employed	-0.28	0.09	**0.002**	-0.15	0.09	0.116	-0.15	0.09	0.094	-0.09	0.09	0.342	-0.21	0.05	**<0.001**	-0.15	0.05	**0.004**	-0.14	0.05	**0.005**	-0.11	0.05	**0.023**
Sex (Male)																								
Female	0.19	0.04	**<0.001**	0.19	0.04	**<0.001**	0.20	0.04	**<0.001**	0.20	0.04	**<0.001**	0.13	0.02	**<0.001**	0.13	0.02	**<0.001**	0.14	0.02	**<0.001**	0.14	0.02	**<0.001**
Age category (years) (16-24)																								
25-34	0.12	0.11	0.266	0.12	0.11	0.241	0.02	0.11	0.834	0.03	0.11	0.792	0.14	0.05	**0.005**	0.15	0.05	**0.004**	0.10	0.05	0.034	0.11	0.05	0.027
35-44	0.20	0.10	0.045	0.20	0.10	0.050	0.03	0.10	0.772	0.03	0.10	0.774	0.30	0.05	**<0.001**	0.29	0.05	**<0.001**	0.24	0.05	**<0.001**	0.24	0.05	**<0.001**
45-54	0.28	0.10	**0.006**	0.26	0.10	**0.010**	0.06	0.10	0.531	0.05	0.10	0.586	0.36	0.05	**<0.001**	0.35	0.05	**<0.001**	0.29	0.05	**<0.001**	0.29	0.05	**<0.001**
55-64	0.39	0.10	**<0.001**	0.37	0.10	**0.000**	0.13	0.10	0.197	0.12	0.10	0.240	0.46	0.05	**<0.001**	0.45	0.05	**<0.001**	0.39	0.05	**<0.001**	0.39	0.05	**<0.001**
Partnership Status (Unpartnered)																								
Partnered	0.02	0.05	0.700	0.04	0.05	0.384	0.00	0.05	0.968	0.01	0.05	0.894	-0.01	0.02	0.667	0.00	0.02	0.978	-0.01	0.02	0.614	-0.01	0.02	0.695
Education Level (Degree)																								
Other higher degree				0.10	0.06	0.078				0.03	0.05	0.539				0.06	0.04	0.101				0.03	0.03	0.424
Secondary 18 or other				0.14	0.05	**0.005**				0.07	0.05	0.149				0.08	0.02	**0.002**				0.04	0.02	0.071
Secondary 16				0.16	0.06	**0.005**				0.09	0.06	0.124				0.09	0.03	**0.002**				0.05	0.03	0.100
No qualifications				0.40	0.08	**<0.001**				0.30	0.07	**<0.001**				0.19	0.04	**<0.001**				0.13	0.04	**0.001**
Subjective financial status Finding it quite or very difficult																								
Just about getting by				-0.10	0.07	0.164				-0.04	0.07	0.562				-0.02	0.03	0.599				0.01	0.03	0.795
Doing alright				-0.15	0.07	0.035				-0.06	0.07	0.376				-0.06	0.03	0.086				-0.01	0.03	0.714

	M1 Coef	M1 SE	M1 p	M2 Coef	M2 SE	M2 p	M3 Coef	M3 SE	M3 p	M4 Coef	M4 SE	M4 p	M5 Coef	M5 SE	M5 p	M6 Coef	M6 SE	M6 p	M7 Coef	M7 SE	M7 p	M8 Coef	M8 SE	M8 p
Living comfortably				-0.29	0.07	**<0.001**				-0.15	0.07	**0.027**				-0.10	0.03	**0.004**				-0.03	0.03	0.309
Smoker status																								
(Non-smoker)																								
Smoker							0.26	0.05	**<0.001**	0.21	0.05	**<0.001**							0.18	0.02	**<0.001**	0.16	0.02	**<0.001**
Obesity																								
(<25)																								
25+							0.57	0.04	**<0.001**	0.56	0.04	**<0.001**							0.23	0.02	**<0.001**	0.22	0.02	**<0.001**
Prescription medication																								
(None)																								
1+							0.28	0.04	**<0.001**	0.27	0.04	**<0.001**							0.06	0.02	**0.004**	0.06	0.02	**0.006**
Long-standing illness or disability																								
(None)																								
1+							0.05	0.04	0.239	0.04	0.04	0.342							0.00	0.02	0.958	0.00	0.02	0.920
Days consumed alcohol in previous week																								
(<5)																								
5+							-0.08	0.05	0.120	-0.05	0.05	0.278							-0.10	0.03	**<0.001**	-0.10	0.03	**0.001**
Constant	0.20	0.11	0.076	0.10	0.12	0.423	-0.29	0.11	**0.011**	-0.33	0.12	**0.008**	2.52	0.05	0.000	2.45	0.06	**<0.001**	2.30	0.05	**<0.001**	2.26	0.06	**<0.001**
R-Squared		0.02			0.04			0.11			0.12			0.07			0.08			0.13			0.13	

Significant associations are highlighted in bold (p<0.025). Reference categories shown in brackets.