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Informal caregiving and metabolic markers in the UK Household Longitudinal Study

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ABSTRACT

Objectives: Informal caregiving is associated with poorer mental and physical health. Little research has yet focused on objectively measured health risk factors, such as metabolic markers. The aim of this study was to investigate whether informal caregiving was associated with markers of metabolism in a large, representative UK longitudinal study. We also investigated whether more intensive caregiving, as indicated by more caregiving hours, was associated with a less favourable metabolic profile.

Study design/outcome measures: Using data on 9408 participants aged 16+ from the UK Household Longitudinal Study, we explored the relationship between caregiving and metabolic markers (blood pressure, total and high density lipoprotein cholesterol, glycated haemoglobin and triglycerides). We additionally investigated the importance of caregiving intensity (number of hours spent caregiving per week). Associations between caregiving/caregiving intensity and metabolic markers were tested using gender-stratified linear regression models adjusted for age, household income, education, social class, chronic illness, number of dependent children in the household, body mass index and partnership status.

Results: Men who were informal caregivers had higher total cholesterol levels than non-caregivers (3.25% higher, 95% CI: 0.07, 6.53). Women caregivers also had higher total cholesterol levels and women providing intensive care (over 20 h per week) had higher triglyceride levels (19.91% higher, 95% CI: 7.22, 34.10) and lower levels of high density lipoprotein cholesterol (8.46% lower, 95% CI: 14.51, 1.99); however, associations for women were attenuated in our final models.

Conclusions: Informal caregiving is associated with less favourable lipid profiles. This may be one mechanism through which informal caregiving is associated with increased disease risk. The health of informal caregivers should be a priority for public health.

1. Introduction

Informal caregiving is arguably the most important component of social care in the United Kingdom (UK) and many other Western countries. There are currently seven million informal caregivers in the UK (approximately 10% of the population) and in the United States (US) around one-fifth of adults are informal caregivers [1,2]. The importance of informal caregiving is set to increase over time in response to rising life expectancy, advances in medical treatment and survivorship, and decreasing funding for adult social care [3].

It is relatively well established that informal caregivers report poorer psychological and physical health, on average, compared to non-caregivers [4,5]. However there is a predominance of cross-sectional studies and a focus on specific subsamples, such as middle- or older-aged caregivers [6–8] and caregivers to specific patient groups, such as those diagnosed with dementia or cancer [9–11]. There are a number of reasons why caregiving might be related to poorer health. These mechanisms include psychological distress, a reduction in social support, loss of self-identity, physical strain and exhaustion, conflict between caregiving activities and other responsibilities such as work and parenting, financial burden and a change in the nature of the caregiver-care recipient relationship, particularly when caring for someone with dementia [12–16]. Informal caregiving may also be related to a host of health and disease outcomes through a physiological stress mechanism, for example mediated via hypothalamic-pituitary-adrenal (HPA) axis dysregulation. Indeed previous studies have shown that caregivers have higher salivary cortisol levels compared to non-caregivers [17]. Cortisol binds to glucocorticoid receptors on adipose tissue in visceral fat which can increase adiposity, and informal caregiving has been related to a higher body mass index [14]. An increase in cytokine release can result

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from increased visceral adipose tissue, resulting in changes in glucose and lipid metabolism and consequently the development of insulin resistance [18]. It is therefore plausible that informal caregivers might have less healthy metabolic profiles relative to non-caregivers. However no longitudinal population studies have yet investigated this.

The relationship between informal caregiving and health might depend on the gender of the caregiver. It is well known that women are more likely to be informal caregivers across the life course, with the exception of older age [19]. Women caregivers tend to report poorer health than male caregivers [4]. This is likely because women caregivers tend to engage in more intense caregiving activities, for example by providing more time investment and more intimate caregiving activities (e.g. personal care), and women are also more likely to be the primary caregiver [20]. Women who are caregiving are also more likely than men caregivers to give up paid employment or to reduce working hours in response to their caregiver responsibilities [21]. The association between caregiving and health is also likely to be modified by the intensity of caregiving engagement. For instance, there is evidence from the ONS Longitudinal Study that caregivers providing more than twenty hours of caregiving peer week have worse health outcomes than caregivers providing 'light caregiving' [22]. Currently, longitudinal studies investigating caregiving and metabolic markers have yet to account for potential modification by gender and caregiving intensity when investigating associations with health.

The purpose of this study was to investigate whether informal caregivers had poorer metabolic profiles compared to non-caregivers in a large UK longitudinal study. We also investigated whether associations between caregiving and metabolic markers were stronger for caregivers doing more intensive caregiving and if associations between caregiving and metabolic markers were stronger for women compared to men.

2. Methods

2.1. Data

This study used a large, nationally-representative panel study – the UK Household Longitudinal Study (UKHLS). The UKHLS is a longitudinal study of 40,000 UK households, initiated in 2009, incorporating the British Household Panel Study (BHPS) which began in 1991. The UKHLS has a stratified, clustered, equal probability sample. Further information on the sampling design can be found in Lynn [23]. Adults aged 16+ in the household are interviewed every year, with each wave of data collection taking two years to complete. To date there are six waves of data available. The response rates for each wave are high; 81.8% of eligible individuals provided a full interview at wave one, 72.4% were re-interviewed at wave two and 78.8% at wave 3.

A health assessment was conducted across waves 2 and 3 (2010–2012) in the homes of a sub-sample of UKHLS participants aged 16+ who resided in England, Wales or Scotland (Great Britain) and who had conducted a full interview at the previous wave in English. The wave 2 component included the general population UKHLS sample (26,961 participants were eligible after excluding 1857 not resident in Great Britain, 2274 who didn't provide a full interview at the previous wave, 122 whose interview was in Welsh not English and 5299 who were not in the selected primary sampling unit). 15,591 of the eligible 26,961 participants (58.6%) participated in the health assessment (262 participants were not eligible due to pregnancy, illness or death, 2590 were not contactable and 7626 refused) [24]. The wave 3 component included the BHPS sample (8914 participants were eligible after excluding 1897 not resident in Great Britain, 514 who didn't provide a full interview at the previous wave and 39 whose interview was in Welsh). 5053 of the eligible 8914 participants (56.7%) were participated in the health assessment (50 were not eligible due to pregnancy, illness or death, 2052 were not contactable and 1728 refused) [25].

The health assessment included physical measurements, the collection of blood samples and a short questionnaire. All analytic variables, with the exception of metabolic markers and smoking status which were only available at wave 2/3, were used at the survey prior to the health assessment (wave 1 for the UKHLS sample component and wave 2 for the BHPS sample component). This study therefore uses data from waves 1–3 (2009–2012). Informed consent was obtained from all participants for all waves. Ethical approval for the UKHLS was obtained from the University of Essex Ethics Committee. This study conforms to the principles embodied in the Declaration of Helsinki.

2.2. Measures

2.2.1. Caregiving and caregiving intensity

Participants were asked two main questions regarding informal care provision: 'is there anyone living with you who is sick, disabled or elderly whom you look after or give special help to (for example, a sick, disabled or elderly relative/husband/wife/friend etc.)?' and 'do you provide some regular service or help for any sick, disabled or elderly person not living with you?' Participants who answered 'yes' to either question were classified as an informal caregiver. Caregivers were subsequently asked about the number of hours per week they spent on caregiving activities. This was categorised as not caregiving, < 5 h, 5–19 h or 20 + h per week. These categories were based on the possible response options and the existing caregiving literature.

2.2.2. Metabolic markers

Six metabolic markers were measured at the health assessment at waves 2 and 3. Firstly, blood pressure (systolic and diastolic) was measured three times by the study nurse using an Omron HEM 907 sphygmomanometer. The mean of the three measurements was used. Participants who were taking anti-hypertensive medications (n = 3799) had their systolic blood pressures (SBP) increased by 10 mmHg and their diastolic blood pressures (DBP) increased by 5 mmHg as recommended [26]. Valid blood pressure measurements were available for 16,846 participants. Non fasting blood samples were taken from participants, enabling the assessment of total and high density lipoprotein (HDL) cholesterol, triglycerides and glycated haemoglobin (HbA1c). Total cholesterol was available for 12,895, HDL cholesterol for 12,876, triglycerides for 12,898 participants. Also 12,162 participants had a valid HbA1c value. In total, 19,147 participants had at least one of the six metabolic measures used in this study.

2.2.3. Covariates

Covariates included gender and age, banded as 16–44 years, 45–64 years and 65+ years. We additionally included a number of indicators of socioeconomic position. The National Statistics Socio-economic Classification (NS-SEC) three-category social class classification was used, with the three categories representing 'management and professional', 'intermediate', or 'routine, never worked or long-term unemployed'. The highest qualification achieved was used as a measure of educational attainment. This variable was categorised as no qualifications, GCSE or equivalent, A-level or equivalent, or higher qualification or degree. Net equivalised household income per month was included and categorised into quintiles. In order to account for potential health selection into caregiving we included information on whether the caregiver had a longstanding physical or mental impairment, illness or disability. We additionally included information on partnership status (single, married and living with spouse, separated/divorced, widowed or cohabiting), the number of dependent children aged 18 or under in the household, smoking status (never smoked, ex-smoker or current smoker) and body mass index (BMI, weight(kg)/height(m)^2).

2.3. Missing data

UKHLS participants who had complete data on each metabolic outcome, caregiving and all covariates were included in the analytic

sample. The analytic samples for each metabolic outcome were as follows: SBP and DBP n = 8272, triglycerides n = 6346, cholesterol n = 6345, HDL cholesterol n = 6334 and HbA1c n = 6000. Differences between the analytic and whole sample were found for most variables. More specifically, those with missing data had higher blood pressure, lower cholesterol, higher HbA1c, were more likely to be caregiving and to be caregiving for 20+ hours/week, were older, were more likely to be in routine occupations, had lower educational attainment, were from richer households, were more likely to have a longstanding health condition, were less likely to be married, had fewer dependent children and were more likely to be a current smoker.

2.4. Statistical analyses

Associations between caregiving and metabolic markers were tested using a series of linear regression analyses. Firstly, the age-adjusted association was estimated. Secondly, all covariates were introduced (age, educational attainment, longstanding illness, social class, household income, smoking status, BMI, number of dependent children and partnership status). The same approach was taken for the investigation of caregiving hours, substituting this variable in place of caregiving status. Both sets of analyses were stratified by gender, as the distributions of both caregiving and metabolic markers differed between men and women. Total cholesterol, HDL cholesterol, HbA1c and triglycerides were all positively skewed and hence log-transformed for all analyses. Estimates for these metabolic outcomes were converted to percentage differences to aid interpretation. All analyses included UKHLS weights which adjust for sampling design, unequal probabilities of selection, potential sampling error and differential non-response.

3. Results

The descriptive statistics shown in Table 1 are presented for participants with at least one observed metabolic outcome with information on caregiving and covariates (n = 9408). This table shows that informal caregiving was more common for women (14.8%) compared to men (10.6%) in our sample. Also women caregivers provided more hours per week of care than male caregivers; 14.9% of women caregivers provided 20+ hours/week compared to 8.9% of men caregivers. Men's blood pressures were higher than women's (e.g. mean SBP for men = 129.3 mmHg, mean SBP for women = 120.3 mmHg). Men also had higher triglyceride levels (men: 1.7 mmol/L, women: 1.3 mmol/L) and lower HDL cholesterol (men: 1.3 mmol/L, women: 1.6 mmol/L) compared to women. Mean levels of total cholesterol and HbA1c were the same for men and women in the sample. Men in the sample tended to be older than women and more likely to be in a management or professional social class or live in a higher income household. Women in our sample were marginally more likely to have a degree or higher qualification but men were more likely to have A-levels as their highest qualification. Just over a third of the sample reported a longstanding illness or impairment and this didn't differ between men and women. The majority of our sample were married and living with their spouse, had no dependent children in the household under 18 years. Approximately one-fifth of the sample were current smokers and this was more common for men. Finally, men in our sample had higher BMIs, on average, than women.

3.1. Informal caregiving and metabolic markers for men

Table 2 shows associations between informal caregiving and metabolic markers for UKHLS men. Men who were informal caregivers had 3.43% higher total cholesterol levels (95% CI: 0.46, 6.49) compared to men who were non-caregivers in age-adjusted linear regression. After adjusting for the other covariates, this association remained unchanged (3.25% higher cholesterol, 95% CI: 0.17, 6.53). This association was also robust to the exclusion of men taking statins (n = 598). No

Table 1
Characteristics of the study sample.

	Men		Women		P value gender difference
Outcomes					
SBP mmHg, mean (SD)	129.3	14.3	120.3	16.1	< 0.001
DBP mmHg, mean (SD)	74.3	10.6	72.2	10.4	< 0.001
Triglycerides mmol/L, median (IQR)	1.7	1.2, 2.5	1.3	0.9, 1.9	< 0.001
Cholesterol mmol/L, median (IQR)	5.3	4.5, 6.1	5.3	4.6, 6.1	0.228
HDL cholesterol mmol/L, median (IQR)	1.3	1.1, 1.6	1.6	1.4, 1.9	< 0.001
HbA1c%, median (IQR)	36	33, 39	35	33, 38	< 0.001
Informal caregiving	N	%	N	%	
Caregiving					
No	3602	89.4	4480	85.2	< 0.001
Yes	471	10.6	855	14.8	
Caregiving intensity					
Caregiving hours					
Not caregiving	3602	89.4	4480	85.2	< 0.001
< 5 h/week	274	6.1	387	6.7	
5–19 h/week	155	3.5	341	5.8	
20 + h/week	42	1.0	127	2.3	
Covariates					
Age					
16–44 years	1438	44.5	2294	49.1	< 0.001
45–64 years	1614	35.9	2190	37.1	
65+ years	1021	19.6	851	13.8	
NS-SEC					
Management & professional	1808	41.2	1929	34.0	< 0.001
Intermediate	865	21.5	1330	24.2	
Routine & never worked	1400	37.4	2076	41.8	
Highest qualification					
No qualifications	464	10.9	661	11.9	< 0.001
GCSE/equivalent	1192	29.4	1757	31.8	
A-level	868	22.6	885	18.3	
Degree/other higher	1549	37.1	2032	38.0	
Net household income quintiles					
Lowest	431	10.5	622	12.1	0.002
2	676	17.2	958	18.4	
3	833	21.4	1144	21.8	
4	994	23.8	1285	23.6	
Highest	1139	27.1	1326	24.1	
Longstanding illness or impairment					
No	2556	66.8	3383	65.3	0.200
Yes	1517	33.3	1952	34.7	
Partnership status					
Single	303	11.7	565	15.1	< 0.001
Married & living with partner	3038	67.8	3496	60.4	
Separated/divorced	263	5.7	634	10.5	< 0.001
Widowed	47	1.1	134	2.3	< 0.001
Cohabiting	422	13.7	506	11.7	0.470
Number of dependent children < 18 years, median (IQR)	0	0,0	0	0,1	< 0.001
Smoking status					
Never smoker	1462	36.9	2432	45.6	
Ex-smoker	1899	43.4	1961	35.7	< 0.001
Current smoker	712	19.7	942	18.7	< 0.001
BMI, mean (SD)	28.2	5.3	27.7	5.9	< 0.001

Descriptive statistics shown for those with complete data on caregiving, covariates and at least one metabolic marker observed (n = 9,408).
Abbreviations: A-level, Advanced-level qualification; BMI, body mass index; DBP, diastolic blood pressure; GCSE, General Certificate of Secondary Education; HDL, high density lipoprotein; IQR, interquartile range; NS-SEC, National Statistics Socio-Economic Classification; SBP, systolic blood pressure; SD, standard deviation.

Table 2
Associations between informal caregiving and metabolic markers for UKHLS men.

	Age-adjusted					
	SBP Regression coeff. (95% CI)	DBP Regression coeff. (95% CI)	Triglycerides % difference (95% CI)	Cholesterol % difference (95% CI)	HDL cholesterol % difference (95% CI)	HbA1c % difference (95% CI)
Informal caregiving						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	−0.68 (−2.43, 1.06)	0.78 (−0.64, 2.20)	7.19 (−0.39, 15.23)	3.43 (0.46, 6.49)	−0.85 (−4.49, 2.93)	−0.45 (−2.50, 1.65)
Caregiving hours						
Not caregiving	0.87 (−1.38, 3.12)	−0.57 (−2.44, 1.30)	−5.47 (−13.82, 3.69)	−2.61 (−6.41, 1.34)	−0.45 (−4.94, 4.25)	1.45 (−0.78, 3.72)
< 5 h/week	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
5–19 h/week	0.89 (−2.52, 4.30)	0.79 (−2.19, 3.78)	7.01 (−7.34, 23.59)	2.85 (−3.31, 9.40)	−2.01 (−9.24, 5.80)	1.17 (−1.91, 4.33)
20+ hrs/week	−1.04 (−5.00, 2.92)	−0.47 (−4.28, 3.35)	−8.05 (−32.97, 26.15)	−1.64 (−10.22, 7.76)	−6.79 (−18.38, 6.46)	7.30 (−5.97, 22.45)
	Fully adjusted[a]					
	SBP Regression coeff. (95% CI)	DBP Regression coeff. (95% CI)	Triglycerides % difference (95% CI)	Cholesterol % difference (95% CI)	HDL cholesterol % difference (95% CI)	HbA1c % difference (95% CI)
Informal caregiving						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	−0.86 (−2.59, 0.86)	0.41 (−0.92, 1.75)	4.44 (−2.94, 12.38)	3.25 (0.07, 6.53)	0.65 (−2.78, 4.20)	−1.09 (−3.15, 1.01)
Caregiving hours						
Not caregiving	0.87 (−1.36, 3.09)	−0.45 (−2.17, 1.27)	−3.46 (−12.15, 6.09)	−2.60 (−6.59, 1.55)	−1.86 (−5.90, 2.34)	1.83 (−0.43, 4.15)
< 5 h/week	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
5–19 h/week	0.47 (−3.09, 4.03)	0.26 (−2.66, 3.18)	4.59 (−9.62, 21.05)	2.03 (−4.35, 8.82)	−1.46 (−8.21, 5.78)	0.81 (−2.09, 3.80)
20+ hrs/week	−1.57 (−5.68, 2.54)	−1.32 (−5.23, 2.60)	−5.96 (−30.97, 28.11)	−0.73 (−9.98, 9.47)	−7.81 (−18.24, 3.95)	5.37 (−7.46, 19.97)

[a] Model adjusted for age, partnership status, number of dependent children, smoking status, social class (NS-SEC), educational attainment, household income quintiles, longstanding illness or disability, BMI. Abbreviations: DBP, diastolic blood pressure; HDL, high density lipoprotein; SBP, systolic blood pressure.

associations were observed between informal caregiving and other metabolic markers, although the association between caregiving and triglycerides approaches statistical significance (7.19% higher, 95% CI: −0.39, 15.23). No associations were observed between hours spent caregiving per week and metabolic markers for men.

3.2. Informal caregiving and metabolic markers for women

Similar to men who were caregiving, women caregivers had higher total cholesterol compared to non-caregivers (Table 3, 2.06% higher, 95% CI: 0.01, 4.18), although the association was relatively weak. This association was attenuated after inclusion of other covariates. When investigating the relationship between caregiving hours and metabolic

Table 3
Association between informal caregiving and metabolic markers for UKHLS women.

	Age-adjusted					
	SBP Regression coeff. (95% CI)	DBP Regression coeff. (95% CI)	Triglycerides % difference (95% CI)	Cholesterol % difference (95% CI)	HDL cholesterol % difference (95% CI)	HbA1c % difference (95% CI)
Informal caregiving						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	−0.27 (−1.75, 1.22)	0.26 (−0.74, 1.27)	2.71 (−2.12, 7.77)	2.06 (0.01, 4.18)	−1.00 (−3.56, 1.64)	−0.24 (−1.78, 1.32)
Caregiving hours						
Not caregiving	−0.69 (−2.66, 1.27)	−0.58 (−1.97, 0.80)	3.11 (−3.32, 9.95)	−0.76 (−3.51, 2.07)	−1.55 (−5.24, 2.27)	0.49 (−1.38, 2.40)
< 5hrs/week	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
5–19 h/week	−1.95 (−4.55, 0.65)	−0.53 (−2.44, 1.38)	7.17 (−2.41, 17.69)	1.69 (−2.08, 5.61)	−2.78 (−7.54, 2.22)	0.09 (−2.96, 3.24)
20+ hrs/week	−1.37 (−5.21, 2.47)	−0.74 (−3.43, 1.95)	19.91 (7.22, 34.10)	3.78 (−1.62, 9.49)	−8.46 (−14.51, −1.99)	1.34 (−2.03, 4.81)
	Fully adjusted[a]					
	SBP Regression coeff. (95% CI)	DBP Regression coeff. (95% CI)	Triglycerides % difference (95% CI)	Cholesterol % difference (95% CI)	HDL cholesterol % difference (95% CI)	HbA1c % difference (95% CI)
Informal caregiving						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	−0.80 (−2.26, 0.65)	−0.35 (−1.34, 0.63)	−0.50 (−5.05, 4.27)	1.72 (−0.33, 3.80)	0.88 (−1.56, 3.38)	−0.59 (−2.04, 0.89)
Caregiving hours						
Not caregiving	−0.28 (−2.22, 1.65)	−0.08 (−1.38, 1.23)	2.89 (−3.51, 9.71)	−0.60 (−3.29, 2.16)	−1.10 (−4.59, 2.52)	0.21 (−1.58, 2.03)
< 5 h/week	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
5–19 h/week	−1.84 (−4.33, 0.65)	−0.47 (−2.24, 1.31)	2.29 (−6.20, 13.02)	1.53 (−2.16, 5.36)	0.38 (−4.18, 5.15)	−0.62 (−3.60, 2.45)
20+ hrs/week	−2.45 (−6.49, 1.58)	−1.64 (−4.57, 1.28)	7.59 (−5.05, 21.90)	3.10 (−2.17, 8.64)	−2.43 (−8.54, 4.09)	−0.83 (−4.03, 2.48)

[a] Model adjusted for age, partnership status, number of dependent children, smoking status, social class (NS-SEC), educational attainment, household income quintiles, longstanding illness or disability, BMI. Abbreviations: DBP diastolic blood pressure; HD Lhigh density lipoprotein; SB Psystolic blood pressure.

markers, statistically significant associations were observed for triglycerides and HDL cholesterol in age-adjusted models; women caregivers who provided more than 20 h of care per week had higher triglyceride levels (19.91% higher, 95% CI: 7.22, 34.10) and lower HDL cholesterol (−8.46%, 95% CI: −14.51, −1.99) compared to women caregivers providing < 5 h per week of care. However, the association between caregiving hours and higher triglycerides and lower HDL cholesterol did not remain in the fully-adjusted model. This attenuation was largely explained by the inclusion of BMI in the final model. The associations observed for triglycerides and HDL cholesterol remained robust to removing those taking statins (n = 407).

4. Discussion

Using a large longitudinal dataset – the UKHLS – we found that informal caregiving was associated with higher total cholesterol for men. Women who were informal caregivers also had higher cholesterol relative to women who were non-caregivers. Also women who were intensive caregivers, providing 20+ hours of caregiving per week, had higher triglycerides and lower HDL cholesterol relative to women caregivers providing < 5 h per week. However, all associations for women were attenuated upon inclusion of covariates, particularly BMI. Caregiving intensity didn't appear to be important for men in our sample. There were no associations, amongst men or women, between either caregiving or caregiving intensity and any of the other metabolic markers, such as blood pressure and HbA1c.To our knowledge, this is the first study to specifically explore associations between informal caregiving and metabolic markers, and therefore this represents a key addition to the evidence base. This work is broadly in line with the findings from other studies, including those operationalising allostatic load which includes several metabolic markers in combination with cortisol, inflammatory markers, catecholamines and body mass index. For instance, Roepke and colleagues [9] found that caregivers for Alzheimer's disease patients had higher allostatic load relative to those without caregiving responsibilities. There is therefore a growing literature on caregiving and biomarker outcomes, through which caregiving might influence disease outcomes.

The finding that caregiving status *per se* was not associated with metabolic risk for women but caregiving intensity was, is consistent with research using the UK Census and a record linkage study in Northern Ireland which investigated relationships between caregiving status and caregiving intensity and health [27,28]. Neither study found statistically significant differences in the health of caregivers and non-caregivers, but that caregivers engaged in more hours of caregiving per week reported poorer self-rated and mental health than lower intensity caregivers. Previous research has shown that women are more likely to engage in more intensive caregiver activities, such as the provision of personal care and are more likely to adopt the primary caregiver role, compared to men [29]. These aspects are likely to have important implications for health but unfortunately we did not have information on caregiving activities to test this in our data (further described below).

There are several potential mechanisms through which caregiving and caregiving intensity might affect metabolic risk. Vitaliano et al. [14] found that male caregivers had higher calorific intakes compared to male non-caregivers, and this might be one mechanism through which caregiving is related to cholesterol levels [30]. It should be noted, however, that this previous study focused on caregivers for a specific patient group with Alzheimer's disease and the results may therefore not be generalised to a general population sample of caregivers. Another mechanism through which informal caregiving might affect health is through a biological stress process. Chronic stress, potentially as a result of informal caregiving, might lead to HPA axis dysregulation. Cortisol binds to glucocorticoid receptors on adipocytes in visceral fat, which can result in an increase in visceral adipose tissue. One consequence of this is cytokine release which resulting in changes in lipid and glucose metabolism and the development of insulin resistance [18]. Another mechanism might be through adiposity, and this might well be linked to the physiological stress process detailed above [31]. In a recent cross-sectional study, informal caregivers had higher BMI than non-caregivers [32]. This was found to be due to reduced frequency of sporting activities. BMI in turn is associated with increased metabolic risk [33]. This mechanism is supported by our data, as BMI was the variable which most attenuated associations between informal caregiving and metabolic markers for women, and particularly for the women who are caregiving for more than 20 h per week.

4.1. Strengths and limitations of this study

There are several limitations to this study. First, non-fasting blood samples were collected during the health assessment at W2/3. Previous work has shown that HDL cholesterol and HbA1c measurements do not require fasting prior to blood collection to be accurate and reliable [34]. Triglycerides are more sensitive to fasting status, although non-fasting triglycerides have been highlighted as risk factors for myocardial infarction, cardiovascular mortality and ischaemic stroke, and also indicators of insulin resistance [35]. Second, metabolic markers were only available at one time point and this occurred early in the UKHLS. It was therefore impossible to investigate change over time with respect to metabolic markers or control for these markers prior to caregiving initiation. Third, we conducted a complete case analysis, including only those participants with complete information on caregiving, covariates and each metabolic marker. Investigation of how our analytic sample differed from the whole UKHLS sample showed differences in most characteristics of interest. In particular our sample appeared to be more socially advantaged and less likely to be engaged in informal caregiving compared to the whole UKHLS sample (see 'missing data' section above). Therefore our findings are likely to be an underestimation of the associations seen had the whole sample been available. Also, there were several aspects of caregiving that we were unable to investigate here. These include the duration of the caregiving responsibility, the reasons the care recipient required care (e.g. frailty, dementia) or the caregiving activities undertaken (e.g. grocery shopping, provision of personal care, dealing with financial affairs). These specific aspects of caregiving are likely to affect health. More research is needed which utilises a different dataset to explore these caregiving characteristics further. Given the large number of comparisons and statistical tests undertaken our results should be interpreted with caution as multiple testing may result in type 1 error. Also, the UKHLS does not include information on the menopause status of women. Women undergoing the menopause experience a reduction in oestrogen which is associated with increased central adiposity, triglycerides, blood glucose and reduced HDL cholesterol [36]. Previous studies have found health differences for caregivers who provide care for household members versus those who are caregiving outside of the household. In a recent study by Kaschowitz and Brandt [37] using the Survey of Health, Ageing and Retirement and the English Longitudinal Study of Ageing, caregivers who were providing care to another household member were less healthy than caregivers provided help to someone elsewhere. In the UKHLS we were able to distinguish between caregiving inside and outside of the household, however very few participants were caregiving inside the household (42 men and 84 women). For this reason we did not report associations between caregiving and health separately by caregiving location. Finally, whilst our analyses involving blood pressure have an excellent level of statistical power (~100%), our analyses involving blood analytes are extremely underpowered (5–35% power) and this is likely to be why we see few associations in our data.

Our study also has a number of strengths. We used a large sample of participants extracted from a nationally representative sample. To some extent we were able to control for caregiver health at baseline, which would not be possible using a cross-sectional design. Our study was not

restricted to one age group or to caregivers for specific patient groups. Finally, we were able to investigate associations between informal caregiving and objective metabolic markers which, if associations are assumed to be causal, give us insights into the potential physiological processes involved linking caregiving and health outcomes.

4.2. Conclusions

This study showed that informal caregiving was associated with higher total cholesterol, particularly for male caregivers. Women caregivers also had higher total cholesterol and women caregivers engaged in more intense caregiving had higher triglycerides and lower HDL cholesterol relative to women caregivers providing less intense caregiving. However all these associations for women were attenuated upon inclusion of sociodemographic and health behavioural factors. Further research is required to explore the explanatory mechanisms linking informal caregiving and metabolic profiles. Possible mediators might include changes in health behaviours, financial hardship, caregiver burden and loss of social support. Given the increasing importance of informal caregiving for adult social care, the health of caregivers should be a public health priority.

Contributors

All authors were involved in the design of the study.

Rebecca Lacey conducted the data analysis and drafted the manuscript.

All authors were involved in the revision of the manuscript and the decision to submit for publication.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical approval

Informed consent was obtained from all participants for all waves of the UKHLS.

Ethical approval for the UKHLS was obtained from the University of Essex Ethics Committee. This study conforms to the principles embodied in the Declaration of Helsinki.

Provenance and peer review

This article has undergone peer review.

Research data (data sharing and collaboration)

There are no linked research data sets for this paper. Data will be made available on request.

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