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Abstract
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Keywords
Health shocks, added worker effect, labour supply, informal care, matching methods, panel data

JEL Codes
C14, I10, I13, J14, J22

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Shocks to health have been shown to reduce labour supply for the individual affected. Less is known about household self-insurance through a partner's response to a health shock. Previous studies have presented inconclusive empirical evidence on the existence of a health-related `added worker effect'. We use UK longitudinal data to investigate within households both the labour supply and informal care responses of an individual to the event of an acute health shock to their partner. Relying on the unanticipated timing of shocks, we combine coarsened exact matching and entropy balancing algorithms with parametric analysis and exploit lagged outcomes to remove bias from observed confounders and time-invariant unobservables. We find no evidence of a health-related 'added worker effect'. A significant and sizeable increase in spousal informal care, irrespective of spousal labour market position or household financial status and ability to purchase formal care provision, suggests a substitution to informal care provision, at the expense of time devoted to leisure activities.

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1 Introduction

The ageing population in Western Countries is becoming one of the most significant social transformations of this Century. According to the European Commission, the old-age dependency ratio, namely the proportion of people aged 65 or older relative to those aged 15-64 years old, is projected to increase from 29.6 % in 2016 to 51.2% in 2070 (European Commission, 2018). Most notably, population ageing has significant implications for social protection systems having to incur higher spending on social insurance programmes and healthcare; and for labour markets, in terms of longer working lives, as witnessed by the rising trend in statutory retirement ages across European countries.

As working life increases, so does the risk of experiencing a health shock while engaged in labour market activity, age being one of the most relevant predictors of health deterioration. Health shocks represent a major source of economic risk. An established literature shows how shocks reduce labour supply for an individual, entailing a significant reduction in earnings (see, for example, recent works by Flores et al. (2019), Lenhart (2019) and Jones et al., (2020) and literature cited therein). Depending on healthcare financing arrangements, the economic consequences of health shocks might extend to an increase in health-related expenditures, leading to the risk of catastrophic payments, reduced access to credit and consumer borrowing, as recently shown for the US by Dobkin et al. (2018). Wealth deteriorations and negative spillover effects might then extend to other family members (Zwysen, 2015), thus involving the whole household.

Other household members, and partners in particular[1], might provide an important source of informal insurance against this economic risk that operates in conjunction with the formal social and healthcare insurance available. Interest in family and partners' responses is growing (e.g. see Dobkin et al., 2018; Fadlon and Nielsen, 2021; and also Gathmann et al., 2020 on the reverse issue of job loss and health spillovers in couples). Enhancing understanding of a partner's response within a household is key to assessing how couples' financial and non-financial wellbeing is affected by shocks, the role of informal insurance mechanisms in complementing social insurance provision, and population welfare.

From a theoretical point of view, under a collective labour supply framework (Apps and Rees, 1997; Chiappori, 1997), the effect of a health shock on spousal labour supply is ambiguous. The income effect arising from the loss of earnings by the person whose health

[1] We are concerned with within household responses between partners. We use partners and spouses interchangeably, although we do not restrict analysis to married couples.

deteriorates (only partially compensated by disability benefits or pension entitlements, given prevailing replacement rates) might increase spousal labour supply, in the spirit of what has been called the Added Worker Effect (AWE) (Mincer, 1962, Lundberg, 1985). While the income effect is diminished if a health shock affects individuals living on pension or non-labour income, additional consumption needs arising from disability might occur, for example in terms of transport, heating, formal care or other extra-costs of disability. In addition to an income effect, in countries such as the USA, where employment-contingent health insurance plays a major role, the importance of extending healthcare coverage to the individual experiencing the health shock creates an additional incentive for a partner to seek suitable employment (Bradley et al., 2013).

In contrast to an AWE, the event of a health shock might also be expected to lead to a reduction in the labour supply of a partner. A shock-induced disability might limit home production necessitating additional spousal involvement at the expense of time devoted to work. Home production in the form of informal care provision would appear particularly relevant. Complementarity of partners' leisure, enhanced by newly acquired health information possibly indicating a shortening lifespan might also contribute to reducing, rather than increasing, spousal labour supply. Indeed, complementarity in the non-market time of older husbands and wives is documented by Kneisner (1976), and confirmed by Hamermesh (2002) and Hallberg (2003) who find that partners prefer consuming leisure at the same time of the day and adjust work duties and schedules accordingly. Complementarity in leisure has also been identified as one of the main drivers of joint retirement decisions (Gustman and Steinmeier, 2000; Stancanelli and Van Soest, 2016).

Previous studies have provided inconclusive empirical evidence on the existence of a health-related AWE[2]. Some studies (van Houtven and Coe, 2012; Garcia Gomez et al., 2013, for the US and Netherlands respectively) have found no empirical support for an AWE, or even a reduction in men's labour supply following a health deterioration for a female partner (but no response in women's labour supply when their male partner's health deteriorates). In these

[2] Even for the unemployment related AWE, evidence on whether increases in labour supply happen or not, is mixed. According to Ashenfelter (1980), spousal labour supply acts as an insurance against partner's unemployment . Lundberg, (1985), Juhn and Potter (2007), Ayhan (2015) and Giannakopoulos (2015) find a positive AWE, but only at the extensive margins. Analysing different European countries, Bredtmann et al. (2014) relate the AWE variation registered along the extensive and intensive margins to welfare regimes and business cycles. However, Heckman and MaCurdy (1980) find no evidence of AWE and explain the result with lifecycle dynamics; Cullen and Gruber (2000) attribute the lack of AWE to the role of unemployment benefit programs. A further explanation is that women's low labour force attachment under a traditional division of labour could explain the lack of an AWE (Prieto-Rodriguez and Rodriguez-Gutierrez, 2000; Başlevent and Onaran, 2003; Bentolila and Ichino, 2008). Relatedly, previous studies suggest that intra-household specialization plays a role in shaping spousal labour market adjustments.

studies, home production needs and the complementarity of leisure appear to dominate the income effect, especially for men who are less exposed to major income losses should their partner's health deteriorate. Lack of an economically significant AWE for non-fatal heart attacks or strokes has recently been confirmed by Fadlon and Nielsen (2021), who use Danish administrative records and construct counterfactuals by exploiting households where both partners experience a health shock but at different times. They attribute the absence of an AWE to the lack of need for self-insurance, given the generous social insurance coverage available in Denmark which almost fully compensates the earnings loss: while the decline in earnings for the individual affected is estimated to be 19%, the corresponding reduction in household post-transfer income amounts to only 3%. In a strikingly different institutional context, a recent contribution by Dobkin et al. (2018) documents the lack of an AWE following hospitalizations in the US. Despite comparable (to Denmark) drops in earnings suffered by hospitalised individuals (about 20% of previous earnings on average), only about 10% of this reduction is compensated by social insurance; yet no AWE is detected.

Contrasting results have emerged for both men and women's responses to a partner's health shock. A reduction in men's labour supply is found in Berger (1983), Blau and Riphahn (1999), Charles (1999) and Nahum (2005). However, a small increase in men's labour supply is found by Coile (2004) and confirmed by Johnson and Favreault (2001), the latter in terms of a reduction in the probability of retirement. For women, Charles (1999) found an increase in labour supply in response to a shock to their male partner's health using US data, but a decrease in a male partner's labour supply in response to a female partner's health shock. This is interpreted as consistent with the idea of a relative gender specialization in income production (men) and home production (women) and a partner's response aimed at compensating for the reduction in time use of the partner who experiences a health shock. Several studies report heterogeneity in the responses of women, reflecting baseline labour market attachment (Berger 1983; Blau and Riphahn, 1999; Jimenez Martin et al., 1999), and in response to disability insurance eligibility and generosity (Berger and Fleisher, 1984; Chen, 2012).

Previous studies have acknowledged the importance of distortions to home production following a health shock, but most have discussed these indirectly while focusing on labour supply. For example, by considering how labour supply adjustments vary by income, and noticing that the reduction in labour market participation is larger for higher income couples, Garcia Gomez et al. (2013) hint at a preference for leisure as an explanatory mechanism, as higher income individuals can afford to purchase home production and informal services in the market. However, it might well be that partners prefer informal home production and care provision, despite market alternatives.

Our study extends the literature by considering both the labour supply and the informal care responses of household partners of individuals who experience an acute health shock. We do this by exploiting household panel data drawn from the Understand Society survey, conducted in the UK since 2009. Information on both labour and home production is collected for every adult household member across a number of waves. This provides direct evidence on informal care (covering both informal care provided to the shocked partner, and to other household members) as well as labour supply responses. The identification strategy follows previous contributions in the field that exploit acute health shocks, such as heart attack, stroke and cancer, as a source of unanticipated variation in the timing of health deteriorations (e.g. Smith, 1999 and 2005; Datta Gupta et al., 2015; Trevisan et al., 2016; Jones et al., 2020). Conditioning on a wide range of observable individual characteristics for both partners, as well as household- and couple-level characteristics, we assume that the chance that a partner experiences an acute health shock at any particular point in time is conditionally random, and match household couples where one partner experiences the health shock, with observationally identical household couples where neither partner experiences a health shock.

Following Jones et al. (2020), matching is performed through a combination of Coarsened Exact Matching and Entropy Balancing. This approach is suited to a setting that offers a much larger number of controls than treated units. ATTs are then obtained through parametric modelling on the matched sample. We do this separately for each of the outcomes: employment, hours worked, informal care provision and hours of care for the non-shocked partner. Our results for labour supply show no evidence of a health-related AWE. However we find a sizeable increase in informal care provision. Together with lack of a significant change in spousal working hours, the increase in spousal time devoted to informal care - which is detected irrespective of affordability of formal care, as proxied by household income - suggests a substitution to personal involvement in caring, at the expense of time devoted to other non-work activities.

2 Data

We use nine waves of Understanding Society, the UK Household Longitudinal Study (UKHLS) that, starting in 2009, builds on the previous British Household Panel Study (BHPS), but offers a larger sample size of about 40,000 households and 100,000 individuals (at wave 1). While the BHPS has been widely used to study health and labour dynamics, the larger UKHLS sample is important as it allows analysis of sub-populations previously regarded as too small for research (Buck *et al.*, 2012): such as couples experiencing one of the three types of health shocks that we select (heart attack, stroke or cancer).

While the fieldwork of each UKHLS wave lasts about two years, all individuals aged 16 or above living in a target household are interviewed yearly, allowing us to use up to nine interviews undertaken by the same person between 2009 and 2019. During the first interview, individuals are asked about their past life history and their health history in terms of diagnoses and events, including the onset of heart attacks, strokes or cancers[3]. This allows us to observe whether an individual had already experienced an acute health shock of the type we select. During subsequent interviews individuals report any new diagnosis or onset of health problems that occurred since the previous interview, so that an annual life history of health shocks can be constructed and updated. In addition, the survey collects a wider set of characteristics that are informative of underlying health risks: for example diagnoses of coronary heart disease, angina, diabetes and high blood pressure, all related to cardiovascular risk (Braunwald, et al., 2015); the presence of a long-standing illness or disability, limitations in activities of daily living (ADLs); information about past and current smoking and intensity; and parents' longevity (whether each parent was alive when the respondent was aged 14), indicative of relevant genetic characteristics.

Demographic information covers age, gender, race, marital status, number of children, and household size. Detailed information collected on individual labour market activity includes employment status (both employment and self-employment), hours worked and earnings. Available socioeconomic indicators cover education (the highest qualification achieved), various income sources (labour, pension, investment and transfers including different types of benefit income e.g. disability-related, means-tested), and home ownership. Individual level and source-specific income information provides indicators of household

[3] The full list covers: asthma; arthritis; congestive heart failure; coronary heart disease; angina; heart attack or myocardial infarction; stroke; emphysema; hyperthyroidism or an over-active thyroid; hypothyroidism or an under-active thyroid; chronic bronchitis; any kind of liver condition; cancer or malignancy; diabetes; epilepsy; high blood pressure; clinical depression.

income composition (e.g. income sources which would not be exposed to health risk, such as pension income and investment income) and each partner's contribution to overall household income. These serve the purpose of assessing the level of household economic exposure to the monetary impact of a partner's health shock.

Finally, individuals are interviewed yearly on care provided to other household members, and their identity, as well as on the intensity of care provided to each, measured by the number of hours provided (in bands: 0-4; 5-9; 10-19; 20-34; 35-49; 50-99; 100 or more). Care received by other informal caregivers living outside the household is also traced[4]. Wider types of home production, such as a variety of household chores, are covered only in specific waves, and for this reason cannot be exploited in our analysis. Descriptive statistics on the full list of variables employed in our study, on the sample selected for analysis, are reported in Table 1, and discussed in Section 3.2.

3 Empirical Methods

3.1 Research design

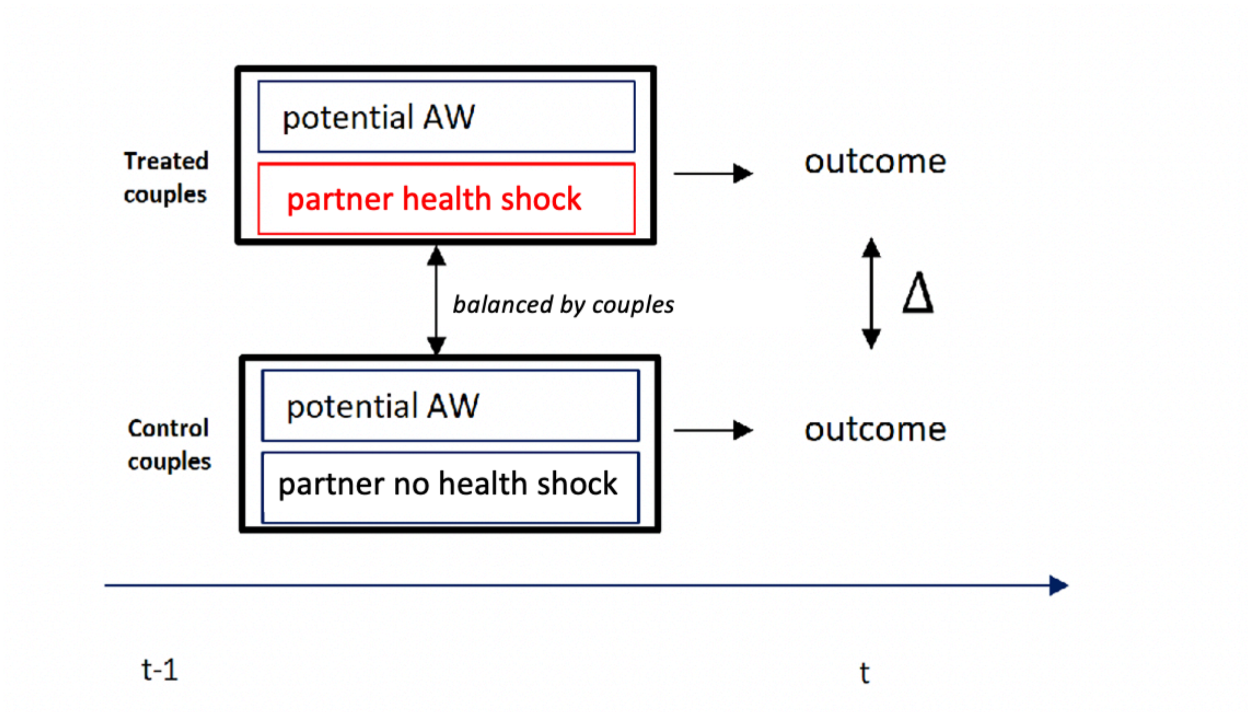
The main challenge for identifying the causal effect of a health shock stems from potential selection bias with respect to labour market outcomes of a partner (see e.g. Siegel, 2006). Empirically documented mechanisms such as assortative mating (Greenwald et al., 2014) and its reflection in terms of partners' health-relevant behaviours such as smoking, diet and exercise (e.g. see Clark et al., 2006) and labour supply patterns; comorbidity in couples (Guner et al., 2018); joint determination of partners' labour supply and home production decisions all contribute to concerns about unobserved heterogeneity and reverse causality. A way to address such concerns is to exploit some source of unanticipated variation in health. Previous authors have, for example, exploited road injuries and commuting car accidents (Dano, 2005; Halla *et al.*, 2013), unplanned hospitalizations (Garcia-Gomez et al., 2013; Belloni et al., 2019) or the onset of acute health shocks (e.g. Smith, 1999 and 2005; Datta Gupta et al., 2015; Trevisan et al., 2016; Jones et al., 2020). We follow this last approach and use the onset of a heart attack, stroke or cancer experienced by one partner in a household to study the spousal (i.e. the unaffected partner and potential added worker) behavioural response. The first two types of health shock are cardiovascular events chosen because they occur suddenly at an identifiable,

[4] Information on formal care received by (paid) providers is collected only in two waves.

yet unpredictable, point in time (Braunwald, 2015); the third type, cancer, although a progressive condition, is often asymptomatic and typically becomes known upon diagnosis. While individuals might reasonably be expected to anticipate their own health risk, in the light of known risk factors, the timing of an acute health shock is likely to be unanticipated. Moreover, the focus on major health conditions minimises the scope for misreporting and recall bias that might be present in analyses based on milder or other progressive conditions.

The research design is illustrated in Figure 1. We study the behaviour of individuals (potential added workers (AW)) whose partner experiences an acute health shock between time $t-1$ and time t: these couples represent our treatment group. The treated couples are compared to a control group of couples, selected so that both partners are individually observationally equivalent (up to the time of the shock) to those in the treatment group, except that neither experiences an acute health shock. The potential AW's responses are observed from time t onwards. Pre-shock (i.e. as of $t-1$ in Figure 1) observational equivalence between partners in treated and control couples is based on a broad set of individual and household variables that accounts for demographic and socioeconomic characteristics, labour market activity, health risks, past acute shocks, and lagged outcomes (both labour supply and informal care).

Figure 1: Research Design



Identification assumes conditional independence. That is, conditioning on these variables is enough to regard the time-specific acute health shock as random, so that no remaining unobserved characteristic would jointly affect the chance of a partner experiencing a time-specific health shock and the spousal labour market and informal care response observable from time t onwards. Conditional independence, while untestable, rests on the rich set of observed variables and the fact that the longitudinal data controls for time-invariant unobservables through lagged outcomes.

To achieve observational equivalence between treatment and control couples, we adopt the preprocessing approach discussed by Ho *et al.* (2007). This uses matching methods to balance the distribution of confounders between treated and control units, to reduce model dependence, before using parametric modelling on the matched data to tackle any remaining imbalance. In this respect the preprocessing approach is doubly robust to either misspecification in the matching or parametric modelling steps.

For preprocessing we follow Jones et al. (2020), who model individual responses to health shocks based on the same UKHLS data and show how a combination of Coarsened Exact Matching (Iacus, King and Porro, 2012) and Entropy Balancing (Hainmueller, 2012) allows attaining a tight balancing of confounding covariates. Combining the two matching methods retains the advantages of each. Coarsened Exact Matching aims at achieving exact matching through stratification followed by exclusion of strata where either only treated or only control units are found. CEM corresponds to exact matching for binary variables, but coarsens continuous variables into intervals and is less data hungry than exact matching for these variables. CEM has the monotonic imbalance bounding property of improving the balance on each covariate without worsening that of others, although at the cost of reducing the sample size available for estimating causal effects as the set of included confounders increases (Iacus et al., 2011). A further implication is that CEM balances the joint distribution of confounding covariates, including interactions and nonlinearities. For this reason, it is used here to attain common support and tight balancing for a limited set of key covariates. Once extreme units are discarded from the common support through CEM, Entropy Balancing (EB) balances the full set of confounders. EB operates by minimizing an entropy distance metric subject to balance constraints (for example equality of means between treated and matched controls) and normalizing constraints, generating weights to be applied in the following regression analysis. While EB operates on univariate distributions for each confounder separately, it is possible to extend the algorithm so that balancing extends to interactions and co-moments. After preprocessing by CEM and EB, average treatment effects on the treated (i.e. potential added workers' response to a partner's acute health shock), are obtained through parametric regression models on the preprocessed data.

3.2 Implementation

The sample for analysis is restricted to couples where both partners are observed, and are cohabiting, for at least two points in time, t and $t-1$, which could correspond to any two interviews across the nine waves available. In the vast majority of cases (91.18%) these are two consecutive waves[5]. Also, we select couples where at least one partner (the potential added worker) is aged below the gender-specific state pension age, regardless of whether employed or not. After discarding couples with missing information on relevant variables, the number of couples in our sample is 49,207.

Treatment assignment operates dynamically, and at the level of the couple, accounting for each partner's history of health shocks. In more detail, all couples begin as untreated in the first wave they are interviewed. At any later wave, a couple is assigned to the treatment group if at least one acute health shock is observed for one partner (the shocked partner), and the other partner is under the state pension age (the potential added worker). The wave that the shock occurs is considered as time t, where outcome measurement begins.

For treated couples where multiple health shocks are observed (possibly to both partners), we consider only the first shock recorded in the UHKLS observational window, and recode their treatment status to missing in any following wave. Couples where a health shock is observed, but the partner is older than the state pension age as of time t, are also discarded. We further drop couples where both partners experience a contemporaneous health shock (3 cases) and couples where the two respective health shocks happen in immediately consecutive years (8 cases). In total, we observe 484 unique couples assigned to the treatment group.

The potential control group includes all couples where no shock is ever observed during the UHKLS observational window, as long as one partner is aged below the gender-specific state pension age. Treated couples never serve as controls. After dropping couples with missing information on relevant variables, there are 48,723 potential control couples, that is, approximately 100 couples on average for each treated couple. It is important to stress that while a treated couple is used only as such, and only once (in t, the year of reported shock for

[5] In a further 6.3% of cases, two waves elapse since the previous interview. So, overall, in 97.5% of cases, either one or two waves elapse since the previous interview.

one partner in the couple), a potential control couple could be used to form the counterfactual for multiple treated couples.

Table 1 reports descriptive statistics for the treated and potential control sub-samples, showing that characteristics are highly unbalanced. In terms of potentially shocked partner characteristics (top panel of Table 1), partners that actually experience an acute health shock are on average older, less educated, more likely to be (past or present) heavy smokers, less healthy according to a variety of general health and disability indicators, exhibit a higher prevalence of specific CVD risk factors, and have fathers with lower longevity. Considering the potential added worker characteristics (mid panel of Table 1), individuals whose partner experiences an acute health shock are on average older, less educated, less likely to be active in the labour market and more likely to be providing informal care to their partner. For household level characteristics, significant differences are apparent in household size, equivalent income, probability of social renting and wave of interview (bottom panel of Table 1).

To control for selection bias arising from observables, we first implement CEM to achieve common support and exact matching on AW-gender, labour market activity and informal care provision as of $t-1$; as well as on (potentially shocked) partners' gender and diagnosis of a CVD risk factor[6]. On top of these binary variables, CEM includes (potentially shocked) partner's age, as a key predictor of risk of health shock, coarsened into five bands (with cut-offs at age 28, 43, 58 and 73 years). These variables were selected based on known risk factors; or because they are key predictors of the AW time allocation decision. Importantly, exact matching on AW's lagged outcomes (in terms of extensive margins) contributes to removing bias from time-invariant unobservables.

CEM stratifies treated and potential control couples into 142 strata, and retains only the couples found in a subset of 77 strata where at least one treated and one potential control couple are found. This corresponds to discarding from further analysis 2 treated couples, and 1,239 control couples, as shown in Table 2. In each matched stratum, the number of treatment couples is systematically lower than the number of potential control couples. CEM weights account for this while maintaining exact matching on the relevant binary variables, and on the coarsened age groups.

[6] Any previous diagnoses of high blood pressure, diabetes, congestive heart failure, coronary heart disease or angina.

Table 1: Descriptive statistics

	Treatment couples (n=484)		*Potential controls couples* (n=48,723)		*Pval (diff)*
Shocked/non-shocked partner	*Mean*	*s.d.*	*Mean*	*s.d.*	
partner's age	50.28	9.51	42.11	11.54	0.000
partner' gender: male	0.48	0.50	0.47	0.50	0.431
partner's race: white	0.87	0.34	0.81	0.39	0.001
partner's education	3.57	1.79	4.25	1.63	0.000
partner's LM participation (t-1)	0.57	0.50	0.79	0.40	0.000
partner's father dead when aged14	0.06	0.25	0.03	0.17	0.000
partner's mother dead when aged14	0.01	0.11	0.01	0.11	0.779
partner's natural children (t-1)	2.02	1.60	1.66	1.39	0.000
partner's current smoker	0.26	0.44	0.20	0.40	0.001
partner's regular smoker past	0.26	0.44	0.21	0.40	0.003
partner's heavy_smoker (current/past)	0.14	0.35	0.07	0.26	0.000
partner's number of limitations (t-1)	0.46	1.13	0.20	0.70	0.000
partner's long standing illness/disability (t-1)	0.40	0.49	0.23	0.42	0.000
partner's shock (t-1)	0.22	0.41	0.03	0.17	0.000
partner's risk (t-1)	0.44	0.50	0.20	0.40	0.000
Potential added worker					
AW age	53.22	8.19	46.65	9.57	0.000
AW male	0.49	0.50	0.52	0.50	0.162
AW education	3.65	1.75	4.26	1.62	0.000
AW labour market participation (t-1)	0.65	0.48	0.81	0.39	0.000
AW hours of work (t-1)	23.38	20.19	30.29	19.26	0.000
AW hours of work (t-1), conditional	36.05	13.08	37.45	13.80	0.073
AW provides informal care to partner (t-1)	0.15	0.35	0.03	0.16	0.000
AW hours of care (t-1)	6.15	18.68	2.05	11.75	0.000
AW hours of care (t-1), conditional	32	31.55	34.19	34.75	0.549
Couple level characteristics					
household size (t-1)	3.13	1.36	3.51	1.29	0.000
household equivalent income (t-1)	2106	1406	2359	1461	0.000
home Tenure: social renter	0.16	0.37	0.09	0.30	0.000
home Tenure: homeowner	0.78	0.41	0.82	0.39	0.054
elapsed months between t and (t-1)	12.68	0.14	12.33	0.01	0.001
wave (t)	4.73	2.32	5.06	2.27	0.002

*Source: UKHLS, waves 1-9. N*ote: Variables in bold if t-test of equality of means between treated and controls rejected at the conventional 5% level.

Table 2: Outcomes of Coarsened Exact Matching

	#treated	#controls	*by stratum:*	#treated	#controls
All	484	48,723	mean	6.26	616.68
Matched	482	47,484	median	3	153
Unmatched	2	1,239	min	1	4
			10th perc.	1	13
			25th	1	32
			75th	8	388
			90th	14	1,456
			max	52	6,875

Source: UKHLS, waves 1-9.

EB aims at balancing (in terms of means) the univariate distribution of all remaining potential confounders, as listed in Table 1, along with the (potentially shocked) partner's exact age, rather than relying solely on CEM. We further include in the EB minimization function the first order interactions between each variable and each of the binary variables included in CEM to balance co-moments. For continuous variables, we include in the EB specification quadratic and cubic terms, so that even if the EB distance minimization targets only the first moments of included variables, in practice balancing extends to the second and third moments (Hainmueller and Xu 2013). Table 3 reports the mean differences between matched couples, and the standardized difference in means or percentage bias, which are systematically lower than 1.5%.

Table 3: Balancing of observables

	Mean difference		*Bias*	
Shocked/non shocked partner	*Unbalanced*	*Balanced*	*Unbalanced*	*Balanced*
partner's age	8.622	0.000	88.9	0
partner' gender: male	0.039	-0.002	7.8	-0.3
partner's race: white	0.057	0.000	15.7	0.1
partner's education	-0.6791	-0.002	-39.7	-0.1
partner's labour market participation (t-1)	-0.223	0.000	-49.3	-0.3
partner's father dead when aged14	0.021	0.001	10.4	0.9
partner's mother dead when aged14	-0.087	-0.008	2.2	-0.0
partner's natural children (t-1)	0.362	-0.005	24.1	-0.6
partner's current smoker	0.064	0.002	17.7	0.4
partner's regular smoker past	0.079	0.000	18.2	0.2
partner's heavy_smoker (current/past)	0.092	0.001	27.2	0.4
partner's number of limitations (t-1)	0.754	0.016	48.4	1.0
partner's long standing illness/disability (t-1)	0.262	0.001	55.1	0.4

partner's shock (t-1)	0.186	0.003	58.8	1.0
partner's risk (t-1)	0.247	0.001	54.8	0.3
Potential Added Worker				
AW age	6.563	-0.061	73.7	-0.7
AW male	-0.032	0.006	-6.4	1.1
AW education	-0.607	-0.010	-35.8	-0.6
AW labour market partecipation (t-1)	-0.160	-0.004	-36.5	-1.0
AW hours of work (t-1)	-6.898	-0.025	-35.0	-0.1
AW provides informal care to partner (t-1)	0.119	0.004	43.2	1.3
AW hours of care (t-1)	4.102	0.037	26.3	0.2
Couple level characteristics				
household size (t-1)	-0.435	-0.006	-33.5	-0.5
household equivalent income (t-1)	-252.8	1.1	-17.6	0.1
home tenure: social renter	0.069	0.003	20.8	1.0
home tenure: homeowner	-0.034	-0.003	-8.5	-0.8
elapsed months (t)	0.359	-0.003	13.0	-0.1
wave (t)	-0.328	-0.003	-14.3	-0.1

Source: UKHLS, waves 1-9.

4. Results

Table 4 reports, for each outcome, the estimated ATT and relative size effect (RSE[7]) at time *t* (top panel) and at *t+1* (bottom panel). In both cases, no significant adjustment in the (potential AW) partner's labour supply emerges, neither along the extensive nor intensive margins. However partners significantly increase their involvement in informal care provided to the shocked spouses[8]. The ATT amounts to a 14 percentage point increase in the probability of providing informal care in the year of the shock, which is double the counterfactual probability. This effect persists in the following year, although halved in size (7.5 percentage point increase) to a 57% increase in the counterfactual probability. The expected number of hours of informal care also increases, particularly in the year of the shock, by about 3.5 hours a week, which is a

[7] The ATT expressed as a percentage of the contemporary average counterfactual outcome measured in the matched control sample.

[8] A similar increase occurs when including other household members, together with the shocked partner, suggesting that the bulk of additional informal care is devoted to the partner.

50% increase on the counterfactual average. However, conditional on providing informal care, no significant increase in hours is registered, suggesting that the effect on the unconditional number of hours reflects an adjustment on the extensive margin.

Table 5 shows estimated ATTs and RSE on the same outcomes, but measured at later points in time, i.e. *t+2*, *t+3* and *t+4*. Expanding the post-shock time horizon offers an indication of the dynamic pattern of response, which is displayed in Figure 2. However, these estimates, obtained on progressively reduced samples suffer from a lack of precision. They are also possibly biased by non-random attrition as treated couples are more likely to leave the panel, leading to a downward bias in estimated ATTs over time. Bearing this limitation in mind, estimates reported in Table 5 suggest that the results obtained in the very short term, in terms of lack of a labour supply response and increase in informal care, do show some persistence.

Table 4: ATT in the short run, full sample

	n (treated)	n (controls)	ATT	Std. Err.	P val	RSE
Potential AW outcome, as of t						
Labour market participation	481	47,449	-0.002	0.016	0.898	-0.003
Hours, unconditional on LMP	478	47,035	0.091	0.680	0.893	0.004
Hours, conditional on LMP	300	37,802	0.121	0.727	0.868	0.003
Informal care provision to partner	481	47,460	**0.137**	0.030	0.000	1.015
Hours of care, unconditional on providing care	478	47,427	**3.443**	1.152	0.003	0.525
Hours of care, conditional on providing care	132	2,764	6.483	4.902	0.188	0.172
Potential AW outcome, as of t+1						
Labour market participation	408	39,492	-0.027	0.022	0.228	-0.044
Hours, unconditional on LMP	404	39,080	-0.996	0.897	0.267	-0.046
Hours, conditional on LMP	259	31,551	-1.169	1.214	0.336	-0.035
Informal care provision to partner	399	39,338	**0.075**	0.026	0.005	0.573
Hours of care, unconditional on providing care	399	39,304	2.225	1.277	0.082	0.362
Hours of care, conditional on providing care	112	2,229	0.099	5.341	0.985	0.003

Source: UKHLS, waves 1-9.

Notes: ATT estimate in bold if significant at the conventional 5% level.

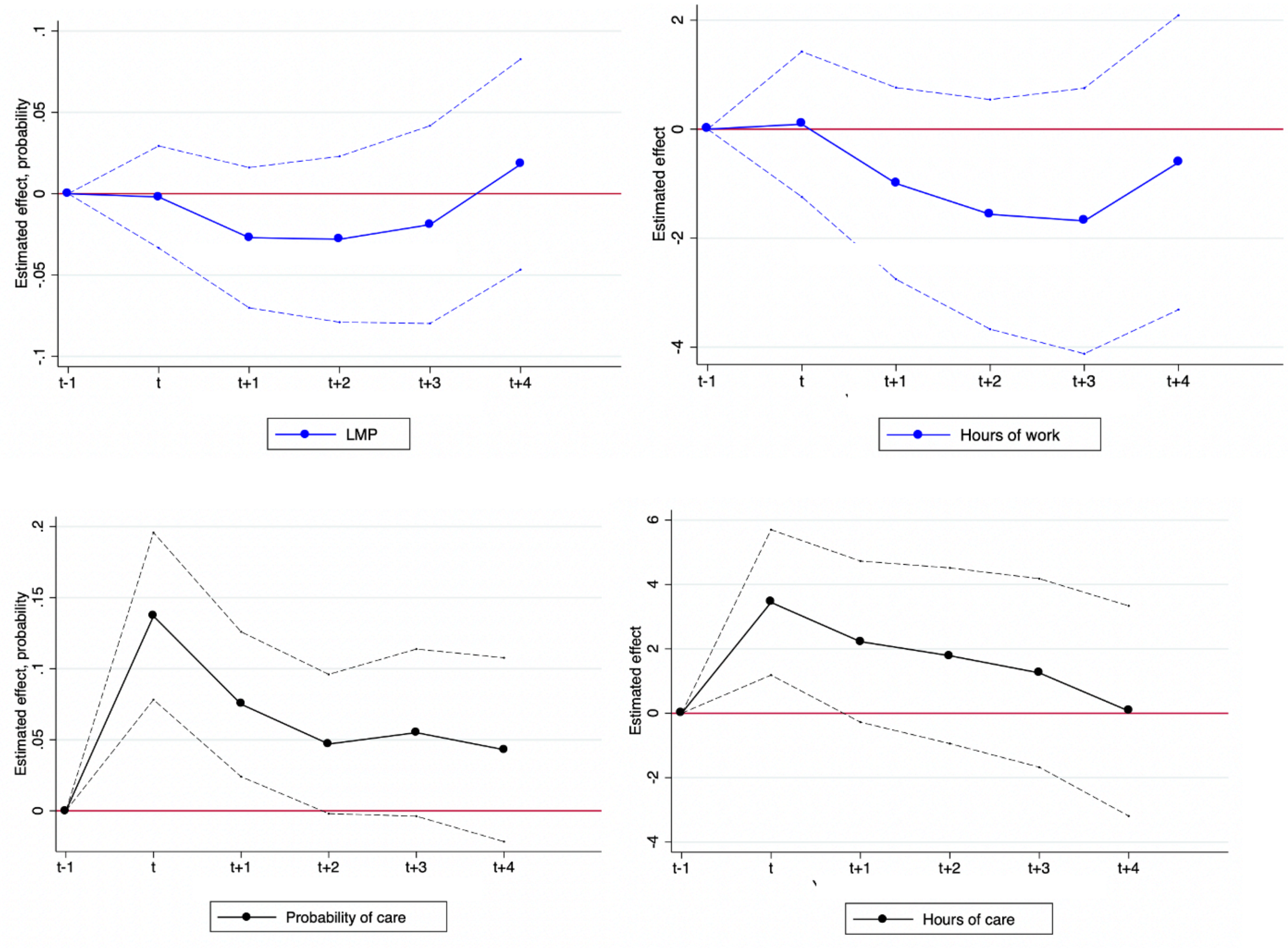
Table 5: ATT in later years, full sample

	n (treated)	n (controls)	ATT	Std. Err.	P val	RSE
Potential AW outcome, as of t+2						
Labour market participation	336	32,237	-0.028	0.026	0.287	-0.047
Hours, unconditional on LMP	333	31,869	-1.563	1.075	0.147	-0.076
Hours, conditional on LMP	213	25,787	-1.791	1.490	0.230	-0.057
Informal care provision to partner	321	31,977	0.047	0.025	0.057	0.370
Hours of care, unconditional on providing care	318	31,943	1.786	1.392	0.200	0.312
Hours of care, conditional on providing care	86	1,757	2.685	6.638	0.687	0.092
Potential AW outcome, as of t+3						
Labour market participation	271	25,549	-0.019	0.031	0.543	-0.033
Hours, unconditional on LMP	268	25,192	-1.684	1.243	0.176	-0.086
Hours, conditional on LMP	174	20,401	-1.906	1.754	0.278	-0.065
Informal care provision to partner	254	25,266	0.055	0.030	0.071	0.455
Hours of care, unconditional on providing care	252	25,241	1.494	1.277	0.402	0.228
Hours of care, conditional on providing care	64	1,377	7.369	5.341	0.930	0.023
Potential AW outcome, as of t+4						
Labour market participation	215	19,121	0.018	0.033	0.589	0.033
Hours, unconditional on LMP	211	18,814	-0.611	1.378	0.658	-0.033
Hours, conditional on LMP	136	15,232	-0.348	1.964	0.860	-0.013
Informal care provision to partner	200	18,849	0.043	0.033	0.202	0.355
Hours of care, unconditional on providing care	199	18,823	0.072	1.665	0.966	0.012
Hours of care, conditional on providing care	52	988	-2.786	8.759	0.752	-0.090

Source: UKHLS, waves 1-9.

Notes: ATT estimate in bold if significant at the conventional 5% level.

Figure 2: Behavioural response (ATT) to a partners' health shock



4.1 Health shocks while active in the labour market

The lack of a positive health-related AWE might be attributable to the income loss following a health shock being of limited relevance. For example, if the shocked partner had already retired from the labour market or was relying on non-labour income sources. To investigate this possibility, we consider a restricted subset of couples where the shocked partner was active in the labour market in the year prior to the shock (i.e. in $t-1$). Descriptive statistics for basic demographics and lagged outcomes in this subsample are reported in Appendix Table A.1. These reveal how these potential AWs are, on average, slightly younger, and more likely to be women. Table 6 reports ATTs for this subsample. While health shocks induce a significant increase in labour market exits for shocked individuals, together with a consequent income loss[9], even in this sub-sample no AWE is detected. In fact, the point estimates on labour supply outcomes becomes negative in the year following the shock. Evidence suggesting that the loss of household labour income following a health shock does not result in a positive AWE also emerges when we further restrict the sample to couples where, in the year prior to the shock, the shocked partner's labour income contributed more than 50% of household income (results reported in Appendix, Table A.2).

As in the full sample, we find a striking behavioural response in informal care provision in the year of shock: the ATT on the likelihood of providing informal care is 7.4 times the counterfactual value (reduced to 2.8 in the following year). The significant ATT on the (unconditional) number of hours of care provided amounts to more than a doubling of the counterfactual value in the year of shock, but loses statistical significance in the following year. Again, this behavioural response relates to the extensive margin rather than the conditional number of hours of care provided.

[9] The ATTs obtained for the labour market participation of the shocked partner, not reported here, are in line (3 to 4 per cent reduction in LMP in the first year past shock occurrence) with evidence from Jones at al. (2020) who, using the same data and methodological approach, report a 7 per cent reduction in the shocked individual's earnings.

Table 6: ATT in the short run, if shocked partner was labour market active as of (t-1)

	n (treated)	n (controls)	ATT	Std. Err.	P val	RSE
Potential AW's outcome, as of t						
Labour market participation	280	38,660	0.006	0.019	0.759	0.007
Hours, unconditional on LMP	277	37,484	0.417	0.951	0.661	0.014
Hours, conditional on LMP	224	31,931	0.244	0.839	0.772	0.007
Informal care provision to partner	280	37,836	**0.215**	0.054	0.000	7.414
Hours of care, unconditional on providing care	280	37,824	**2.263**	0.930	0.015	1.358
Hours of care, conditional on providing care	47	1,373	10.841	10.466	0.309	0.414
Potential AW's outcome, as of t+1						
Labour market participation	236	31,606	-0.036	0.032	0.261	- 0.046
Hours, unconditional on LMP	232	31,255	-1.332	1.245	0.285	- 0.048
Hours, conditional on LMP	191	26,743	-1.340	1.341	0.318	- 0.040
Informal care provision to partner	234	31,489	**0.083**	2.140	0.032	2.862
Hours of care, unconditional on providing care	234	31,471	2.049	1.167	0.080	1.298
Hours of care, conditional on providing care	39	1,139	7.921	14.974	0.603	0.417

Source: UKHLS, waves 1-9.

Notes: ATT estimate in bold if significant at the conventional 5% level.

4.2 Gender effects and shock-induced disability.

Table 7 and Figure 3, report results separately for men and women whose partner experienced an acute health shock[10]. Neither men nor women adjust their labour supply in the year of shock or the following year. While the ATTs are never statistically significant, the point estimate for women, who may be vulnerable to larger income losses when the male partner experiences a health shock, is systematically negative, suggesting that any income effect, which would induce an increase in labour supply, is outweighed by other factors. Indeed, both women and men significantly increase their informal care provision when their partner experiences a health shock. In the year of the shock this amounts to a 60% increase in the probability of caring for women and more than doubles (150%) for men who have lower baseline probabilities of caring

[10] Descriptive statistics for gender-specific lagged outcomes are reported in the Appendix, Table A.3.

than women (13.5% for men and 15.7% for women). In the following year (i.e. t+1), the increase in informal care provision persists for women in both statistical significance and magnitude, but loses statistical significance for men.

Table 8 and Figure 4, report results separately for individuals whose shocked partner does experience an increase in functional limitations (ADLs) when the health deterioration occurs, and for individuals whose partner does not. The remarkable gradient visible in the informal care adjustment, by shocked partner's increase in disability (number of functional limitations) documents the central role partners play as informal care providers, when that need arises. A lack of labour supply adjustment is common across the two subgroups of couples. Such evidence suggests that beyond informal care needs other mechanisms act as counterweights to the income effect that would otherwise increase labour supply.

Table 7: ATT in the short run, by potential AW's gender

	Male						Female					
Potential AW's outcome as of t	n (treat)	n (contr)	ATT	Std. Err.	P val	RSE	n (treat)	n (contr)	ATT	Std. Err.	P val	RSE
Labour market participation	233	24,533	0.0003	0.022	0.990	0.000	248	22,916	-0.009	0.022	0.650	-0.015
Hours, unconditional on LMP	232	24,325	0.206	1.135	0.856	0.008	246	22,710	-0.301	0.807	0.710	-0.016
Hours, conditional on LMP	155	20,750	0.308	1.106	0.781	0.008	145	17,052	-0.179	0.992	0.857	-0.006
Informal care provision to partner	232	24,540	**0.183**	0.049	0.000	1.578	248	22,920	**0.094**	0.035	0.008	0.610
Hours of care, unconditional on providing care	231	24,522	2.926	1.503	0.052	0.511	247	22,905	**3.516**	1.781	0.049	0.480
Hours of care, conditional on providing care	62	1,281	8.383	7.360	0.259	0.221	70	1,483	5.656	7.613	0.460	0.151
Potential AW's outcome as of t+1												
Labour market participation	201	20,269	-0.019	0.031	0.543	-0.030	207	19,223	-0.030	0.031	0.324	-0.051
Hours, unconditional on LMP	197	20,075	-1.132	1.483	0.446	-0.045	207	19,005	-1.135	1.092	0.299	-0.067
Hours, conditional on LMP	138	17,167	-1.294	1.881	0.492	-0.035	121	14,384	-1.019	1.654	0.538	-0.036
Informal care provision to partner	197	20,178	0.042	0.034	0.220	0.356	200	19,160	**0.094**	0.039	0.015	0.657
Hours of care, unconditional on providing care	198	20,160	0.261	1.596	0.870	0.047	201	19,144	3.695	2.029	0.069	0.554
Hours of care, conditional on providing care	54	1,011	0.380	8.282	0.964	0.012	58	1,218	1.985	8.346	0.813	0.065

Source: UKHLS, waves 1-9.

Notes: ATT estimate in bold if significant at the conventional 5% level

Figure 3: Behavioural response (ATT) to a partners' health shock, by potential AW's gender

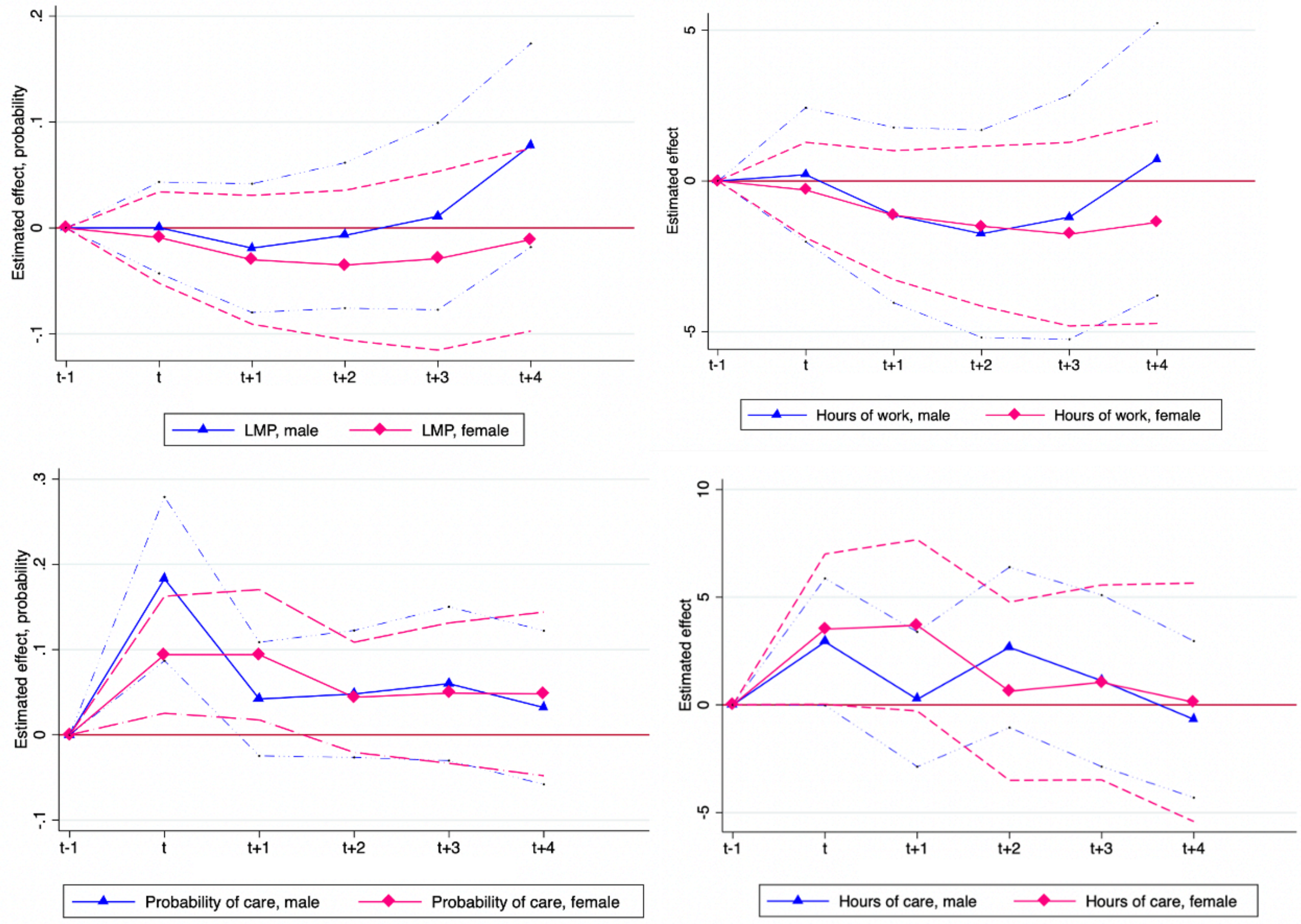


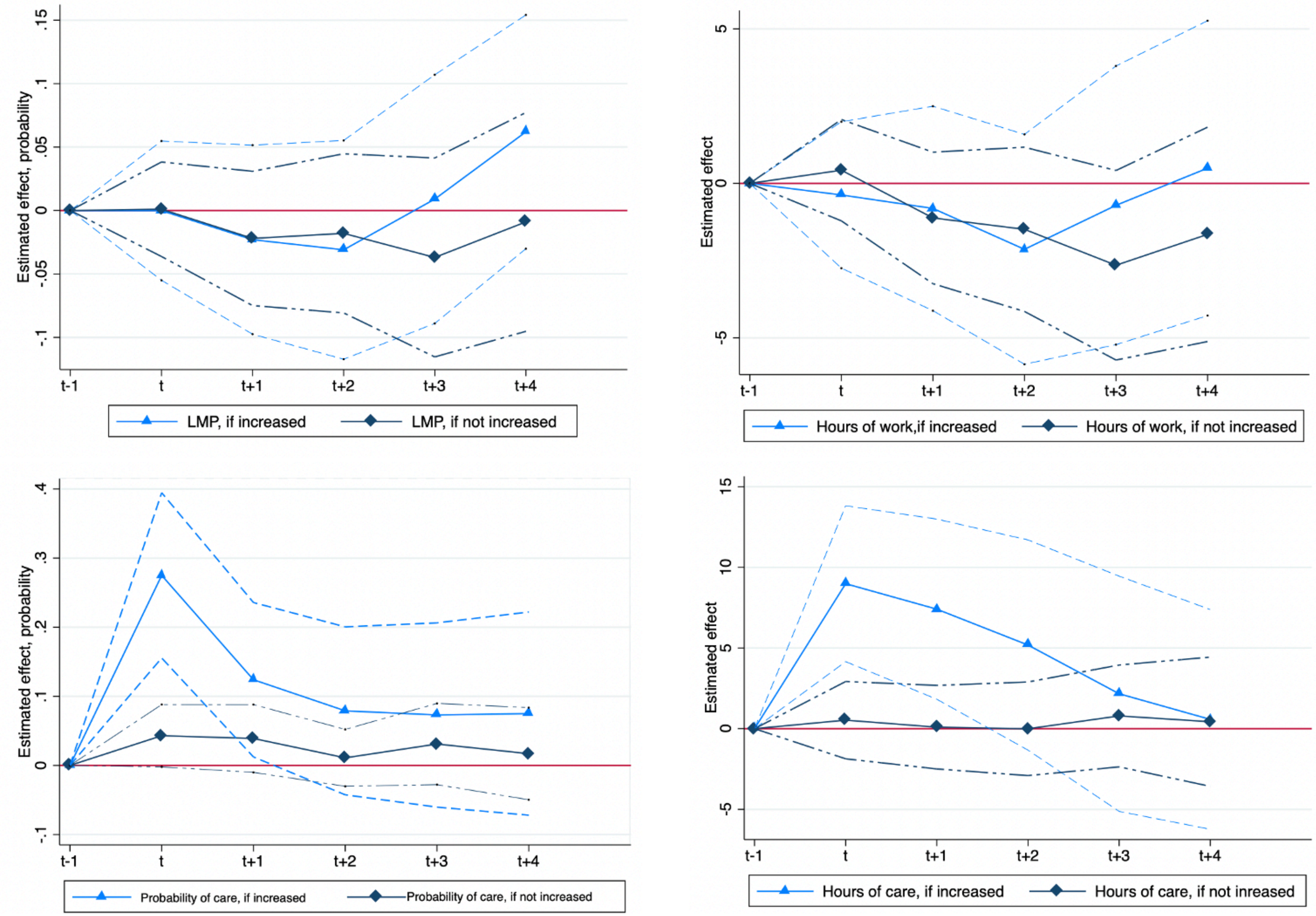
Table 8: ATT in the short run, by increase in shocked partner's number of limitations

	If no increase in reported ADLs						*If increase in reported ADLs*					
After one year (t)	n (treated)	n (controls)	ATT	Std. Err.	P val	RSE	n (treated)	n (controls)	ATT	Std. Err.	P val	RSE
Labour market participation	321	42,862	0.001	0.019	0.956	0.002	159	3,915	-0.000	0.028	0.992	0
Hours, unconditional on LMP	321	42,487	0.427	0.837	0.610	0.018	157	3,879	-0.374	1.209	0.757	-0.017
Hours, conditional on LMP	210	34,656	0.604	0.856	0.481	0.017	89	2,943	-1.009	1.506	0.504	-0.032
Informal care provision to partner	321	42,873	0.043	0.023	0.069	0.344	159	3,916	**0.275**	0.061	0.000	2.254
Hours of care, unconditional on providing care	319	42,850	0.527	1.222	0.666	0.078	158	3,908	**8.987**	2.465	0.000	1.537
Hours of care, conditional on providing care	62	1,986	3.125	7.028	0.658	0.075	69	538	12.240	7.852	0.124	0.372
After two years (t+1)												
Labour market participation	276	35,822	-0.022	0.027	0.407	-0.034	131	3,136	-0.023	0.038	0.550	-0.042
Hours, unconditional on LMP	273	35,440	-1.118	1.086	0.304	-0.050	130	3,107	-0.810	1.688	0.632	-0.042
Hours, conditional on LMP	180	29,015	-0.809	1.414	0.568	-0.024	78	2,378	-2.237	2.659	0.402	-0.070
Informal care provision to partner	273	35,690	0.039	0.025	0.118	0.325	125	3,116	**0.124**	0.057	0.029	0.743
Hours of care, unconditional on providing care	273	35,672	0.092	1.321	0.945	0.015	125	3,103	**7.407**	2.849	0.010	1.311
Hours of care, conditional on providing care	54	1,717	-3.306	7.617	0.666	-0.082	37	414	16.482	11.202	0.153	0.588

Source: UKHLS, waves 1-9.

Notes: ATT estimate in bold if significant at the conventional 5% level.

Figure 4: Behavioural response (ATT) to a partners' health shock, by increase in partner's number of limitations



4.2 Placebo checks

Balancing observed confounders does not guarantee against bias arising from additional unobserved confounders, such as risk and time preferences, potentially affecting both health and time use. In order to assess whether our strategy has successfully removed potential sources of bias, we estimate treatment effects for placebo outcomes, i.e. outcomes for which the treatment is expected, *a priori*, to have no effect. This is, for example, the case for lagged outcomes observed at $t-2$, two years before the health shock is reported, as the matching adjustment exploits only $t-1$ outcomes as lagged outcomes. Significant ATTs estimated on outcomes at $t-2$, would signal pre-existing differences in unobservables between treated couples and matched controls. However, results from this placebo test, reported in Table 9, reveal that, following preprocessing, no statistically significant difference in $t-2$ outcomes is detected.

Table 9: Placebo checks: ATT on outcomes measured in $t-2$

	n (treated)	n (controls)	ATT	Std. Err.	P val
Outcomes as of t-2					
Labour market participation	356	38,514	-0.012	0.018	0.499
Hours worked	352	38,210	-0.034	0.832	0.967
Informal care provision to partner	356	38,491	0.004	0.015	0.781
Hours of care provided	355	38,467	1.170	1.112	0.293

Source: UKHLS, waves 1-9.

Notes: ATT estimate in bold if significant at the conventional 5% level.

5. Conclusion

Informal insurance within households may protect against the economic consequences of health shocks. However, the literature is ambiguous on the existence of a health-related “Added Worker effect”. We contribute to this literature by providing evidence on the within household informal care responses to a health shock of a partner as a mechanism that may counteract income effects that would otherwise increase a partner’s labour supply.

We do this by exploiting nine waves of panel data drawn from Understanding Society. Major health events such as heart attacks, strokes and cancers, offer a source of unanticipated variation in the timing of health shocks. We assume the chance that one partner experiences a major health shock at any particular point in time is conditionally random, and match couples where one partner experiences a health shock with observationally identical (in terms of labour, demographic, health, socioeconomic characteristics and lagged outcomes) controls. The matching algorithm combines coarsened exact matching and entropy balancing in a setting that offers a much larger number of control than treated units. ATTs are obtained through parametric modelling on the matched samples. Placebo tests on pre-shock outcomes fail to detect systematic differences between treated and matched control couples - which would have suggested a role for selection bias on unobservables.

Results indicate that, in the case of UK couples where one partner experiences an acute health shock, there is no evidence that, on average, the labour supply of their partner increases. This is in line with the recent findings of Fadlon and Nielsen (2021) in Denmark and Dobkin et al. (2018) in the US. Instead, and although lacking in precision, our point estimates suggest a possible reduction in labour supply, at least in the short run, for both men and women. The loss of labour income, which has been estimated to be around 7% of counterfactual individual earnings for shocked individuals (see Jones et al., 2020), does not result in a corresponding increase in their partners effort to earn labour income, at least in the short run. A plausible explanation for this is the presence of a national healthcare system in the UK, as opposed to an employment-contingent health insurance system, together with the availability of social security coverage in terms of disability-related benefits. Indeed, in related work Jones et al. (2020) detect a spike in disability benefit receipt after major income shocks, with an estimated ATT amounting to twice the baseline counterfactual value of disability benefit coverage.

Potential added workers of both genders display a significant response to their partner’s health shock in informal care provision, suggesting that any negative income effect of a health shock is fully offset by care giving. No evidence emerges for behavioural responses driven by gender specialization in labour income production versus home production which would have resulted in asymmetric responses by gender, with women increasing time devoted to paid work, and men increasing time devoted to informal care in the event of partners' health shock. Our results hold whether or not the individual experiencing a health shock is active in the labour market prior to the shock.

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Appendix

Table A.1: Descriptive statistics for AW's age and lagged outcomes, if shocked partner was labour market active as of (t-1)

	Mean	Std. Dev.
AW's age	51.81	7.82
Hours of work (t-1)	29.93	18.09
Hours of care (t-1)	2.05	10.62
Informal care provision (t-1)	0.05	0.23
Labour market participation (t-1)	0.83	0.38
Partner's age	52.97	7.85

Source: UKHLS, waves 1-9.

Table A.2. ATT, if shocked partner's labour income (t-1) >50% of total household's income

	n (treated)	n (controls)	ATT	Std. Err.	P val	Relative effect
After one year (t)						
Labour market participation	250	35,487	0.005	0.019	0.791	0.006
Hours, unconditional on LMP	247	35,161	0.326	1.012	0.747	0.011
Informal care provision to partner	250	35,492	**0.201**	0.056	0.000	8.739
Hours of care	250	35,481	**2.847**	0.957	0.003	2.421
After two years (t+1)						
Labour market participation	213	29,665	-0.039	0.034	0.254	-0.048
Hours, unconditional on LMP	209	29,344	-1.466	1.334	0.272	-0.050
Informal care provision to partner	211	29,549	0.072	0.039	0.062	3.130
Hours of care	211	29,536	**2.463**	1.176	0.037	2.116

Source: UKHLS, waves 1-9.
Notes: ATT estimate in bold if significant at the conventional 5% level.

Table A.3 Descriptive statistics on potential AW's characteristics, by potential AW's gender

	Male		*Female*	
	Mean	Std. Dev.	Mean	Std. Dev.
AW's age	54.66	8.53	51.98	7.54
Hours of work (t-1)	27.56	21.16	19.49	18.44
Hours of care (t-1)	5.78	18.95	6.43	18.50
Informal care provision (t-1)	0.13	0.33	0.16	0.36
Labour market participation (t-1)	0.69	0.46	0.61	0.49
Partner's age	53.67	9.13	57.32	9.22

Source: UKHLS, waves 1-9