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Body mass, physical activity and future long-term care use

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Abstract

Obesity and physical activity rates are known to be strong predictors of disability and functional limitations, and in turn use of health care. In this study we aim to explore whether obesity and physical activity are also significant risk factors for future long-term care need (both informal and formal care). We use regression analysis of data from the English Longitudinal Study of Ageing (ELSA) between 2002 to 2011 to addres this aim. Selection issues are tackled using the rich set of control variables in ELSA; exploiting the longitudinal structure of the data; and accounting for loss to follow-up (including death). Control factors include: impairment (ADLs) and specific existing health conditions – notably diabetes, high blood pressure, and CVD. We find that obese older people are 25% more likely to be in receipt of informal or privately paid care in two year's time, but this does not hold for formal care. People who are physically active are 38% less likely to be using any care two years later, with the strongest effect for formal care use. Sensitivity analysis suggests that the results are not driven by either prediabetes, or a link between obesity and subjective health and depression, or unobserved factors.

Keywords: long-term care, social care, elderly people, informal care, obesity, BMI

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1 INTRODUCTION

The widespread rise of obesity rates has become a worldwide health concern (WHO 2003). In the UK, as in many other countries, the prevalence of obesity is rising to epidemic proportions: about 40% of Britons are projected to be obese by 2025 and Britain to become a largely obese society by 2050 (Foresight 2007). The high and rising prevalence of obesity is a cause of major challenges for a society. In addition to being a debilitating condition in its own right, obesity is related to premature mortality (Calle et al.1999) and is an important risk factor for a number of chronic conditions including type II diabetes (Colditz et al. 1990, Chan et al. 1994), cardiovascular diseases (Whelton et al. 1998), cancer (Michaud et al. 2001, Bergstrom et al. 2001) and osteoarthritis (Cooper et al. 1998). It is also related to physical disability, impaired quality of life and decreased cognitive function and dementia among the elderly (Han et al. 2011, Andrade et al. 2013, Al Snih et al. 2007, Sturm et al. 2004). The upward shift in the age at which body fat and body mass index stop increasing due to the ageing process and current trends in population ageing suggest that the prevalence of obesity in the elderly will be on the increase as well (Han et al. 2011, Vlassopoulos et al. 2014).

The increased burden of fatal and non-fatal conditions associated with obesity is likely to impose substantial financial costs on societies and governments (Buchmueller et al. 2015, Veiga et al. 2008). These costs are firstly monetary medical costs corresponding to an increased use of resources devoted to manage obesity-related diseases such as ambulatory care, hospitalisation, drugs, tests and long-term care (including nursing homes) (Wang et al. 2011). It is estimated that an extra £5.5 billion of such medical costs will be added to the NHS by 2050 (Foresight 2007). Moreover, indirect costs including lost workdays, disability pensions, premature mortality, productivity reduction and decrease in disability-free life years are likely to be even greater (WHO (2003), Wang et al. (2011)).

Although there is some recent evidence around the effects of obesity on health care utilisation and costs, not much is known about the relationship between obesity and long-term care utilisation (Public Health England, 2013). Our aim is to estimate the effects of obesity on overall long-term care use and separately on various forms of long-term care. We investigate how the impact of obesity is transmitted, considering the direct impact on the use of various modes of care in the future, overall, and also the indirect effect through changes in people's long-term conditions, and their functional ability. An estimate of the future LTC use that is attributed to obesity beyond the currently known indicators of impairment will be useful information for decision making in both public health (PH) and social care. This allows us to incorporate a wider range of benefits from tackling obesity epidemics into decision-making, and thus reach more socially optimal levels of investment in corresponding intervetions. If obesity serves as a signal for impairment, and so future care need, not yet diagnosed or assessed, accounting for increases in target population obesity rates would improve planning and budgeting processes, and allow better targeting of care system resources in the future.

We also explore the effects of physical activity (PA), given people's conditions including diabetes, on LTC utilisation. Promoting physical activity is a potentially cost-effective public health intervention to tackle rising societal costs attributed to obesity. If there is an additional effect of physical activity on long-term care use which is not accounted for, we risk underestimation of benefits of physical activity and thus a resulting underinvestment in measures to promote PA.

This paper contributes to the literature in several ways. First, we focus on a country with moderate but increasing levels of obesity compared to high obesity burden country such as USA in the previous literature. Second, we consider the whole spectrum of long-term care: informal, formal home care (privately purchased and publicly-supported), and institutional care, while previous studies mostly focused on nursing home admissions. Third, we address the problem of attrition due to a non-response and death, which in elderly population is likely to be related to health and care status. Finally, we investigate the pathways through which obesity leads to higher use of long-term care, within and beyond conventionally known risk factors.

In our analysis we focus on people aged 65 years and over as this population group is most at risk of requiring long-term care and is more likely to be using expensive institutional care. We use the English Longitudinal Study of Ageing (ELSA) in a multinomial logit framework to estimate the impact of current obesity status and physical activity on the use of various modes of care two years in the future.

The remainder of the paper is organised as follows. Section 2 describes institutional and theoretical background on the matter, offering a literature review and formulating hypotheses. Econometric methodology is presented in Section 3, followed by the description of the data used in the analysis in Section 4. Section 5 discussed the results. Section 6 concludes.

2 BACKGROUND

Long-term care support for adults with chronic health conditions and disabilities usually comprises nursing care, personal care and assistance with domestic tasks (Comas-Herrera et al.

2010). Care can be provided either informally by family members, friends and neighbours or formally through professional services paid by individuals or their local authority (National Audit Office 2014). The formal long-term care system in England is means-tested providing a 'safety-net' for those in greater need (Fernandez, Forder and Knapp 2011), with most care being provided 'informally' by unpaid carers. Approximately 85 percent of all older people with a functional disability living in private households in England receive some informal care (Comas-Herrera et al. 2010). The number of informal carers has increased over the years (11% between 2001 and 2011) while informal care has become more intensive (National Audit Office 2014)." According to some estimates the total value of informal care to society in England sums up to £55 billion (National Audit Office 2014) .

A small number of US studies have tried to explore directly the relationship between BMI and long-term care utilisation. Elkins et al. (2006) find some evidence that obesity in midlife is associated with a higher probability of nursing home entry. Similarly, Ziza et al. (2002), Resnik et al. (2005) and Yang and Zhang (2014) show that obesity in older people increases the risk of nursing home admissions, use of personal care assistance and LTC costs. Looking at the role of physical activity, Demakakos, Hamer et al. (2010) demonstrate that any type of physical activity is associated with a reduced risk of type 2 diabetes in adults aged 70 years and older while vigorous or moderate activity reduce type 2 diabetes risk for adults aged 50 to 69.

The literature suggests that obesity is a risk factor for a number of long-term conditions such as type 2 diabetes, cardiovascular disease, muscular skeletal disease, some cancers, arthritis, hypertension and respiratory disease and others (Guh et al. 2009). These conditions lead to functional impairments and reduced cognitive and psychological wellbeing, which in turn generate a need for long-term care. This process is an indirect pathway of the effect of obesity on the need for long-term care. Moreover, obesity is also directly associated with functional limitations (e.g. mobility) and disability in old age (Han et al. 2011, Andrade et al. 2013, Al Snih et al. 2007, Sturm et al. 2004). We can also theorise that there may be direct effects of obesity on the use of care that stem from obesity status being used as a proxy for need and given that assessment of a need for long-term care is imperfect.. In this way, an obese person might be regarded as having a need for long-term care even if directly assessed indicators of impairment are accounted for in the analysis.

We hypothesise that obesity and physical activity might affect the need for LTC in a number of ways, as summarised in Figure 1. First, obesity and lack of physical activity are well-known risk factors for a range of chronic diseases, and as such will have an indirect effect on the need for care. In turn, these diseases lead to various functional impairments that generate a need for LTC. We also distinguish between diagnosed and undiagnosed illnesses to emphasise that even after controlling for the health conditions available in the data, we may still see an independent effect of obesity on future care use, which will still be related to health.

Second, some functional limitations may be caused directly by obesity, independent of specifically health conditions, reflecting impairment of physical activity resulting from excessive body weight – for example reduced mobility and self-care capability.

We also note in the diagram the potential for certain diseases and functional limitations to be *causes* of obesity, recognising the issues with establishing the causal effects of obesity on the need for care.

A similar diagram can be considered with respect to physical activity.

Based on these theoretical considerations, we test the following hypothesis:

H1: Obesity among older individuals increases future use of long-term care.

H2: Higher future use of long-term care by obese older people is only partially explained by health conditions and functional limitations.

H3: Physical activity among older individuals reduces future use of long-term care.

H4: Lower future use of long-term care among older people who engage in physical activity is only partially explained by health conditions and functional limitations.

3 ECONOMETRIC METHODOLOGY AND DATA

Specification

We start with a (linear) model:

$$y_{itj} = \alpha_0 + \alpha_1 W_{it} + \alpha_2 x_{it}(W_{it}) + e_{it} \quad (1)$$

where y_{itj} is the outcome which in this case is the utilisation of long-term care (of type j e.g. informal care or formal home care) by person i at time t. In theory, utilisation is a function of a set of risk factors, including whether the person is (a) obese or (b) undertakes physical activity (written as elements in the vector W_{it}) and other needs-related risk factors (x_{it}) such as the prevalence of chronic conditions, and also a set of 'other' factors (e_{it}). The α's are the coefficients that measure the size of the effect of the risk factors on utilisation. Moreover, we assume that the other needs-related risk factors for LTC use are also partly dependent on the person's obesity and physical activity i.e. factors x_{it} are functions of W_{it}.

In practice, not all the relevant risk factors are available in the data; some are unobservable. Suppose we re-write (1) as:

$$y_{itj} = \alpha_0 + \alpha_1 W_{it} + \alpha_{21} X_{it}(W_{it}) + \alpha_{22} Z_{it}(W_{it}) + e_{it} \quad (2)$$

where $\alpha_2 x_{it}(W_{it}) = \alpha_{21} X_{it}(W_{it}) + \alpha_{22} Z_{it}(W_{it})$ with X_{it} being the observable risk factors, such as reported long-term conditions, and Z_{it} being the unobservable factors (e.g. behavioural responses/preferences).

This specification presents a number of econometric challenges. First, we need to be clear about the different ways that obesity could affect LTC use, both as a direct effect captured by α_1 in (2) and indirectly where obesity status affects other factors that are included in the estimation e.g. having a diabetes diagnosis or ADL limitations that stem from being obese (which are factors in X_{it}) . The latter is partly captured in the coefficient vector α_{21}. Second, any unobserved risk factor that is also correlated with the person being obese or not will bias the estimated coefficients in a standard (OLS) estimation of y_{itj} on W_{it} and X_{it}. We cannot be certain that the estimated effect of obesity is the actual causal effect or whether it also is capturing some effect of an unobserved factor that happens to be correlated with the prevalence of obesity (e.g. the person's inherent self-confidence).

This problem can be addressed (to a certain extent) by exploiting the longitudinal nature of the data and the persistence of conditions like obesity in affecting the need for services. Suppose that current obesity is a function of lagged obesity plus the change in obesity between the lagged and current period e.g. $W_{it} = \Delta W_{it} + W_{it-1}$. Subsituting for W_{it} in (2) (and also for X_{it} in the same way) we then estimate the model:

$$y_{itj} = \beta_0 + \beta_1 W_{it-1} + \beta_2 X_{it-1}(W_{it-1}) + \epsilon_{it}\big(Z_{it}\big(W_{it}(W_{it-1})\big), \Delta W_{it}, \Delta X_{it},\big) \quad (3)$$

The endogeneity problem will likely be reduced, depending on the extent of the correlation between current unobserved factors Z_{it} and lagged obesity. Where a subset of current unobserved variables Z_{it}^{W} causally affect current obesity (or physical activity rates), W_{it}, and the need for long term care, then this potential endogeneity problem is mitigated if lagged obesity/physical activity variables (W_{it-1}) are used. For example, if the person's current level of self-confidence is unobserved and this leads to a need for care and also affects current obesity, then previous rates of obesity are not endogenous. The problem remains if unobserved variables (e.g. self-confidence, stress etc.) have a historical effect on lagged obesity where this lagged effect also perpetuates to impact directly on current utilisation.

In short, potential endogeneity problems from any short-term (less than 2-year) unobserved causal effects on obesity/physical activity are avoided. Where time-invariant factors are unobserved, this could cause bias. In theory, a fixed effects approach would also reduce this endogeneity issue. The problem is that obesity rates are also largely time invariant giving relatively few cases (where a change in obesity status has occurred) to work with. Furthermore, with multinomial models, many observations will be perfectly predicted, again substantially limiting the valid cases.

The feasible set of outcomes y_{itj} in the general (older) population include the use of various types of long-term care support, no support, non-response and death. We estimate the model using multinomial logistic regression, which allows us to simultaneously account for this range of outcomes:

$$ln\left(\frac{p_{itj}}{p_{it1}}\right) = \beta_{0j} + W_{it-1}\beta_{1j} + X_{it-1}\beta_{xj} + \varepsilon_{it} \quad (4)$$

where j refers to the category corresponding to the mode of care and $p_{itj} = prob(y_{itj}|X_{it-1}, W_{it-1})$ is the probability that the individual experiences outcome j. By focusing on the future care use we are relating current wave obesity status to the care use in two years.

Data

ELSA is a longitudinal 2-yearly survey of individuals aged 50 and over with replacement. It was originally sampled from the pool of respondents to the Health Survey of England (1998, 1999, 2001). It collects vast amount of data on individual and family circumstances and quality of life of older people. It explores the dynamic relationships between health and functioning, social networks and participation, and economic position of people during the pre-retirement period and after retirement. We pooled data from waves 1 to 5.

Variables

The dependent variable for the basic model is constructed based on the responses to the set of questions on whether the person receives help from different sources for different reasons as a result of having difficulties with activities of daily living. The relevant questions differ between waves 1-2 and waves 3-5, which is reflected in Table 1. To avoid difficulties with correspondence and have reasonable share of cases per category, we aggregated to broader care categories, as shown in the table.

With respect to the future care use, we explored different specifications and decided to focus on two main specifications. The *basic* one categorises the dependent variable into four categories:

- respondent, no future care use (the base category);
- respondent, any care used in the future;
- non-respondent;
- died

The *extended* set disaggregates future care use into several categories[1]:

- respondent, no future care use (the base category);
- respondent, future informal care user;
- respondent, future informal and privately purchased care user;
- respondent, future formal care (care home and LA social care) user;
- non-respondent;
- died

Keeping in line with the literature, our main indicator for *obesity* is constructed from the body mass index (BMI). We classify the respondents into four groups according to the WHO definition.[2] – underweight (BMI less than 18.5), normal weight (BMI 18.5 to 24.99), overweight (BMI 25 to 29.99) and obese (BMI of 30+). BMI could be directly calculated for waves 2 and 4, and imputed for wave 1 (using wave 0 data). This was used as a risk factor for outcomes at waves 2, 3 and 5 (waves are two years apart in ELSA)[3].

The *physical activity* indicator in our analysis was based on the ELSA question about whether an individual is engaging in any of the following situations: (i) vigorous physical activity at least 1-3 times per month or more often, (ii) moderate physical activity at least once a week or more often, or (iii) light physical activity more than once per week.

Control factors included indicators of functional limitations and health conditions. We define functional limitations as a set of three variables operationalized as a number of limitations with

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[1] We also tried the specification where care home residents are place into a separate category but there was a small number of observations in this category per wave.
[2] http://apps.who.int/bmi/index.jsp?introPage=intro_3.html&
[3] Excluding the data from waves 0/1 does not change the main results, however it does prevent us from analysing heterogeneous effects due to the small sample size.

(i) activities of daily living (ADLs) e.g. dressing, washing, transfer (ii) instrumental activities of daily living (iADLs) e.g. shopping, meal preparation, and (iii) mobility, e.g. walking 100 yards.

A more extensive specification, in addition to the above listed variables, includes a number of controls for specific health conditions, such as high blood pressure, diabetes, cancer, lung disease, heart-related problems, stroke, psychiatric disorders, and arthritis. Other control variables include respondent's age, number of children, real per capita total household income and wealth, indicators whether a respondent is female, has no educational qualifications, is non-white, married, living alone, or owns the accommodation, and time dummies.

4 RESULTS

Descriptive statistics

Table 2 presents summary statistics for the main sample used in the analysis, presented as a whole and by category. Overall in the whole sample, 30% of respondents are receiving some type of care two years later, among which 1% are in nursing homes, 27% receive informal care, 3% formal care, and 4% purchase care privately.

To gain insight into the nature of the relationship between care use and BMI we initially conducted a simple (non-parametric) analysis using the lowess procedure (fitted using STATA 13). As could be seen from Figure 2, individuals with higher BMI are far more likely to use care two years later across all forms, except for care home.

Any Care specification

Tables 3 shows the main results for the coefficients of interest from the estimation of (4), with standard errors clustered at the individual level (full estimation results are presented in Appendix Tables A1-A2). We estimate various specifications to explore the impact of the inclusion of additional controls on the magnitude of the effect of obesity status and physical activity on the future care use. Relative Risk Ratios from the multinomial regressions are presented in sets of three columns, corresponding to the different main outcomes: care, non-response and death. These results are for the full sample of people aged 65 and above, with respondents who do not use any care being the base category.

As can be seen from Column (1), obese people as compared to normal weight people are 1.75 times more likely to use some care two years later than not to use any care (controlling for death and non-response). If we add controls for such health behaviours as physical activity, smoking and drinking (column (2)), the magnitude of the effect decreases somewhat but still remains significant at 1.65.

Being physically active means that the person is 80% (100*(1-0.20)) less likely to use care. As we add demographic and socio-economic controls, as well as ADL, iADL, and mobility limitations counts in the third specification (Table 3, column (3)), the effect of obesity and physical activity decreases further, but still remains statistically and economically significant: obese individuals are 28% percent more likely to use care in the future, and those engaged in physical activity 38% less likely.

Column (4) of Table 3 present the specification that includes a full set of health risk factors, such as high blood pressure, diabetes, cancer, lung and heart problems, stroke, psychiatric problems and arthritis. As can be seen, the effect has decreased further, while still remaining at significant magnitude: being obese means that in two years the person is around 25% more likely than the person with normal weight to be using some form of care. Yet, those who are physically active are still 38% less likely to be using care in the future.

In previous literature (Flegal et al. 2013), obesity is reported as having some protective effect with respect to mortality. We find that overweight and obese individuals were ~20% less likely to be dead at follow-up . At the same time those who are underweight are 2-2.5 times (depending on the specification) more likely to die in two years' time. With respect to our concerns of non-respondents, only being overweight is reducing the probability of being a non-respondent. Concerning other control variables, females are much more likely to be using care in the future and less likely to die. Those with no educational qualifications[4] are more likely to drop out of the survey or die, while having no effect on the probability of care among respondents. Older people are equally less likely to be in the base category. Married people and people with children are more likely and those living alone are less likely to be using any care, which is expected given that this is most likely driven by the informal care.
Neither home ownership, nor wealth or income have any sizeable effect on any category. However, this may be because we do control for the limitations in (instrumental) activities of daily living, and they are likely to be related to the socio-economic status (Gjonca, Tabassum et al. 2009). As expected the indicators of impairment are positively related to the chance of using care. The health condition controls also have the expected effects. Details for these estimates can be found in Appendix Tables A1 and A2.

[4] ELSA educational qualification question lists the following options: (i) NVQ4/NVQ5/Degree or equivalent, (ii) Higher education below degree, (iii) NVQ3/GCE A Level equivalent, (iv) NVQ2/GCE O Level equivalent, (v) NVQ1/CSE other grade equivalent, and (vi) Foreign/other qualification.

Extended specification

Rather than outcomes categorised as any care (or not), plus non-response and death, the analysis can be conducted using an extended set of outcomes. Columns (5)-(7) of Table 3 (panel A) shows results where care categories are defined as: (i) only informal care (IC), (ii) informal and privately purchased care (IC+PC), (iii) formal care (both nursing homes and LA provided social care) (FC). Respondents who receive the latter type of care are allocated to this category irrespective of their use of informal or privately purchase care.

The impact of obesity on care use is primarily due to the effect on informal care while the effect on privately purchased care or formal care is smaller (16% compared to 26%) and not statistically significant. However, the latter may be due to the relatively low number of cases in this category (see Table 1 for descriptive statistics). At the same time, the protective effect of physical activity is large. Those engaged in physical activity are 36% less likely to use informal care, 27% less likely to use privately purchases/informal care and 64% less likely to use formal care (controlling for non-response and death).

Potentially, respondents' current care status may be driving the effect on future care use. To test this, we ran all the specifications on the sample restricted to those who are currently not using any forms of care – see Panel B of Table 3. We find almost no difference in the results between the two samples. If anything, the effect is larger in magnitude for the sample with no initial care use.

We also assess whether effect sizes with regard to obesity and physical activity differ by gender. Estimating models with interaction terms on these variables, we find no statistically significant difference between sexes of obesity, but do find that physical activity is associated with a somewhat greater reduction in future care use for males than for females (any care model).

Sensitivity Analysis

To assess the robustness of the results to different model specifications, we estimated a range of alternatives (see Table 4).

First, we investigated the use of the BMI-based measure of obesity vs an abdominal obesity measure. The abdominal obesity indicator is calculated as the ratio of waist-hip (WHR) measurement. This measure was available in a sub-sample of the data. We found that WHR abdominal obesity was not significant when used alongside BMI-based measures. When just using WHR, the effect on informal care use was significant at the 10% level, with a relative risk of 1.12. Whilst there is some suggestion in the literature about the superiority of the abdominal obesity measure, this finding seems to show that, at least in the context of long-term care, the BMI-based measure of obesity is of greater relevance.

Second, we considered pre-diabetes as an explanation for the obesity effect. ELSA also contains data on blood sugar levels for around a quarter of the sample, from which a ‘pre-diabetes’ indicator can be calculated using fasting blood glucose levels. This indicator can be used alongside an obesity measure, as a likely immediate consequence of being obese. When both pre-diabetes and obesity indicators are used, both are insignificant, suggesting multi-collinearity.

Third, we explored subjective health and depression as explanations for the obesity effect. In the main analysis we focused mostly on the ADLs and iADLs as major determinants of care, plus health conditions that have been diagnosed by a doctor (although where these diagnoses are self-reported). We explored the effect of self-rated health state and Centre for Epidemiologic Studies Depression scale as proxies for other yet undiagnosed health conditions. As reported in Table , when various combinations of these control factors were specified in the main model, we found no difference from the main result with regard to the effect of obesity and physical activity.

In the table, column (5) reports the estimates from a regression where the count of ADLs, iADLs, and functional limitations two years later are included i.e. not lagged with respect to the ‘need care’ outcome measure. Their inclusion reduces the significance and magnitude of the effect of obesity. The effect of physical activity remains significant, however. We might expect the current need for care to be highly correlated with current impairment rates (essentially by definition). Indeed, (lagged) obesity does not appear to have an effect on care need beyond its effect on impairment rates. However, physical activity does seem to have a further distinct effect after controlling for current impairment rates. Column (6) tests for the interaction effect between obesity and a number of long-term health conditions. As can be seen, the effect of obesity is again insignificant and reduced compared to the baseline specification, while the interaction terms are not statistically significant.

Although the indicator variables for the obesity status in the main specification represented an obstacle for the estimation of the coefficients of interest allowing for the unobserved heterogeneity, we estimated an alternative specification with a quadratic function in BMI using the unobserved effect logit model. As Figure 3 shows, there is no statistically significant difference in the predictions from the two models.

One of the most discussed limitation of the MNL model is the assumption on the Independence of Irrelevant Alternatives. There exist a number of tests (most of which are incorporate in STATA routines) and we have implemented those which can be applied to the models with clustered standard errors – Small-Hsiao test and the one based on the Seemingly Unrelated Estimation (*suest* command in Stata). The results for the basic model with "any care" category mostly supported the IIA assumption. The results for the extended model with several care categories turned out to be more problematic as the tests in most specifications rejected the independence of other alternatives. We note there seems to be an agreement in the literature, nonetheless, that both of the tests which we could apply perform rather poorly even in large samples (Cheng and Long 2007; Fry and Harris 1996, 1998). Alternative estimators for the extended model specification that do not rely on IIA assumptions are computationally intensive and were not feasible given the relatively low number of cases in the privately purchased and formal care categories, or require additional alternative specific information (for example, distance to the nearest nursing home or the price of alternative modes of care), which is not available.

Indicative Estimates of the Costs of Obesity Epidemic

Increasing obesity rates among other things imply greater care costs. An estimation of these costs can give a sense of the total implications of obesity epidemic. In particular, we seek to calculate the 'excess' costs of informal care that result from obesity. We start with a base year of 2009 – the last year of our sample with data on obesity – and consider the impact two years later (2011).

The proportion of people who are previously obese that need care is around 1.25 greater than the proportion of previously non-obese people that need care, according to our estimates above. The excess number due to previous obesity can be determined as the difference between the number of people who previously had obesity (but were not care user) assuming a 1.25 greater obesity effect and the number as though there was no such effect. The relative risk ratio (rrr) is:

$$rrr = \frac{\pi^1}{\pi^0} = \frac{\pi^0 \beta}{\pi^0} = \beta = 1.25 \qquad (5)$$

where $\pi^k = \frac{N_{1k}^t}{N_{1k}^t + N_{0k}^t}$, and N_{jk}^t is the population (at time t) who either have care needs or not, denoted $j = 0{,}1$ and obesity or not, denoted $k = 0{,}1$. Accordingly, we can project the number of people at time $t + 1$ with care needs using estimate of π^k and assuming this rate remains unchanged through time:

$$N_{1k}^{t} = N_{0k}^{t}\left(\frac{\pi^{k}}{1-\pi^{k}}\right) = N_{0k}^{t-1}\left(\frac{\pi^{k}}{1-\pi^{k}}\right) \tag{6}$$

Moreover, the excess effect of obesity is the difference Δ^t between the projected number of people with care needs and (previous) obesity when (a) applying the estimated obesity effect rate π^1 and (b) assuming no obesity effect, that is applying π^0:

$$\begin{aligned} \Delta^{t} &= N_{11}^{t} - N_{11}^{t\pi^0} = N_{01}^{t-1}\left(\frac{\pi^{1}}{1-\pi^{1}}\right) - N_{01}^{t-1}\left(\frac{\pi^{0}}{1-\pi^{0}}\right) \\ &= N_{01}^{t-1}\pi^{0}\left(\frac{\beta}{1-\beta\pi^{0}} - \frac{1}{1-\pi^{0}}\right) = N_{01}^{t-1}\pi^{0}\frac{\beta-1}{(1-\beta\pi^{0})(1-\pi^{0})} \end{aligned} \tag{7}$$

This calcaulation assumes no differential mortality rate between obese and non-obese people (as assumption that is largely consistent with our results above). The no-obesity-effect rate π^0 is assumed to be the observed proportion of people in the ELSA sample in 2009 that used care *but were not obese*, a rate of $\pi^0 = 0.175$. We use our estimation results of $\beta = 1.25$. The previous number of people with obesity and no care use is also based on sample estimates from our data. In particular, we observe that around 20.78% of older people in the 2009 sample wave were obese but not using care.[5] We apply this rate to the England population, giving $N_{01}^{t-1} =$ 1.799m people in this category, to calculate the excess effect in 2011.

This calculation can also be repeated for later pairs of years, e.g. 2013 compared with 2011. In this case, we uprate our starting value of the number of older people in the 2011 that were obese but were not receiving care using the projected changes in obsesity rates as produced by Foresight (2007) (an average of 1.67% over a two-year period). We assume this figure applies equally to all ages. Population change is based on the ONS population projections.[6]

Table 5 shows the results of this projection. We start with 20.78% of 65+ population who are obese and not using any care in row 4 for 2009 (a 1.67% biennial increase is applied to this number to obtain the corresponding share for 2013). Combining information in row 3 and row

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[5] The overall rate of obestity based on our sample is 29.59%, slightly higher than the estimate of 27.88% based on the 2009 Health Survey of England[5]

[6] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/articles/nationalpopulationprojections/2014basedextravariantsreport#appendix-c-charts-population-aged-65-and-over-for-the-constituent-countries

4 we obtain the size of the obese population among those 65 years old and older who do not use any care in the current year (row 5).

Row 6 applies equation (7) to calculate Δ^t the number of people who over the two-year period that developed a need for informal care because they were obese, other things held constant. This 'excess' number of people in need of informal care corresponds to about 7.29% of the total number of informal care users.

We can estimate a cost associated with this excess effect by calculating a unit cost of informal care, as follows. First, we take estimates from our sample on the share of informal care users in the 65+ population of 21.90% in year 2009, we apply this share to the size of older population and arrive at the estimates of the numbers of informal care users in row 7. Second, we deflate the above quoted estimate of the value of informal care of £55 billion in 2011 to £53.3 billion in 2009. Together, these figures give the average value of informal care per care user in the amount of £28,410 per year (row 9).

Key financial results from the projections are given in rows 10 and 12 in the table (with corresponding percentages in rows 11 and 12). Applying the 2009 unit value of informal care to the numbers in row 6 (assuming no inflation and no wage growth) gives the estmate of the annual value of informal care linked to past obesity (row 10). In year 2011 it is calculated to be £3.9 billion, with a value of £4.3 billion in 2013. This amount can be interpreted as the excess use of informal care which could have been avoided if obesity was addressed in people who did not use care two years ago. In other words, if the cost of addressing obesity via public health interventions among 65+ population group was up to £3.9 billion in 2011 , then this would still represent an overall cost saving from a societal perspective.

For a comparison, Scarborough et al. (2011) estimates the direct cost of both overweight and obesity to the NHS at £5.1 billion per year. Another comparison is to the Public Health England budget: programmes tackling obesities are funded from the ring-fenced local authority grant which in year 2015-2016 totalled £3.4 billion[7] and was not limited to obesity focused interventions or to the elderly population.

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7 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539768/PHE_annual_report_2015_2016_web.pdf

The second noteable result is the additional cost of *increasing* obesity rates through time. Other things equal, at 2009 obesity rates the excess number of informal care users is 137,000 in 2011. But starting in 2011, the equivalent figure is higher at 151,000. This increase can be expressed in monetary terms (row 12), with the following interpretation. If obesity rates were halted at the level of 2009 (for 2011), the cost of informal care would have been almost £400 million less two years later in year 2011. In other words, halting further increases in obesity would have saved a projected £200 million per year in care costs.

These projections in cost terms are particularly sensitive to the assumed unit value of informal care. For example, using a value of half that in the tables would reduce all other financial figures by a half. However, the results do indicate the not inconsiderable magnitude of the effect, given reasonable assumptions.

5 CONCLUSIONS

The rising trend in the prevalence of obesity presents a challenge for future health care and social care need. Although the impact on health care has received more attention, the implications of obesity in relation to long-term care utilisation and costs are not yet well understood. This paper explores the relationship between current obesity status and physical activity and future use of various modes of long-term care.

Using data from the English Longitudinal Study of Ageing and a cohort study design we find a significant association between obesity indicators and future (two-year hence) care use. Control factors included various health conditions, ADLs, iADLs, mobility limitations, and the analysis also accounted for attrition due to non-response and death.

In line with the literature we expected obesity to be a risk factor for a number of long-term conditions (e.g. diabetes, arthritis, heart failure etc.) as well a cause of impaired functioning in everyday life through ADLs, iADLs and mobility limitation. Loss of functioning from either cause would increase the need for (and benefits of) long-term care. Observed indicators of long-term conditions (e.g. reported/diagnosed chronic diseases) and impairment (e.g. reported failure to achieve ADLs) would be associated with increased use of services, other things equal.

We also hypothesised that obesity could be an independent direct risk factor for future care use even where these observed indicators were used in the estimation, for three reasons. First, because obesity is a proxy for undiagnosed/unobserved health conditions. Second, because disability and 'need' are in part socially constructed so that being obese implies a need for care.

Third, because assessment of need is imperfect and could give too much weight to overt indicators like obesity (although less so physical activity). Similar arguments can be made about the effects of physical activity but in the opposite direction, reducing the need for long-term care.

Overall, we found a strong, significant association between obesity indicators and LTC need in the base model. This effect of obesity on LTC need is almost entirely on the use of informal care, although as noted we need to be aware of the modelling limitations when estimating the effect on particular types of care. As regards the different effects of obesity, with a full set of controls for other conditions and impairment we also found a significant but smaller effect. With reference to (3), we found an overall effect of: $\frac{\partial y_{it}}{\partial W_{it-1}} = \beta_1 + \beta_2 \frac{\partial X_{it-1}}{\partial W_{it-1}} > 0$. Controlling for other factors X_{it}, we also found that $\frac{\partial y_{it}}{\partial W_{it-1}} > \beta_1 > 0$ which implies that part of the effect of obesity is via other factors i.e. $\frac{\partial X_{it-1}}{\partial W_{it-1}} > 0$. The main indirect effect of obesity is picked up through changes in reported ADLs, iADLs, and mobility limitations at the two-year later stage. Exploring the nature of these effects, we reach the conclusion that the additional development of problems with ADLs, iADLs, and mobility limitations explain almost half of the effect of obesity on future care use and about quarter of the effect of physical activity. This is in line with the medical literature (Mullen et al. 2012) emphasizing protective effect of physical activity against functional limitations. Although we find a significant 'direct' effect of obesity, we cannot rule out that this might be impact on the need for care via some unobserved factor ($\frac{\partial Z_{it-1}}{\partial W_{it-1}} > 0$). Nonetheless, we have included factors for the most theoretically likely factors and taken some steps to address omitted varaibles.

In terms of the policy implications, we would argue that the 'direct' effects of obesity or physical activity is more likely to be influenced by the care system and local public policy. The indirect effects of obesity – especially as they work through impairment and chronic disease – fall more under the remit of the health service.

There are a number of limitations. First, there are different forms of long-term care and effects might be different. Accordingly, we assessd the relationship between obesity and different forms of long-term care, including formal and informal care. Second, there may be unobserved control factors that are associated with, but not caused by obesity. Certain (pre-existing) conditions might cause obesity and also the disabilities that give rise to a long-term care need. Possible examples might be: vitamin D deficiency or psychological factors such a self-confidence/independence and willingness to cope. Where the analysis does not control for these pre-existing conditions, the observed impact of obesity on long-term care need might be somewhat biased. Using lagged obesity and physical activity measures should help to mitigate (short-term) endogeneity issues. However, our test for the differences between the results with and without accounting for the unobserved factors reveals that the coefficients of interest are not affected.

As regards the size of the direct effect of obesity, our main specification suggested that obese people are 25% more likely to use care. At the same time those who engage in physical activity are 38% less likely to use care. These effect sizes concern the additional effect of obesity and physical activity, after controlling for a range of health conditions that might themselves be caused or exacerbated, to some degree, by obesity or poor physical activity. The total effects are likely to be larger. Moreover, we have established the close association between long-term conditions and obesity (or physical activity) and the need for long-term care.

Applying our estimates of the impact of obesity on future care use to the quoted earlier value of informal care of £55 billion in 2011 we find that the overall value of informal care linked to past obesity is around £3.9 billion per year, and that the increase in this cost which purely attributable to the upward trend in obesity is a almost £200 million per year. From an economic perspective, these numbers suggest that we could have invested up to these amounts to tackle obesity issues among elderly. Both of these figures when compared to the ring-fenced Public Health Budget (£3.4 billion in 2015-16) suggest a considerable underinvestment in measures addressing obesity epidemics from the societal perspective.

This study indicates the importance of obesity for future care costs and provides a rationale for promoting healthier weight for economic benefits, not only in relation to health care but also long-term care.

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TABLES AND FIGURES

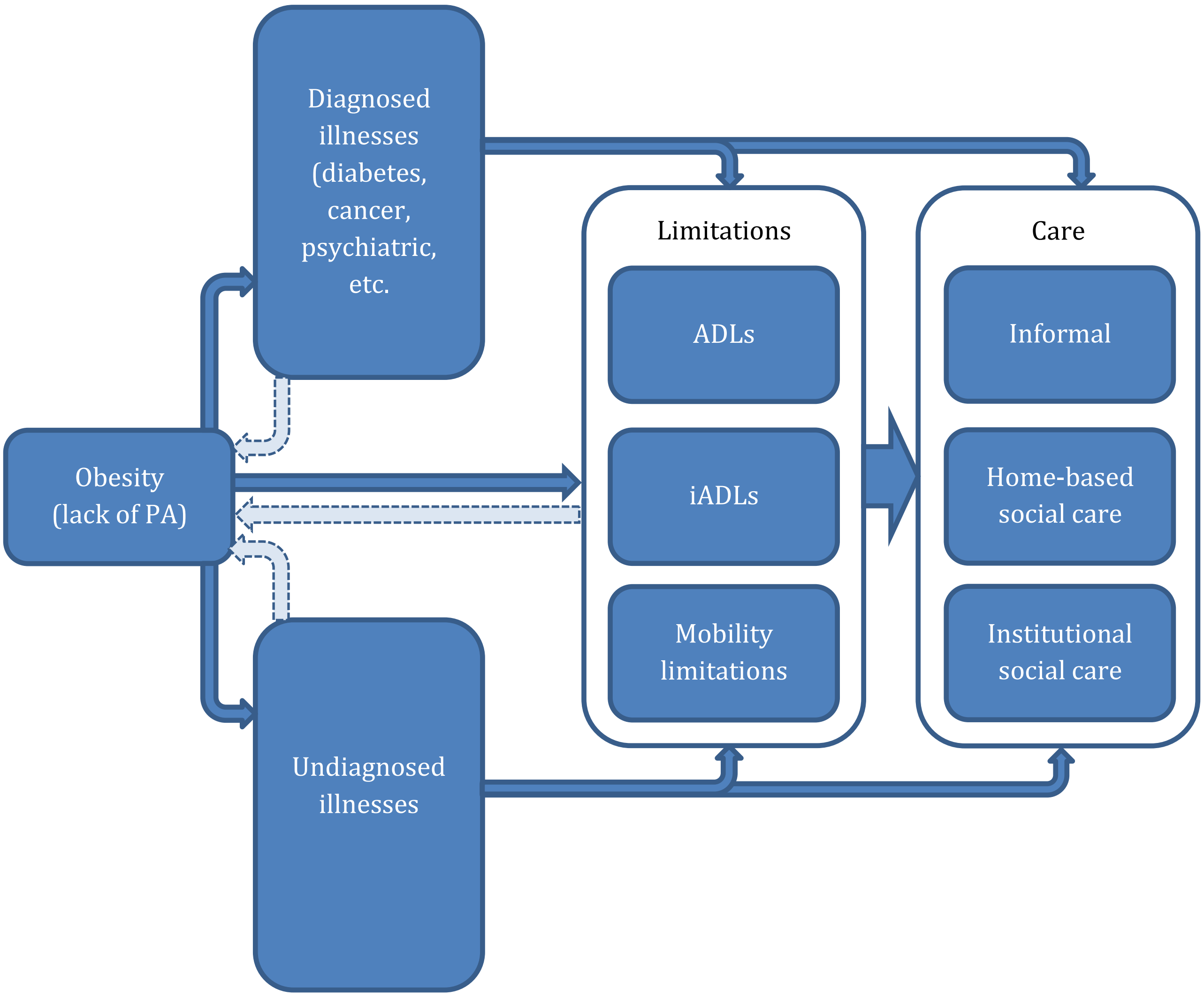

Figure 1 : Pathways of impact of obesity on future use of care.

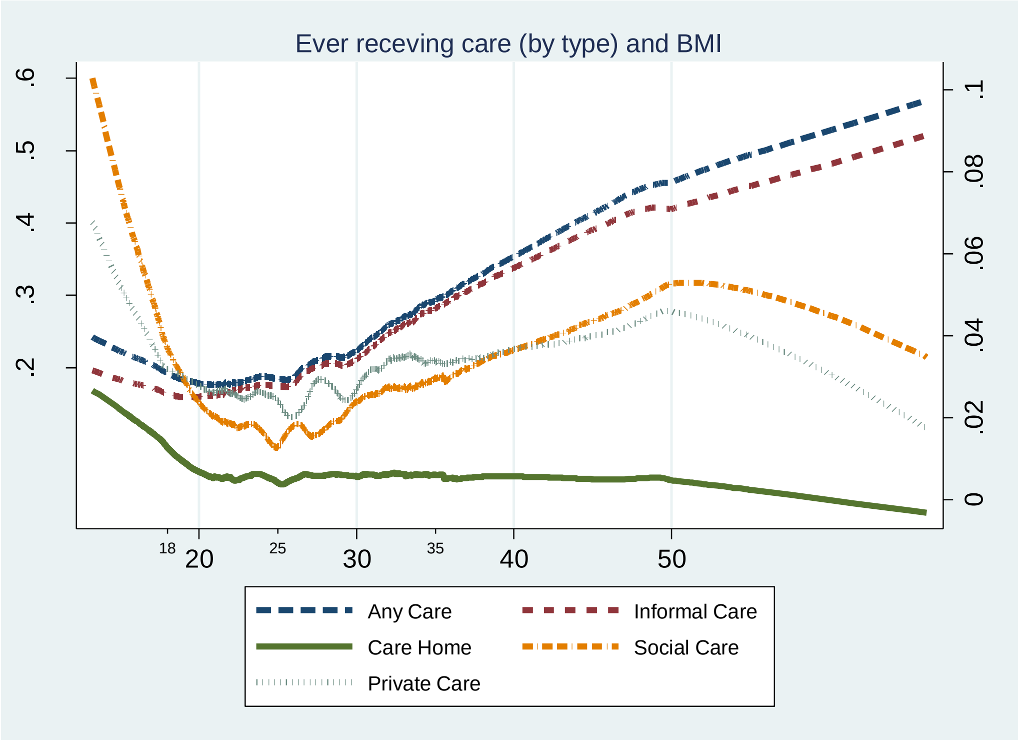

Figure 2 : Non-parametric relationship between care use and BMI 2 years ago.
Note: Any Care and Informal Care are on the scale of the left-hand y-axis, Care Home, Social Care and Private Care are on the scale of the right-hand y-axis.

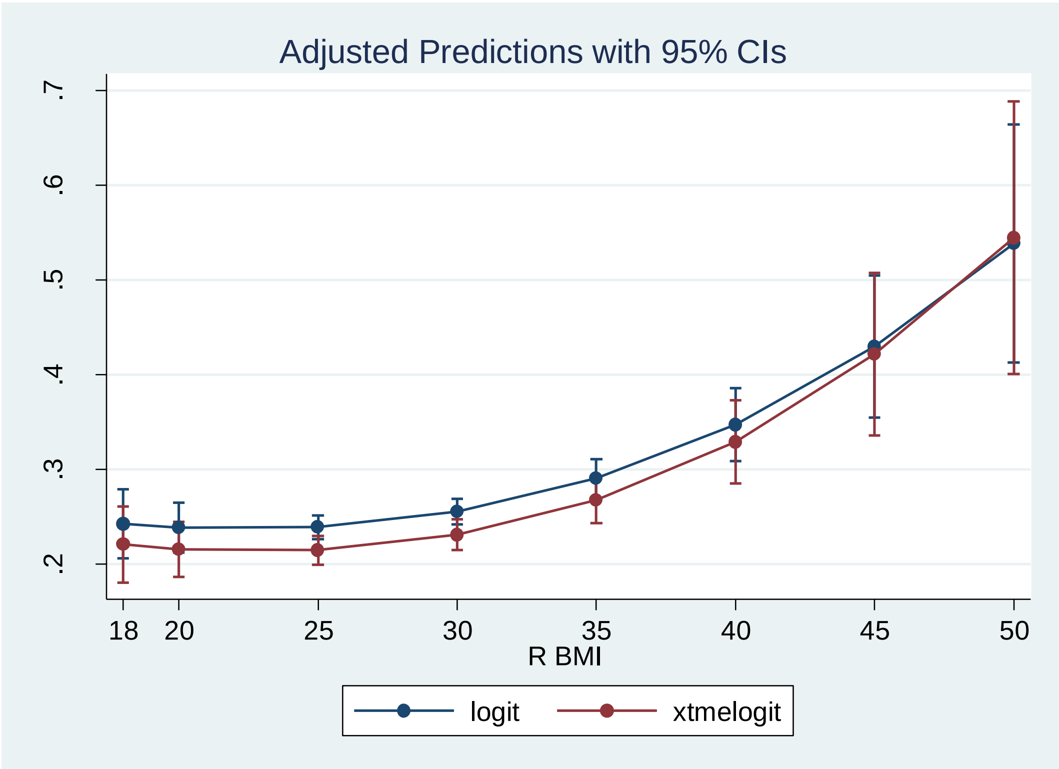

Figure 3 : Predicted probability of future care use from the model with and without unobserved effects.

Table 1: Wave Correspondence of Questions/ Responses on Care Incidence.

Variable	Questions in waves 1-2	Questions in waves 3-5
	(1)	(2)
Any care received = 1 if "yes" to at least one of the Qs	1. Individual outcome code (if in institution) 2. "Thinking about the activities that you have problems with, does anyone ever help you with these activities (including your partner or other people in your household)?"	1. Individual outcome code (if in institution) 2."Functioning: whether ever has help with mobility, ADL, IADL"
	"Who helps you with these activities?".	"Whether receives help moving around house (wash/dress, preparing meal/eating, etc.) from.." asked individually
Informal care received	- husband/wife - mother/father - son - son-in-law - daughter - daughter-in-law - sister - brother - grandson - granddaughter - other relative - friend/neighbour - other person - unpaid volunteer	- spouse or partner - parent - son - son-in-law - daughter - daughter-in-law - sister - brother - grandson - granddaughter - other relative - friend/neighbour - other person - voluntary organisation
Formal care received	- social or health service worker	- social services/LA arranged care - nurse - other health or social services
Privately paid care	- privately paid employee	- privately arranged care
Nursing home care received	Derived from respondent's individual outcome code	Derived from respondent's individual outcome code

Table 2: Summary Statistics

	Whole sample	No care	Informal care (only)	Informal and privately paid care	Formal (care home/ LA care)	Non-response	Died
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
No of observations	12323	7041	2504	347	187	1561	683
In care home	0.01				0.10**		
Any mode of care	0.30		1.00	1.00	1.00		
Informal care	0.27		1.00	0.31+	0.56**		
Formal care	0.02				0.95**		
Privately paid care	0.04			1.00	0.09**		
Underweight	0.01	0.01**	0.01	0.02	0.02	0.01	0.03**
Overweight	0.44	0.47**	0.39**	0.38*	0.36*	0.41*	0.40*
Obese	0.27	0.24**	0.36**	0.33*	0.32	0.27	0.23**
BMI	27.73	27.41**	28.81**	28.11	28.52*	27.61	26.87**
	[4.77]	[4.28]	[5.40]	[5.51]	[6.38]	[4.88]	[5.29]
Physical Exercise	0.84	0.93***	0.72***	0.71***	0.46***	0.79***	0.55***
Alcohol Drinking	0.86	0.89***	0.81***	0.84	0.64***	0.82***	0.77***
Smoked Ever	0.63	0.62***	0.65*	0.57**	0.63	0.65*	0.72***
R Smokes Now	0.11	0.10***	0.11	0.07**	0.13	0.13**	0.16***
Female	0.55	0.51**	0.64**	0.80**	0.73**	0.56	0.44**
No Educ Qualif	0.46	0.39**	0.54**	0.40*	0.59**	0.58**	0.59**
Non-white	0.01	0.01	0.01	0.01	0.01	0.03**	0.01
Age	73.87	72.37**	75.17**	78.57**	81.13**	74.20*	79.40**
	[6.91]	[5.87]	[6.99]	[6.92]	[9.22]	[7.21]	[8.74]
Married	0.57	0.59**	0.57	0.27**	0.17**	0.61**	0.45**
Number of Children	2.22	2.20*	2.42**	1.83**	1.89**	2.21	2.08*
	[1.53]	[1.45]	[1.61]	[1.48]	[1.77]	[1.59]	[1.69]
Living Alone	0.29	0.26**	0.28	0.55**	0.60**	0.27	0.40**
R Working	0.03	0.04**	0.01**	0.01*	0.00*	0.03	0.00**
Home owned	0.73	0.78**	0.68**	0.75	0.51**	0.66**	0.61**
Real per Capita Total HH Wealth 100K	149.45	177.05**	107.35**	167.42	83.09**	114.78**	107.47**
	[211.84]	[241.61]	[148.24]	[180.64]	[103.66]	[171.38]	[143.83]
Real per Capita HH Total Income 1K	10.48	11.56**	8.91**	10.37	9.28*	8.90**	9.05**
	[8.49]	[9.53]	[6.22]	[6.60]	[4.67]	[6.75]	[7.80]
ADL count	0.46	0.18**	0.94**	0.89**	1.51**	0.56**	0.95**
	[0.99]	[0.54]	[1.29]	[1.30]	[1.52]	[1.13]	[1.38]
IADL count	0.43	0.14**	0.89**	0.96**	1.45**	0.51**	1.07**
	[0.88]	[0.44]	[1.14]	[0.99]	[1.20]	[0.96]	[1.30]
Mobility limitations count	2.32	1.39**	4.00**	4.35**	5.26**	2.45*	3.75**
	[2.48]	[1.79]	[2.58]	[2.56]	[2.58]	[2.60]	[2.71]

	Whole sample	No care	Informal care (only)	Informal and privately paid care	Formal (care home/ LA care)	Non-response	Died
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High Blood Pressure	0.47	0.44**	0.54**	0.60**	0.63**	0.48	0.49
Diabetes	0.10	0.08**	0.13**	0.17**	0.14*	0.11	0.14**
Cancer	0.09	0.09**	0.09	0.11	0.12	0.08*	0.20**
Lung Disease	0.08	0.05**	0.11**	0.10	0.17**	0.08	0.16**
Heart Disease	0.26	0.20**	0.34**	0.36**	0.40**	0.27	0.40**
Stroke	0.06	0.04**	0.10**	0.11**	0.17**	0.07	0.12**
Psychic Problems	0.06	0.05**	0.07**	0.11**	0.06	0.05	0.05
Arthritis	0.42	0.34**	0.60**	0.64**	0.58**	0.41	0.43

Notes: ** indicates that the average for a specific category is statistically different from the average for the whole sample at 1% level of significance, * - at 5% level and + - at 10% level.

Table 3: Simple vs Extended Model Results

	Basic Model (Any Care)				Extended Model (Full controls)		
					IC	IC+PC	FC (NH+LA)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. All 65+ respondents (N=12,323)							
Underweight	1.78*	1.57+	1.32	1.36	1.28	1.53	1.73
	(0.42)	(0.37)	(0.35)	(0.36)	(0.36)	(0.83)	(1.02)
Overweight	0.93	0.96	0.98	0.96	0.96	0.99	1.02
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.15)	(0.20)
Obese	1.75**	1.65**	1.28**	1.25**	1.26**	1.27	1.16
	(0.12)	(0.11)	(0.09)	(0.09)	(0.10)	(0.21)	(0.26)
Physical Activity		0.20**	0.62**	0.62**	0.64**	0.73*	0.36**
		(0.01)	(0.05)	(0.05)	(0.05)	(0.11)	(0.07)
Panel B. Respondents 65+ with no care initially (N=8,770)							
Underweight	1.77+	1.66	1.41	1.44	1.42	1.16	1.90
	(0.58)	(0.54)	(0.47)	(0.49)	(0.53)	(1.09)	(2.13)
Overweight	0.99	0.99	0.97	0.93	0.92	1.20	0.68
	(0.08)	(0.08)	(0.08)	(0.08)	(0.09)	(0.27)	(0.25)
Obese	1.71**	1.65**	1.34**	1.27*	1.30*	1.32	0.80
	(0.15)	(0.14)	(0.13)	(0.12)	(0.13)	(0.34)	(0.35)
Physical Activity	1.77+	0.40**	0.65**	0.66**	0.66**	0.82	0.47*
	(0.58)	(0.04)	(0.08)	(0.08)	(0.08)	(0.23)	(0.18)
Controls:							
Health behaviours	No	Yes	Yes	Yes		Yes	
Socio-demographic _ functional limitations	No	No	Yes	Yes		Yes	
Diagnosed health conditions	No	No	No	Yes		Yes	

Table 4: Relative Risk Ratios from Multinomial Logit –Sensitivity Check with Basic Model

	Basic Model (Any Care)					
	(1)	(2)	(3)	(4)	(5)	(6)
Underweight	1.36	1.39	1.28	1.25	2.03*	1.43
	(0.36)	(0.36)	(0.34)	(0.33)	(0.63)	(0.59)
Overweight	0.96	0.96	0.97	0.97	0.95	1.06
	(0.06)	(0.06)	(0.06)	(0.07)	(0.08)	(0.12)
Obese	1.25**	1.25**	1.24**	1.24**	1.15	1.14
	(0.09)	(0.09)	(0.09)	(0.09)	(0.11)	(0.15)
Physical Activity	0.62**	0.62**	0.65**	0.65**	0.74**	0.62**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.08)	(0.05)
Added/excluded controls						
Full controls for health and health behaviours	Yes	No alcohol	Yes	Yes	Yes	Yes
Self-rated health good or better			0.60**	0.59**		
			(0.04)	(0.04)		
CESD score				1.00		
				(0.02)		
Concurrent characteristics						
N ADLs					1.08	
					(0.07)	
N iADLs					4.09**	
					(0.31)	
N of mobility limitations					1.41**	
					(0.03)	
Underweight *N(comorbidities)						0.98
						(0.25)
Overweight *N(comorbidities)						0.94
						(0.05)
Obese *N(comorbidities)						1.04
						(0.06)

Table 5: Estimates of the future costs of obesity epidemics in terms of the value of informal care

		2009	2011	2013
1	Total population, 000	52,640	53,110	53,870
2	% 65 plus	16.27%	16.44%	17.27%
3	Population 65 plus, 000	8,565	8,731	9,303
4	% obese among 65 plus, no care use	20.78%	22.45%	24.12%
5	Obese population 65 plus, no care use (N_{01}^{t-1})	1,779,917	1,960,386	2,244,194
6	Excess number of informal care users due to obesity, as compared to previous period		136,671	150,528
7	Informal care users 65 plus (2009)	1,875,970	7.29%	8.02%
8	Value of informal care per year, 000 GBP	53,300,000		
9	Average annual value of informal care per care user, GBP	28410		
10	Value of informal care per year linked to past obesity, 000 GBP		£3,882,813	£4,276,497
11	Value of informal care linked to past obesity, % of total		7.28%	8.02%
12	Annual increase in value of informal care per year linked to obesity epidemic, 000 GBP			£393,684
13	Annual increase in value of informal care per year linked to obesity epidemic, % total			0.74%

Appendix

Table A1: Relative Risk Ratios from Multinomial Logit – No controls, Parital controls A

	No controls			Partial controls A		
	Any care	Non-response	Died	Any care	Non-response	Died
	(1)	(2)	(3)	(4)	(5)	(6)
Underweight	1.78*	1.37	3.05**	1.57+	1.21	2.45**
	(0.42)	-0.41	-0.87	-0.37	-0.37	-0.73
Overweight	0.93	0.82**	0.68**	0.96	0.85*	0.73**
	(0.06)	-0.06	-0.06	-0.06	-0.06	-0.07
Obese	**1.75****	1.13	0.80*	**1.65****	1.1	0.75*
	(0.12)	-0.09	-0.09	-0.11	-0.09	-0.09
Physical Activity				**0.20****	0.31**	0.10**
				-0.01	-0.02	-0.01
Drink				0.53**	0.57**	0.48**
				-0.04	-0.05	-0.05
Smoked ever				1.11+	1.15*	1.59**
				-0.06	-0.07	-0.15
Smoke now				0.87	1.02	1.01
				-0.08	-0.1	-0.13
Wave=2	0.57**	0.47**	0.40**	0.60**	0.49**	0.43**
	-0.03	-0.03	-0.04	-0.03	-0.03	-0.05
Wave=4	0.53**	0.25**	0.42**	0.55**	0.26**	0.45**
	-0.03	-0.02	-0.04	-0.03	-0.02	-0.05
Observations		12,323			12,323	
Pseudo R2		0.0267			0.0737	

Notes: All regressions include time dummies, and standard errors are clustered at individual level. ** indicates significance at 1% level, * - at 5% level and + - at 10% level.

Table A2: Relative Risk Ratios from Multinomial Logit – Partial controls B, Full controls

	Partial controls B			Full controls		
	Any care	Non-response	Died	Any care	Non-response	Died
	(1)	(2)	(3)	(4)	(5)	(6)
Underweight	1.32	1.2	2.50**	1.36	1.18	2.33*
	-0.35	-0.38	-0.82	-0.36	-0.38	-0.78
Overweight	0.98	0.84*	0.77*	0.96	0.83*	0.77*
	-0.06	-0.06	-0.08	-0.06	-0.06	-0.08
Obese	**1.28****	0.94	0.79+	**1.25****	0.93	0.79+
	-0.09	-0.08	-0.1	-0.09	-0.08	-0.1
Physical Activity	**0.62****	0.57**	0.34**	**0.62****	0.58**	0.35**
	-0.05	-0.05	-0.04	-0.05	-0.05	-0.04
Drink	0.84*	0.75**	0.67**	0.86*	0.76**	0.70**
	-0.06	-0.06	-0.08	-0.07	-0.07	-0.08
Smoked ever	1.06	1.1	1.26*	1.04	1.09	1.18
	-0.06	-0.08	-0.13	-0.06	-0.07	-0.12
Smoke now	0.91	0.98	1.40*	0.93	0.99	1.42*
	-0.08	-0.1	-0.2	-0.09	-0.1	-0.2
Female	1.42**	1.15*	0.51**	1.44**	1.18*	0.55**
	-0.09	-0.08	-0.05	-0.09	-0.08	-0.06
No Educ Qualif	0.96	1.44**	1.26*	0.98	1.45**	1.30**
	-0.06	-0.1	-0.12	-0.06	-0.1	-0.13
Non-white	0.79	1.68*	0.87	0.81	1.69*	0.99
	-0.19	-0.38	-0.37	-0.19	-0.38	-0.42
Age	1.06**	1.04**	1.11**	1.06**	1.04**	1.11**
	0	-0.01	-0.01	0	-0.01	-0.01
Married	1.19*	1.43**	0.99	1.20*	1.43**	1.01
	-0.1	-0.14	-0.13	-0.1	-0.14	-0.14
Number of Children	1.04*	0.98	0.97	1.03+	0.98	0.96
	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03
Living Alone	0.76**	0.78*	0.81	0.75**	0.77*	0.81
	-0.07	-0.08	-0.11	-0.07	-0.08	-0.11
Working	0.67+	1.29	0.45	0.72	1.32	0.51
	-0.14	-0.23	-0.27	-0.15	-0.24	-0.31
Home owned	1.05	0.76**	0.84+	1.07	0.76**	0.82+
	-0.07	-0.06	-0.09	-0.07	-0.06	-0.09
Real per Capita Total HH Wealth 100K	1.00**	1.00*	1.00	1.00	1.00+	1.00
	0.00	0.00	0.00	0.00	0.00	0.00
Real per Capita HH Total Income 1K	1.00*	1.00+	1.00+	1	1.00*	1.00+
	0.00	0.00	0.00	0.00	0.00	0.00
ADL Count	1.15**	1.26**	1.14*	1.15**	1.26**	1.14*
	-0.05	-0.06	-0.06	-0.05	-0.06	-0.06
IADL Count	1.79**	1.62**	1.95**	1.76**	1.60**	1.89**
	-0.09	-0.08	-0.12	-0.09	-0.08	-0.11
Mobility limitations count	1.38**	1.08**	1.24**	1.32**	1.06**	1.20**
	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03

	Partial controls B			Full controls		
	Any care	Non-response	Died	Any care	Non-response	Died
	(1)	(2)	(3)	(4)	(5)	(6)
High blood pressure				1.12*	1.06	1.07
				-0.06	-0.07	-0.1
Diabetes				1.15	1.05	1.30+
				-0.10	-0.11	-0.18
Cancer				1.04	1.01	2.82**
				-0.09	-0.11	-0.35
Lung				1.31*	1.15	1.75**
				-0.14	-0.14	-0.26
Heart				1.30**	1.24**	1.64**
				-0.08	-0.09	-0.16
Stroke				1.44**	1.28+	1.35+
				-0.17	-0.17	-0.22
Psychiatric				1.23+	1.03	0.97
				-0.15	-0.15	-0.21
Arthritis				1.41**	1.07	0.93
				-0.08	-0.07	-0.09
Wave=2	1.83**	3.38**	2.23**	1.98**	3.46**	2.50**
	-0.12	-0.29	-0.26	-0.13	-0.3	-0.3
Wave=4	0.93	1.65**	0.85	0.95	1.66**	0.9
	-0.06	-0.15	-0.11	-0.07	-0.15	-0.12
Observations		12,323			12,323	
Pseudo R2		0.1786			0.1841	

Notes: All regressions include time dummies, and standard errors are clustered at individual level. ** indicates significance at 1% level, * - at 5% level and + - at 10% level.