

# **Pro-environmental behaviours and attitudes are associated with health, wellbeing and life satisfaction in multiple occupancy households in the UK Household Longitudinal Study**

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# **Pro-environmental behaviours and attitudes are associated with health, wellbeing and life satisfaction in multiple occupancy households in the UK Household Longitudinal Study**

## **Abstract**

Pro-environmental behaviours (PEBs) and attitudes (PEAs) may influence different domains of health and wellbeing through several mechanisms. The household plays an important role in this relationship, however, there is no previous research on household level PEBs, or the PEAs of other household members in relation to health and wellbeing. We used data from 22,427 people in 9,344 multiple occupancy households in the UK Household Longitudinal Study. Explanatory variables were household level PEBs, individual PEAs and PEAs of other household members. We used five common physical and mental health and wellbeing outcome measures. Household PEBs were associated with higher life satisfaction. Individual PEAs were associated with lower life satisfaction and worse mental health. PEAs of other household members were associated with higher physical health, mental health and life satisfaction scores for all outcome measures. Findings suggest that ‘greener’ households can produce a ‘win-win’ result for the environment and public health.

Keywords: environment; behaviour; attitudes; household; health.

## **Introduction**

There is evidence from recent studies to suggest that pro-environmental behaviours (PEBs) such as recycling or minimising energy consumption are positively associated with wellbeing and life satisfaction, irrespective of whether they lead to positive changes to the environment (Verhofstadt et al. 2016; Schmitt et al. 2018). There is also evidence to suggest that the attitudes people hold towards the environment and perceptions of the influence that humans have on the environment are related to wellbeing and life satisfaction (Capaldi et al. 2014). However, studies have found differential associations between pro-environmental attitudes (PEAs) and wellbeing. PEAs that represent an enhanced connection to nature have been shown to be positively associated with wellbeing (Capaldi et al. 2014). However, concepts including ‘climate grief’ and ‘ecological grief’ have recently been used to describe potential negative associations between PEAs and wellbeing brought about by emotional responses to fear, recognition or actual experiences of climate change (Cunsolo and Ellis 2018; Cunsolo and Landman 2017).

Few studies examining the relationships between PEB/As and wellbeing have distinguished between hedonic and eudaimonic wellbeing (Venhoeven et al. 2013). Hedonic wellbeing is related to physical and emotional concepts such as pleasure attainment and pain avoidance, whereas eudaimonic wellbeing is related to feelings of virtue and meaningfulness and more conceptually close to aspects of mental health (Bošković and Šendula Jengić 2008). Evidence of positive associations between PEBs and wellbeing may be explained by increased eudaimonic wellbeing resulting from doing something meaningful or moral. However, Venhoeven et al. (2013) describe how PEBs could potentially be negatively associated with hedonic wellbeing as they often require effort and can be difficult or aggravating. In a similar way, PEAs that represent virtuous or meaningful attitudes may be related to eudaimonic wellbeing, whereas PEAs that

represent perceptions of the influence that humans have on the environment may elicit negative emotions related to hedonic wellbeing, such as anxiety or grief (Cunsolo and Landman 2017). Previous studies have most frequently used single item measures of wellbeing that do not distinguish between hedonic and eudaimonic wellbeing, or measures of overall life satisfaction, which are conceptually closer to eudaimonic wellbeing (Diener and Biswas-Diener 2011). More detailed and conceptually distinct measures of physical and mental health and wellbeing may help to establish whether PEB/As are similarly or differentially associated with outcomes related to hedonic wellbeing (e.g. physical and mental quality of life, self-rated health) or outcomes related to eudaimonic wellbeing (e.g. mental health or life satisfaction). Furthermore, both hedonic and eudaimonic wellbeing are known to be associated with physical and mental health outcomes (Ryff and Boylan 2016), but previous studies have not examined whether associations between PEB/As and wellbeing also translate into commonly used measures of physical and mental health and wellbeing.

Previous research on PEBs has been dominated by a focus on the role of either the macro level (e.g. institutions or nations) or the micro level (individual people) and on relationships between behaviours at these levels and individual wellbeing. Research on PEAs has focussed almost exclusively on individuals at the micro level. Reid et al. (2010) argue that the household represents a meso level that has been neglected in research on PEB/As. This is because household members cannot be reduced to individual actors when they live in the same household and have shared resources and approaches to everyday living within the same house. PEBs such as sustainable energy use involve decisions that must be made at the household level. For example, a decision to install solar panels results in a change to the characteristics of the household, rather than the individuals living within it. Similarly, household recycling behaviour is usually a

collective decision as refuse is collected from households rather than individuals. Furthermore, individual PEBs can be different inside and outside the home. For example, an individual may recycle bottles at home as part of a collective household decision, but not in the workplace (Whitmarsh et al. 2018). Previous studies have been limited by measuring PEB/As only at the individual level, and therefore have sometimes conflated pro-environmental characteristics of households with PEBs of individuals (Toole et al. 2016).

In the following sections we first review the evidence on the relationships between PEBs and wellbeing and suggest how household level PEBs may be related to conceptually different measures of physical and mental health and wellbeing. Secondly, we review the evidence on PEAs and wellbeing and suggest how PEAs may be related differentially to measures of physical and mental health and wellbeing. We also suggest how the PEAs of other household members may influence physical and mental health and wellbeing outcomes.

### *Pro-environmental behaviours and physical and mental health and wellbeing*

Evidence from studies across several nations have identified a consistent positive association between PEBs and wellbeing or life satisfaction (Kasser 2017). For example, Schmitt et al. (2018) found in a Canadian sample that 37 out of 39 PEBs were positively associated with life satisfaction. Similarly, Binder and Blankenberg (2017) found that in a large representative sample of UK residents, PEBs including purchasing recycled items and switching off lights in rooms that aren't being used were positively associated with life satisfaction. Kasser (2017) reviewed 13 studies finding a consistent positive associations between PEBs and wellbeing or life satisfaction and suggested three possible explanations for these associations: i) PEBs may provide a direction and purpose to behaviour, fulfilling psychological needs satisfaction, and therefore leading to feelings of wellbeing and satisfactions with life; ii) the causal direction of the relationship may be opposite,

such that feelings of wellbeing and satisfaction lead people to engage in more PEBs; iii) confounding factors such as mindfulness or intrinsic values cause both PEBs and feelings of wellbeing and satisfaction.

There is insufficient evidence from current studies to rule out the explanations of reverse causation or confounding, however, some authors have suggested plausible mechanisms through which PEBs may be causally associated with wellbeing and life satisfaction. Venhoeven et al. (2016) proposed that PEBs are inherently moral and are therefore more likely to elicit eudaimonic wellbeing. The authors found that PEBs were associated with positive emotions and this relationship was mediated by positive self-image. Similarly, Welsch and Kühling (2018) found that PEBs were associated with a positive self-image, which subsequently led to improved wellbeing and life satisfaction outcomes.

An alternative explanation for the positive impact of PEBs on wellbeing or life satisfaction is that they can promote social interaction. Schmitt et al. (2018) found that PEBs that involved a degree of social interaction or were more easily observed by others were the strongest predictors of life satisfaction. This may suggest that exhibiting PEBs that are observed by others more easily bring about the feelings of virtue or morality that make up eudaimonic wellbeing. Conversely, it may be that the element of social interaction involved in these PEBs provides the positive emotional responses described by hedonic wellbeing. Many leisure time activities that do not induce high carbon emissions can also induce wellbeing (Druckman and Gatersleben, 2019). Indeed, PEBs may also influence hedonic wellbeing because they require an element of physical activity that may result in positive physical and mental experiences (Lapa 2015).

There is no previous research on household level PEBs in relation to physical and mental health. As described above, household level PEBs will often require some form of collective decision

making (such as a decision to recycle items) which is then followed by collective action on this decision. This process of collective decision making and collective action, especially as part of a shared routine, may bring about a sense of harmony and elicit positive emotional responses related to hedonic wellbeing (Stone and Mackie 2013). Furthermore, if PEBs contribute to positive dynamics including a sense of harmony, routine and collective action within households (especially within families), there is a substantial evidence base supporting the idea that these positive dynamics can influence mental and physical health through reduced stress and a framework for supporting health enhancing behaviours (Denham 2002). Furthermore, if participating in household PEBs such as recycling receives collective approval from household members, this may promote feelings of purpose or moral value that are related to eudaimonic wellbeing (Venhoeven et al. 2013). It is also possible that household level PEBs influence wellbeing through multiple mechanisms. Therefore, research on conceptually distinct measures of physical and mental health and wellbeing may help to establish whether household PEBs are associated similarly or differentially to outcomes related to hedonic wellbeing (e.g. physical and mental quality of life, self-rated health) or outcomes related to eudaimonic wellbeing (e.g. mental health or life satisfaction).

#### *Pro-environmental attitudes and physical and mental health and wellbeing*

Attitudes that people hold towards the environment and perceptions of the influence that humans have on the environment have been shown in multiple studies to be associated with wellbeing and life satisfaction (Capaldi et al. 2014). Capaldi et al. (2014) argue that pro-environmental attitudes, perceptions of one's influence over the natural environment and emotional feelings about the environment are expressions of a single construct: subjective connection to nature. Tam (2013) demonstrated empirically that pro-environmental attitudes, including commitment to

environmental issues, perceptions of one's individual connection to the environment, and perceptions about the role humans play in environmental sustainability are strongly correlated and part of this same construct. A meta-analysis of 30 studies by Capaldi et al. (2014) found that subjective connection to nature, often expressed through positive attitudes towards the environment, is associated with subjective wellbeing. The overall effect size in this study was small, but the strongest relationships were found between nature connectedness and positive affect, vitality, and life satisfaction.

In a study of a large UK sample, using the UK Household Longitudinal Study, Binder and Blankenberg (2017) found that a positive environmental self-image was a better predictor of life satisfaction than pro-environmental behaviours. These findings are helpful in explaining the relationship between PEAs and life satisfaction, even when PEAs do not necessarily lead to PEBs. Interestingly, Binder and Blankenberg (2017) also found that expressing a desire to do more for the environment was negatively associated with life satisfaction. This suggests that pro-environmental self-image may promote life satisfaction, whereas wanting to do more has a negative impact on life satisfaction. The finding that PEAs are positively associated with life satisfaction is consistent with a study by Welsch and Kühling (2018) who found in a study of 35 countries that pro-environmental self-image was consistently associated with life satisfaction and that this association was amplified when PEAs were socially normative.

Binder and Blankenberg's (2017) finding that 'wanting to do more' is associated with reduced life satisfaction may relate to the growing literature suggesting that fear or recognition of climate change or environmental problems may elicit negative emotions (Cunsolo and Ellis 2018). This negative emotional response has variously been described as 'climate grief', 'ecological grief' and 'climate anxiety' (Cunsolo and Landman 2017). However, there is insufficient evidence from



previous studies to suggest that fear or recognition of climate change or environmental problems leads to measurable associations with mental health and wellbeing outcomes. Furthermore, it is not known whether experiencing ‘climate grief’ has an impact on mental and physical health outcomes in the same way as other experiences of grief, such as following a bereavement (Ott 2003; O’Connor 2019). If associated positively or negatively with health and wellbeing, individual PEAs may also influence relationships between household PEBs and health and wellbeing, especially if there is discordance between an individual’s attitudes and perceptions regarding climate change and the collective PEBs in the household they live in.

Households also play an important role in PEAs because a household is not only a physical unit of living, it is also socially connected unit. Households with multiple occupants are social groupings in which identities and bonds are formed and places where emotions are invested in and expressed (Gibson et al. 2011). The pro-environmental attitudes held and expressed by occupants of the same household may form a collective identity in which important beliefs and emotions are invested. The pro-environmental attitudes of the people an individual lives with may therefore be an important influence on their health, wellbeing and life satisfaction. If pro-environmental attitudes are harmonised within a household, socially normative beliefs may be reinforced and supported, potentially leading to positive impacts on eudaimonic wellbeing. Conversely, if PEAs within a household are discordant, this may be stressful for household members and impact physical and mental quality of life (Denham 2002). PEAs of other household members may therefore influence the relationship between individual PEAs and physical and mental health and wellbeing.

*Beyond measures of general wellbeing and life satisfaction.*

The focus of the previous research described above has been on the relationship between PEB/As and measures of subjective wellbeing, with most studies using a measure of life satisfaction. Life satisfaction is an important general measure of subjective wellbeing and because of known associations between life satisfaction and physical and mental health outcomes, life satisfaction is increasingly used as a key outcome measure for public policy studies (Cheung and Lucas 2014). However, we have suggested how PEB/As may relate differently to domains of wellbeing, mental health and mental and physical quality of life. There is no previous research on whether associations between PEB/As and life satisfaction translate into associations with these physical and mental health outcomes.

Life satisfaction is a subjective measure of overall life circumstances and is therefore a measure of personal judgement or acceptance of these circumstances and more closely related to eudaimonic wellbeing (Diener and Biswas-Diener, 2008). Quality of life measures and validated measures of health status are different from life satisfaction measures in that they seek to measure specific concepts in a way that individuals can be compared on the same set of criteria (Lins and Carvalho 2016). Furthermore, quality of life is known to have specific, measurable domains, of which physical quality of life and mental quality of life are the principle domains (Jenkinson 1999). These physical and mental quality of life measures are more closely conceptually related to hedonic wellbeing. It would be of value to policy makers and health planners to know if associations between PEB/As and life satisfaction are purely reflective of subjective assessment of life circumstances or whether these associations are consistent with specific and measurable quality of life domains and validated measures of mental health status. Research into the relationship between PEB/As and validated measures representing components of hedonic wellbeing (e.g. physical and mental quality of life and self-rated health) or measures related to

components of eudaimonic wellbeing (e.g. mental health or life satisfaction) would help to elucidate the mechanisms through which PEB/As influence general measures of wellbeing and life satisfaction.

Due to the limitations of datasets used in previous studies, there is no previous research distinguishing between the impact of household PEBs and the impact of individual PEAs on physical and mental health and wellbeing. Nor have previous studies examined the impact of PEAs of other household members, which may plausibly be important to health and wellbeing, given what is known about the positive impact of PEBs that involve social interaction and are motivated by social norms (Schmitt et al. 2018).

A further limitation of previous research is the substantial variation in measures of PEB/As in these studies and some inconsistency in the findings across several studies. Much of this previous research has been limited by a lack of high quality, representative data sets on both PEB/As and measures of health and wellbeing (Lenzen and Cummins 2013). With the notable exception of Binder and Blankenberg (2017), many of these previous studies are limited by their use of small unrepresentative datasets (Howell et al. 2011; Venhoeven et al. 2016). The research we present in this paper uses data from the UK Household Longitudinal Study (UKHLS), also known as ‘Understanding Society’ (University of Essex 2018). Binder and Blankenberg (2017) analysed data from the same study, but it is important to note that the research we present in this paper is different from that conducted by Binder and Blankenberg (2017) in the following ways: i) We focus on household level PEBs rather than individual level PEBs; ii) We focus on a broader set of PEAs, including perceptions of human influences on climate change; iii) In addition to life satisfaction we use four distinct measures of physical and mental health and wellbeing that may, through mechanisms we have described, be differentially associated to PEB/As.

The UKHLS provides a unique opportunity to overcome limitations of previous studies and extend previous research to examine the physical and mental health impacts of pro-environmental behaviours and attitudes for households and individuals simultaneously. The Understanding Society dataset provides the opportunity to examine measures of physical and mental health and life satisfaction in the same study to investigate the following research questions:

- 1) Are household level pro-environmental behaviours associated with occupant health, wellbeing and life satisfaction?
- 2) If such a relationship exists, is it explained by individual pro-environmental attitudes?
- 3) Are individual level pro-environmental attitudes and pro-environmental attitudes of other household members associated with occupant health, wellbeing and life satisfaction?
- 4) What proportion of the variance in outcome measures can be attributed to the individual level, household level and postcode level?

## **Materials and Methods**

### **Data Source**

The UKHLS is a longitudinal survey with a nationally representative sample of 40,000 households in the UK. The UKHLS includes multiple measures of social, psychological and environmental characteristics as well as commonly used measures of health and wellbeing, allowing interdisciplinary research. The UKHLS differs from many other panel studies because at each survey wave comparable data is collected from all individuals (aged 16 or above) living within the same household. If original sample members at the first survey wave moved address by wave 2, they would be surveyed at their new address along with all other eligible household members living at the new address. This household focus allows analyses of influences on health at the household level as well as the individual level and analyses of interrelationships between

participants within households. Detailed information on the sampling, recruitment and data collection methods used by the UKHLS are available in previous publications (Mcfall et al. 2013). The analyses in this paper are based on the UKHLS General Population Sample (GPS), a sample of households drawn randomly from stratified clustered postcode sectors in the UK. Participants (aged 16 or above) from households in the GPS provide information annually on household and individual characteristics. Responses to questions on household characteristics, including pro-environmental behaviours such as household recycling, are provided by one household member. Our analyses were restricted to the unweighted GPS, which has been shown to be broadly demographically and geographically representative of the UK population (compared to 2011 census data), though males are slightly under-represented (Petersen and Rabe 2013). We excluded single-occupancy households from the analyses as this was necessary to allow the investigation of PEAs of other household members in this sample. Data on PEB/As and health outcomes were not available at the same survey wave. We therefore selected a final sample of participants who had complete data on all PEB/As at wave 1 (2009) and health and wellbeing outcomes at wave 2 (2010), resulting in a sample of 22,427 people in 9,344 households.

## **Variables**

### *Explanatory variables (Wave 1 - 2009)*

a) *Household Pro-Environmental Behaviour:* We created a household PEB score for each household by combining items on household energy use and recycling behaviour (see table 1). These items are taken from the household interview component of the UKHLS which is completed by just one of the household members. The household energy use items represent physical characteristics of households that are pro-environmental because they reduce energy expenditure. Energy use items such as solar panels are considered household level because they represent

characteristics of households rather than individuals. The recycling behaviour items are considered household level as household recycling is usually a collective decision and refuse is collected from household rather than individuals. We generated the household PEB score by summing all items on energy use and recycling and rescaling the total to a score ranging between 0 and 1. We have not included an individual level PEB measure as individual PEBs can be different inside and outside the home. For example, an individual may recycle bottles at home, but not in the workplace (Whitmarsh et al. 2018).

*b) Individual Pro-Environmental Attitudes:* We created an individual PEA score for all individuals based on responses to eleven statements on attitudes towards environmental issues (see table 1). These statements were adapted from the New Ecological Paradigm Scale (Dunlap et al. 2000) which has been developed and revised drawing on environmentalism research since the 1970s. The statements are designed to represent generalised beliefs about the environment and to capture fundamental beliefs and attitudes towards the relationship between humans and the environment. Further information about the use of these items in the UKHLS are available elsewhere (Lynn and Longhi 2011). We combined the responses to statements into factor scores using confirmatory factor analysis (CFA). CFA is statistical method used to produce latent variables based on the correlations between measured items (Gallagher and Brown 2013). The CFA produced a latent factor score for PEAs ranging from 0 to 1 for each individual respondent (Distefano, Zhu and Mîndrilă 2009). A higher latent PEA score based on these statements represents stronger beliefs that humans can influence the balance of nature and environmental problems such as climate change (Dunlap et al. 2000). The factor loadings for each item are reported in table 1.

c) *Pro-Environmental Attitudes of other household members:* We generated the score for PEAs of other household members by taking the mean of the individual PEA scores for all other individuals living in the same household. For example, in a household containing three individuals (individual 1, 2 and 3), the score for ‘PEAs of other household members’ would be calculated separately for the three members. In this household: the score for individual 1 would be the mean PEA score of individual 2 and 3; the score for individual 2 would be the mean PEA score of individual 1 and 3, and; the score for individual 3 would be the mean PEA score of individual 1 and 2. There was a weak positive correlation between individual PEAs and PEAs of other household members (Pearson correlation coefficient 0.09,  $p < 0.001$ ).

#### *Health and Wellbeing Outcomes (Wave 2 - 2010)*

We selected five commonly used measures of health and wellbeing as outcome measures. As there is little previous research on this topic, we selected outcome measures to cover broad definitions of physical health, mental health and subjective wellbeing that are commonly used and valued by health planners, policy makers and the public. The selected measures include well validated scales representing physical and mental health and single item measures of subjective wellbeing. The outcome measures are described below, and measurement details are presented in Table 1.

a) *Life satisfaction:* Self-reported life satisfaction is an important measure of subjective wellbeing and is the most commonly used outcome measure in previous research on PEB/As in relation health and wellbeing. Subjective wellbeing is a broad overarching concept that relates to one’s cognitive and affective evaluation of their own life. Life satisfaction is a component of subjective wellbeing that assesses whether a person is happy with their life (Diener et al. 2002)

and is conceptually closer to eudaimonic wellbeing (Diener and Biswas-Diener 2011). Life satisfaction has consistently been shown to be associated with positive life outcomes including health and income, and for this reason is increasingly used as a key outcome measure for public policy studies (Cheung and Lucas 2014). We used a single item measure of life satisfaction that has been shown to perform equally as well as multiple item measures (Cheung and Lucas 2014).

b) *Self-rated health*: Subjective reports of health status are simple measures that are increasingly used by policy makers and health planners as an efficient method of identifying those with the greatest health needs (DeSalvo et al. 2006). Self-rated health has been shown to consistently and strongly predict mortality from all causes after controlling for social, demographic, biological and behavioural characteristics (Mavaddat et al. 2014). It is thought that this predictive power is an indicator of underlying disease, awareness of symptoms, or characteristics that may influence future health outcomes (Mavaddat et al. 2014). We used a 5-point Likert scale to measure self-rated health, dichotomised as '*excellent/very good*' vs '*good/fair/poor*';

c) *Mental health*: We measured mental health using the 12-item version of the General Health Questionnaire (Goldberg 1997). The General Health Questionnaire is one of the most commonly used measures of mental health status and has been shown to be valid and reliable in a variety of populations in both clinical and community settings worldwide (Jackson 2007). The questionnaire includes 12 items designed to measure mental health problems, and their severity in the preceding four weeks. Items include questions about negative mental health experiences such as '*have you felt constantly under strain?*' and questions about positive mental health experiences such as '*all things considered have you been feeling reasonably happy?*'. All items have Likert scale responses (*less than usual / no more than usual / rather more than usual / much more than usual*)



which are scored 0 to 3 for negative items and the reverse for positive items, resulting in a 36 point scale (Goldberg 1997).

d) *Physical Quality of Life*: Participant reported quality of life is recognised as an important measure of how people feel in relation to a variety of health conditions, symptoms and diseases (Carr and Higginson 2001). Subjective physical quality of life has become a standard outcome measure in healthcare and community settings (Lam 2010) and patients often find that quality of life measures relate more to their experience than narrow physical and biological markers of health (Matcham et al. 2014). For policy makers, quality of life measures are valued as they can be used to demonstrate the value of health interventions beyond clinical outcomes (Contopoulos-Ioannidis et al. 2009). The 12-item Short Form Health Survey is one of the most common quality of life measures and has been used in over 9000 studies (Lins and Carvalho 2016). The physical component summary of the survey (Jenkinson et al. 1999) covers items including physical functioning, pain, discomfort, and general health giving a total score ranging from 0 (for worse health) to 100 (best possible health as measured by the questionnaire).

e) *Mental Quality of Life*: Health related quality of life is multidimensional with many studies demonstrating that there is a mental component of quality of life that is distinct from physical quality of life (Jenkinson et al. 1999). Mental quality of life includes components such as emotional wellbeing, vitality, happiness and depression (Lam 2010). Policy makers and health planners value mental quality of life for the same reasons that physical quality of life is valued (Lins and Carvalho 2016). We used the mental component summary of the 12-item Short Form Health Survey, with items including energy, vitality, social functioning and mental health producing a score ranging from 0 to 100 (Jenkinson et al. 1999).

### Covariates

We included key individual level covariates (age, sex, social class and education) based on their known influence on health, wellbeing and pro-environmental behaviours and attitudes (see table 1 for measurement details). We also included a measure of household income on the basis that participants with better health outcomes are more likely to live in high-income households and some pro-environmental household characteristics may be influenced by income. Household size (number of occupants) was included as a covariate on the basis that the measures of household PEBs and PEAs of other household members are influenced by household size.

### **Data Analysis**

We used three level mixed effects multilevel regression models to analyse associations between PEB/As and outcomes measures. The three levels of the models were: 1) Individual; 2) Household; and, 3) Primary Sampling Unit (PSU – Postcode Sector). Multilevel linear regression models were used for all outcomes except self-rated health, where we used multilevel binary logistic regression models. In these models, the household and PSU were entered as random effects.

We first used unadjusted models to examine separately the relationships between the household PEB score, individual PEA score, other household members PEA score and each outcome measure (Model 0). To provide information to answer research question 1 (*Are household level pro-environmental behaviours associated with occupant health, wellbeing and life satisfaction?*), we used a model examining the relationship between household PEB score and outcome measures adjusted for covariates (Model 1). The household PEB variable was entered as a household level variable in the multilevel model because each individual within the same household has the same value on this variable. To answer research question 2 (*If a relationship between PEBs and outcome measures exists, is it explained by individual pro-environmental attitudes?*), we then

added to Model 1 the individual PEA score (Model 2) and the PEAs of other household members score (Model 3). Models 2 and 3 also provided information to enable us to answer research question 3 (*Are individual level pro-environmental attitudes and pro-environmental attitudes of other household members associated with occupant health, wellbeing and life satisfaction?*). The ‘pro-environmental attitudes of other household members’ variable was entered as an individual level variable in the multilevel model because each individual observation in the dataset has their own value on this variable. To answer research question 4 (*What proportion of the variance in outcome measures can be attributed to the individual level, household level and postcode level?*) we calculated variance partitioning coefficients for each of the models described above. As our analyses involved five outcome measures and therefore multiple comparisons, we have reported results after applying a Bonferoni correction (Sedgwick 2012). We calculated variance inflation factors (VIFs) to examine the possibility of multicollinearity among explanatory variables. The VIFs ranged from a minimum 1.01 to a maximum of 2.24, indicating that multicollinearity was not a significant problem (Thompson et al. 2017).

### **Ethical approval**

The Understanding Society study was approved by the University of Essex Ethics Committee and the National Research Ethics Service. No additional ethical approval was necessary for this secondary data analysis.

### **Results**

Descriptive statistics for explanatory and outcome variables are shown in table 2.

### **Household PEBs**

Household PEBs were associated with higher life satisfaction in all models. Coefficients in all models for self-rated health, mental health, physical quality of life and mental quality of life scores were higher for increased household PEB scores, but there were no statistically significant associations between these variables (see table 3). This finding suggests, in relation to our first research question, that household PEBs are associated only with improved life satisfaction and not associated with other physical and mental health and wellbeing outcomes. This indicates that household PEBs may be more important to eudaimonic wellbeing than to measures related to hedonic wellbeing or physical and mental health. In relation to research question 2, after adjusting for individual PEAs and PEAs of other household members, the relationship between household PEBs and life satisfaction was slightly attenuated but remained significant. This suggests that the relationship between household PEBs and life satisfaction cannot be explained by individual PEAs or PEAs of other household members.

### **Individual PEAs**

In fully adjusted models, individual PEA scores were significantly associated with lower outcome scores on the life satisfaction and mental health scores. There was no evidence of an association between individual PEAs and self-rated health, physical quality of life, and mental quality of life scores (see table 3). In relation to research question 3, these findings suggest that this measure of individual PEAs, capturing generalised beliefs about the environment and beliefs and attitudes towards the relationship between humans and the environment, is associated with worse mental health and lower life satisfaction. This indicates that individual PEAs may be more important to eudaimonic wellbeing than to measures related to hedonic wellbeing or physical health.

### **PEAs of other household members**

In fully adjusted models, PEAs of other household members were significantly associated with all five health, wellbeing and life satisfaction outcomes. This suggests that individuals living in houses where, on average, other occupants have more positive environmental attitudes, have better health and wellbeing outcomes (see table 3). In relation to research question 3, this indicates that PEAs of other household members may be important to measures related to both eudaimonic and hedonic wellbeing.

### **Partitioning of variance**

The largest proportion of variance in the outcome measures was attributable to the individual level, followed by the household level (see table 3). In fully adjusted models, the proportion of variance in outcome measures attributable to the household level was largest for mental health (24.6%) and life satisfaction (23.7%) and smallest for physical quality of life (13.5%). This indicates that variance in outcomes at the household level was largest for measures related to eudaimonic wellbeing. The amount of variance in outcome measures that could be attributed to local area (postcode sector) differences was small (1-2%) in all models.

### **Sensitivity Analysis**

The finding that living in a ‘greener’ household and a household with a higher average PEA score for other members was associated with higher life satisfaction scores, but an individual’s own PEA score being associated with lower scores, is paradoxical. One explanation might be that ‘greener’ households represent PEBs in action while individual PEA scores are beliefs/attitudes which are not necessarily put into practice. Alternatively, ‘greener’ households may benefit from PEB/As of other members. To test these explanations, we ran the models for household level PEBs and individual level PEAs using single-occupancy households. In all models the difference in the

direction of associations for household PEBs and individual PEAs remained the same in the sample of single-occupancy households as in the original sample.

## **Discussion**

The first finding presented in our study is that life satisfaction is higher in ‘greener’ households. This finding was established using a measure of household pro-environmental behaviour in relation to life satisfaction, but not other outcome measures, suggesting that household PEBs are more likely to positively influence components of eudaimonic wellbeing than hedonic wellbeing. Individual pro-environmental attitudes were negatively associated with mental health and life satisfaction, which are both conceptually close to eudaimonic wellbeing. We investigated whether these associations were influenced by our sampling approach, in which we selected only multiple occupancy households, but these associations remained after sensitivity analysis using only single-occupancy households. Living with others who have more pro-environmental attitudes was associated with higher levels of health, wellbeing and life satisfaction in all five measures we used in this study, suggesting that living with household members who have pro-environmental attitudes may be positive for both eudaimonic and hedonic wellbeing

There are no previous studies on household PEBs or PEAs of other household members in relation to individual physical health, mental wellbeing and life satisfaction in a large representative sample. We therefore cannot compare the present study to others but can tentatively offer explanations for these findings. In particular, we posit several explanations for the paradoxical finding that household PEBs and PEAs of other household members are associated with positive outcomes, while individual PEAs are associated with negative outcomes. This finding may be artefactual and explained by the differences in methods of measurement at the household- and individual levels. We operationalised household PEBs using measures of more concrete and

permanent household attributes, whereas we operationalised PEAs using the level of agreement with statements pertaining to individual actions and environmental issues in general. For example, the household PEB score may not reflect concerns about the environment, but instead a proxy measure of neighbourhood social capital. If household PEB score reflects conforming to social norms in areas with greater levels of PEBs (Schmitt et al. 2018), improvement in life satisfaction may be more a reflection of this area-level social integration than a direct impact of household attributes on health and life satisfaction. However, the partitioning of variance in outcome measures indicated that only a small amount of variance in outcome measures can be attributed to postcode level differences.

This paradox may also reflect previous findings that positive self-image is vital in the relationship between PEB/As and life satisfaction. Our household PEB score included household attributes and behaviours that are largely ‘outward-facing’, therefore projecting a pro-environmental self-image, whereas our individual PEA score was a more ‘inward-facing’ measure, asking individuals to reflect on the consequences of personal actions and individual beliefs about environmental issues. Leonidou, Leonidou and Kvasova (2010), found that measures of ‘inward’ pro-environmental attitudes were associated with pro-environmental consumer behaviour and product satisfaction. However, more ‘outward’ pro-environmental attitudes led to more general pro-environmental behaviours and life satisfaction. It is likely that our measure of household PEBs is close to some measures of individual PEBs in previous studies (Venhoeven et al. 2016; Welsch and Kühling 2018) that have been found to positively impact self-image and subsequently life satisfaction.

Social norms are known to be important determinants of pro-environmental behaviour (Farrow et al. 2017). The theory of normative expectations posits that individuals are motivated to meet the

expectations of others and will therefore adhere to social norms, such as normative PEB/As, so they can avoid resentment from others (Sugden 2000). Similarly, the theory of planned behaviour states that individuals are motivated by their perception of what important others (e.g. parents, partners, friends, neighbours) think they should do (De Leeuw et al. 2015). There is some agreement in the economic and social psychology literature on PEBs that individuals are motivated to comply with social norms in order to receive anticipated psychological payoffs, such as sense of wellbeing (Farrow et al. 2017). Our findings suggest that psychological payoffs from normative pro-environmental behaviour are more likely to be associated with life satisfaction than quality of life or mental health.

Our finding that individual PEAs are negatively associated with measures of mental health and life satisfaction may be explained by negative emotions connected to concerns about the environment. The PEA measure we used was adapted from the new ecological paradigm statements, which represent generalised beliefs about the relationship between humans and the environment and the perceived seriousness of environmental problems caused by humans. This measure may capture recognition of climate change or environmental problems that elicit negative emotions (Cunsolo and Ellis 2018). Smyth, Mishra and Qian (2008) found a belief that environmental protection is important, on its own, is not associated with subjective wellbeing. But, in the presence of a high sense of collectivism these pro-environmental beliefs were associated with lower subjective wellbeing. This suggests that our measure of PEAs implies a greater concern for the environment and those affected by harm to the environment, and that this concern elicits negative emotions.

The finding that PEAs of other household members are consistently associated with higher health and wellbeing scores is novel, so cannot be compared to previous studies. The paradox of the positive outcomes for PEAs of other household members and negative outcomes for individual



PEAs leads us to search for potential explanations that can be applied to households, but not individuals. It is possible that our findings are reflective of the importance of harmony to health and wellbeing within households. Households with the highest average PEAs of other household members are likely to include some individuals who share the same positive attitudes towards the environment, suggesting that it may be the concordance of attitudes, a component of social capital, which is important to health and wellbeing (Giordano et al. 2013). An individual with positive PEAs, who lives in a household with low average PEA scores is likely to experience a lack of harmony and social capital within the household, which may result in poorer health and wellbeing outcomes.

The strengths of this study are in the use of a large nationally representative dataset that allowed us to examine PEB/As in relation to five different measures of health, wellbeing and life satisfaction. Furthermore, the Understanding Society dataset provided the opportunity to study, for the first time, the role of household level environmental attributes and the impact of pro-environmental attitudes of household members on health, wellbeing and life satisfaction. A limitation of this study is that we were unable to track all households between waves in the analysis. This is because the longitudinal survey design of the UKHLS dictates that individuals are followed to new addresses between waves and household composition may therefore vary between waves (Mcfall et al. 2013). This design prevented us from examining the influence on health outcomes of longitudinal changes in household PEBs or the PEAs of other household members. This inability to track households over time means that we cannot make inferences with certainty about the causal direction of the relationships presented. Kaida and Kaida (2016) suggest that PEB/As may be both antecedents and consequences of subjective wellbeing. This is because psychosocial factors closely related to health and wellbeing (e.g. social capital,

collectivism) may be prerequisites for achieving desirable pro-environmental behaviours, while sustained PEB/As are predictive of future health and wellbeing outcomes.

Future research in this area is required to unpack some of these psychosocial factors in relation to sustained health and wellbeing (Poškus 2018). This could involve testing commonly used models of health behaviour in relation to health and wellbeing outcomes. For example, the theory of planned behaviour and emanating from it the model of goal directed behaviours (Esposito et al. 2016) are frequently used in relation to health behaviours (healthy eating and physical activity) and may be helpful in explaining the discordance between pro-environmental attitudes and pro-environmental behaviours for individuals and within households, especially in relation to their opposing relationships with health and wellbeing outcomes.

## **Conclusions**

Our findings suggest that household level pro-environmental behaviours and pro-environmental attitudes of other household members produce a ‘win-win’ result for the environment and public health. For the first time, we have presented evidence that households with higher PEBs are more satisfied with life and that people living with those who have pro-environmental attitudes are healthier and happier on different measures of physical and mental health and wellbeing. Our findings suggest that the household level is an important target for policies and interventions to most effectively promote PEB/As and elicit subsequent improvements in health and wellbeing. This evidence provides further weight to arguments for cross-disciplinary action on Sustainable Development Goals relating to health and wellbeing, climate change, affordable and clean energy, and sustainable cities and communities.

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| Variable Role | Construct                               | Measurement  |
|---------------|---|--|
| Outcome       | Life satisfaction                       | 7-point Likert scale (from ‘ <i>completely dissatisfied</i> ’ to ‘ <i>completely satisfied</i> ’).   |
| Outcome       | Self-rated health                       | 5-point Likert scale, dichotomised as ‘ <i>excellent/very good</i> ’ vs ‘ <i>good/fair/poor</i> ’.   |
| Outcome       | Mental Health                           | 12-item version of the General Health Questionnaire (GHQ-12), coded as a continuous 36-point scale.  |
| Outcome       | Physical Quality of Life                | Physical Component Summary of the 12-item Short Form Health Survey (SF-12 PCS), giving a score ranging from 0 (for worse health) to 100 (best possible health as measured by the questionnaire).   |
| Outcome       | Mental Quality of Life                  | Mental Component Summary of the 12-item Short Form Health Survey (SF-12 MCS), giving a score ranging from 0 (for worse health) to 100 (best possible health as measured by the questionnaire).   |
| Explanatory   | Household pro-environmental behaviours. | <p>Score based on household responses to survey questions about:</p> <ol style="list-style-type: none"> <li>1) Household energy use: <ol style="list-style-type: none"> <li>a) installed solar panels for electricity</li> <li>b) installed solar water heating</li> <li>c) installed wind turbine(s) to generate electricity</li> </ol> </li> <li>2) Household recycling behaviour: <ol style="list-style-type: none"> <li>a) separating of items for recycling</li> <li>b) frequency of using bottle banks</li> <li>c) frequency of using paper recycling points</li> <li>d) frequency of using plastic bag recycling points</li> <li>e) frequency of using garden compost recycling facilities</li> </ol> </li> </ol> <p>The score was generated by summing all items on energy use and recycling and rescaling the total to a score ranging between 0 and 1.</p>   |
| Explanatory   | Individual pro-environmental attitudes. | <p>Score for all individuals based on responses to eleven statements on attitudes towards environmental issues. Responses indicating positive environmental attitudes were coded as ‘1’ and other responses coded as ‘0’. All responses were combined in factor scores using confirmatory factor analysis, and saved a latent factor score ranging from 0 to 1 for each individual respondent (Distefano, Zhu and Mîndrilă, 2009). Goodness of fit for the confirmatory factor analysis (Root Mean Square Error Of Approximation) = 0.053.</p> <ol style="list-style-type: none"> <li>1) <i>Which of these would you say best describes your current lifestyle? (I don’t really do anything that is environmentally-friendly/ I do one or two things that are environmentally-friendly vs I do quite a few things that are environmentally-friendly/ I’m environmentally-friendly in most things I do/ I’m environmentally-friendly in everything I do (Factor loading = 0.435).</i></li> <li>2) <i>Do you agree or disagree that being green is an alternative lifestyle, it’s not for the majority? (Agree strongly/ agree vs disagree/disagree strongly) (Factor loading = 0.530).</i></li> </ol> |

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- 3) *I don't believe my behaviour and everyday lifestyle contribute to climate change (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.367).*
  - 4) *I would be prepared to pay more for environmentally friendly products (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.512).*
  - 5) *If things continue on their current course, we will soon experience a major environmental disaster (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.557).*
  - 6) *The so-called 'environmental crisis' facing humanity has been greatly exaggerated (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.677).*
  - 7) *Climate change is beyond control – it's too late to do anything about it (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.602).*
  - 8) *The effects of climate change are too far in the future to really worry me (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.804).*
  - 9) *Any changes I make to help the environment need to fit in with my lifestyle (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.470).*
  - 10) *It's not worth me doing things to help the environment if others don't do the same (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.857).*
  - 11) *It's not worth Britain trying to combat climate change, because other countries will just cancel out what we do (Yes, I believe this vs No, I do not believe this) (Factor loading = 0.879).*
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|             |  |   |
|-------------|--|---|
| Explanatory | Household pro-environmental attitudes. | The mean 'individual pro-environmental attitudes' score for all other individuals living in the same household.                     |
| Covariate   | Age                                    | Age in years (continuous).  |
| Covariate   | Sex                                    | Male / Female.  |
| Covariate   | Social economic classification         | National Statistics Socio-Economic Classification (NS-SEC: Three categories: professional, intermediate and routine occupations).   |
| Covariate   | Education                              | Highest level of educational qualification: Four categories (Degree or other higher qualification; 'A' level; GCSE; None or other). |
| Covariate   | Household Income                       | Two categories: top 20% (high-income households) vs other.  |
| Covariate   | Household size                         | Number of occupants.  |

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**Table 2:** Descriptive statistics for explanatory and outcome variables

| Explanatory variables        | Total  |       |
|------------------------------|--------|-------|
|                              | Mean   | SD    |
| Household PEBs               | 0.31   | 0.20  |
| Individual PEAs              | 0.41   | 0.36  |
| Other Household Members PEAs | 0.41   | 0.29  |
| Outcome variables            |        |       |
| Life Satisfaction            | 5.22   | 1.47  |
| Self-Rated Health (% good)   | 50.27% |       |
| Mental Health                | 11.20  | 5.51  |
| Physical Quality of Life     | 49.42  | 11.36 |
| Mental Quality of Life       | 49.98  | 9.58  |

**Table 3:** Associations between Household PEBs, Household and Individual PEAs and health and wellbeing outcomes.

|                                    | Life-satisfaction |       |          |       |          |       |          |       |          |       |          |       |
|------------------------------------|-------------------|-------|----------|-------|----------|-------|----------|-------|----------|-------|----------|-------|
|                                    | Model 0           |       |          |       | Model 1  |       | Model 2  |       | Model 3  |       |          |       |
|                                    | Coeff             | SE    | Coeff    | SE    | Coeff    | SE    | Coeff    | SE    | Coeff    | SE    |          |       |
| Household PEBs                     | 0.139**           | 0.053 |          |       |          |       | 0.127**  | 0.053 | 0.123*   | 0.053 | 0.125*   | 0.052 |
| Individual PEAs                    |                   |       | -0.101** | 0.042 |          |       |          |       | -0.109** | 0.042 | -0.980*  | 0.042 |
| Other Household Members PEAs       |                   |       |          |       | 0.289*** | 0.032 |          |       |          |       | 0.251*** | 0.035 |
| Age                                |                   |       |          |       |          |       | 0.006*** | 0.001 | 0.006*** | 0.001 | 0.006*** | 0.001 |
| Sex - Female (reference)           |                   |       |          |       |          |       |          |       |          |       |          |       |
| Sex - Male                         |                   |       |          |       |          |       | -0.027   | 0.018 | -0.027   | 0.019 | -0.036   | 0.018 |
| Education - None / Other (Ref)     |                   |       |          |       |          |       |          |       |          |       |          |       |
| GCSE                               |                   |       |          |       |          |       | 0.038    | 0.031 | 0.037    | 0.031 | 0.033    | 0.031 |
| A-level                            |                   |       |          |       |          |       | 0.101**  | 0.032 | 0.100**  | 0.032 | 0.099**  | 0.032 |
| Degree                             |                   |       |          |       |          |       | 0.152*** | 0.029 | 0.151*** | 0.029 | 0.149*** | 0.030 |
| NSSEC - Unemployed (Ref)           |                   |       |          |       |          |       |          |       |          |       |          |       |
| NSSEC - Intermediate               |                   |       |          |       |          |       | 0.001    | 0.029 | 0.001    | 0.030 | -0.002   | 0.029 |
| Managerial / professional          |                   |       |          |       |          |       | 0.054*   | 0.026 | 0.055*   | 0.026 | 0.054*   | 0.027 |
| Income - Lowest 80% (Ref)          |                   |       |          |       |          |       |          |       |          |       |          |       |
| Income - Highest 20%               |                   |       |          |       |          |       | 0.283*** | 0.029 | 0.283*** | 0.029 | 0.271*** | 0.029 |
| Household size (no of occupants)   |                   |       |          |       |          |       | 0.052*** | 0.012 | 0.052*** | 0.012 | 0.018*** | 0.129 |
| Variance Partitioning – PSU        | 1.8%              |       | 1.9%     |       | 1.8%     |       | 1.2%     |       | 1.2%     |       | 1.2%     |       |
| Variance Partitioning – Household  | 27.4%             |       | 27.4%    |       | 27.2%    |       | 24.8%    |       | 24.8%    |       | 24.6%    |       |
| Variance Partitioning – Individual | 70.8%             |       | 70.7%    |       | 71.0%    |       | 74.0%    |       | 74.0%    |       | 74.2%    |       |
| Model Fit - AIC                    | 78419.9           |       | 78425.93 |       | 78351.6  |       | 78145.02 |       | 78140.2  |       | 78089.25 |       |

Note: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ; OR = Odds Ratio; SE = Standard Error; AIC = Akaike Information Criterion.

**Table 3 (continued):** Associations between Household PEBs, Household and Individual PEAs and health and wellbeing outcomes.

|                                    | Self-Rated Health |       |          |       |          |       |          |       |          |       |          |       |
|------------------------------------|-------------------|-------|----------|-------|----------|-------|----------|-------|----------|-------|----------|-------|
|                                    | Model 0           |       |          |       |          |       | Model 1  |       | Model 2  |       | Model 3  |       |
|                                    | OR                | SE    | OR       | SE    | OR       | SE    | OR       | SE    | OR       | SE    | OR       | SE    |
| Household PEBs                     | 1.116             | 0.970 |          |       |          |       | 1.129    | 0.950 | 1.129    | 0.952 | 1.125    | 0.948 |
| Individual PEAs                    |                   |       | 0.922    | 0.065 |          |       |          |       | 0.920    | 0.064 | 0.923    | 0.063 |
| Other Household Members PEAs       |                   |       |          |       | 1.398*** | 0.074 |          |       |          |       | 1.124*   | 0.062 |
| Age                                |                   |       |          |       |          |       | 0.979*** | 0.001 | 0.980*** | 0.031 | 0.982*** | 0.001 |
| Sex - Female (reference)           |                   |       |          |       |          |       |          |       |          |       |          |       |
| Sex - Male                         |                   |       |          |       |          |       | 0.964    | 0.030 | 0.980    | 0.030 | 0.941    | 0.030 |
| Education - None / Other (Ref)     |                   |       |          |       |          |       |          |       |          |       |          |       |
| GCSE                               |                   |       |          |       |          |       | 1.366*** | 0.070 | 1.366*** | 0.070 | 1.367*** | 0.070 |
| A-level                            |                   |       |          |       |          |       | 1.600*** | 0.085 | 1.600*** | 0.084 | 1.600*** | 0.085 |
| Degree                             |                   |       |          |       |          |       | 2.124*** | 0.105 | 2.123*** | 0.105 | 2.123*** | 0.106 |
| NSSEC - Unemployed (Ref)           |                   |       |          |       |          |       |          |       |          |       |          |       |
| NSSEC - Intermediate               |                   |       |          |       |          |       | 1.322*** | 0.064 | 1.322*** | 0.064 | 1.322*** | 0.066 |
| Managerial / professional          |                   |       |          |       |          |       | 1.555*** | 0.070 | 1.555*** | 0.069 | 1.555*** | 0.071 |
| Income - Lowest 80% (Ref)          |                   |       |          |       |          |       |          |       |          |       |          |       |
| Income - Highest 20%               |                   |       |          |       |          |       | 1.414*** | 0.066 | 1.413*** | 0.066 | 1.358**  | 0.068 |
| Household size (no of occupants)   |                   |       |          |       |          |       | 1.024    | 0.125 | 1.024    | 0.019 | 1.020    | 0.020 |
| Variance Partitioning – PSU        | 2.4%              |       | 2.4%     |       | 2.4%     |       | 1.8%     |       | 1.8%     |       | 1.7%     |       |
| Variance Partitioning – Household  | 24.5%             |       | 24.5%    |       | 24.4%    |       | 18.7%    |       | 18.7%    |       | 18.4%    |       |
| Variance Partitioning – Individual | 73.1%             |       | 73.1%    |       | 73.1%    |       | 79.5%    |       | 79.5%    |       | 79.9%    |       |
| Model Fit - AIC                    | 30057.0           |       | 30057.31 |       | 30018.55 |       | 28444.1  |       | 28443.7  |       | 28430.6  |       |

Note: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ; OR = Odds Ratio; SE = Standard Error; AIC = Akaike Information Criterion.

**Table 3 (continued):** Associations between Household PEBs, Household and Individual PEAs and health and wellbeing outcomes.

|                                    | Mental Health |       |          |       |           |       |           |       |           |       |           |       |
|------------------------------------|---------------|-------|----------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|
|                                    | Model 0       |       |          |       | Model 1   |       | Model 2   |       | Model 3   |       |           |       |
|                                    | Coeff         | SE    | Coeff    | SE    | Coeff     | SE    | Coeff     | SE    | Coeff     | SE    |           |       |
| Household PEBs                     | -0.365        | 0.195 |          |       |           |       | -0.329    | 0.194 | -0.328    | 0.193 | -0.325    | 0.193 |
| Individual PEAs                    |               |       | 0.425**  | 0.157 |           |       |           |       | 0.431**   | 0.156 | 0.407**   | 0.156 |
| Other Household Members PEAs       |               |       |          |       | -0.827*** | 0.118 |           |       |           |       | -0.555*** | 0.127 |
| Age                                |               |       |          |       |           |       | -0.006*** | 0.002 | -0.006*** | 0.002 | -0.006**  | 0.002 |
| Sex - Female (reference)           |               |       |          |       |           |       |           |       |           |       |           |       |
| Sex - Male                         |               |       |          |       |           |       | -0.917*** | 0.115 | -0.918*** | 0.068 | -0.899*** | 0.068 |
| Education - None / Other (Ref)     |               |       |          |       |           |       |           |       |           |       |           |       |
| GCSE                               |               |       |          |       |           |       | -0.476*** | 0.114 | -0.473*** | 0.115 | -0.462*** | 0.114 |
| A-level                            |               |       |          |       |           |       | -0.615*** | 0.118 | -0.613*** | 0.118 | -0.612*** | 0.118 |
| Degree                             |               |       |          |       |           |       | -0.703*** | 0.109 | -0.700*** | 0.110 | -0.697*** | 0.109 |
| NSSEC - Unemployed (Ref)           |               |       |          |       |           |       |           |       |           |       |           |       |
| NSSEC - Intermediate               |               |       |          |       |           |       | -0.256*   | 0.109 | -0.256*   | 0.109 | -0.249*   | 0.109 |
| Managerial / professional          |               |       |          |       |           |       | -0.213*   | 0.099 | -0.216*   | 0.099 | -0.214*   | 0.099 |
| Income - Lowest 80% (Ref)          |               |       |          |       |           |       |           |       |           |       |           |       |
| Income - Highest 20%               |               |       |          |       |           |       | -0.599*** | 0.106 | -0.599*** | 0.107 | -0.572*** | 0.107 |
| Household size (no of occupants)   |               |       |          |       |           |       | -0.105*   | 0.044 | -0.106*   | 0.044 | -0.032    | 0.047 |
| Variance Partitioning – PSU        | 1.4%          |       | 1.4%     |       | 1.4%      |       | 1.1%      |       | 1.1%      |       | 1.1%      |       |
| Variance Partitioning – Household  | 23.9%         |       | 23.9%    |       | 23.7%     |       | 23.7%     |       | 23.8%     |       | 23.7%     |       |
| Variance Partitioning – Individual | 74.7%         |       | 74.7%    |       | 74.9%     |       | 75.2%     |       | 75.1%     |       | 75.2%     |       |
| Model Fit - AIC                    | 135696.9      |       | 135699.1 |       | 135657.2  |       | 135327.9  |       | 135322.2  |       | 135305.3  |       |

Note: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ; Coeff = Coefficient; SE = Standard Error; AIC = Akaike Information Criterion.

**Table 3 (continued):** Associations between Household PEBs, Household and Individual PEAs and health and wellbeing outcomes.

|                                    | Physical Quality of Life |       |          |       |          |       |          |       |           |       |           |       |
|------------------------------------|--------------------------|-------|----------|-------|----------|-------|----------|-------|-----------|-------|-----------|-------|
|                                    | Model 0                  |       |          |       | Model 1  |       | Model 2  |       | Model 3   |       |           |       |
|                                    | Coeff                    | SE    | Coeff    | SE    | Coeff    | SE    | Coeff    | SE    | Coeff     | SE    |           |       |
| Household PEBs                     | 0.074                    | 0.416 |          |       |          |       | 0.135    | 0.353 | 0.135     | 0.353 | 0.130     | 0.353 |
| Individual PEAs                    |                          |       | 0.159    | 0.328 |          |       |          |       | 0.047     | 0.294 | 0.040     | 0.294 |
| Other Household Members PEAs       |                          |       |          |       | 2.173*** | 0.248 |          |       |           |       | 0.635**   | 0.235 |
| Age                                |                          |       |          |       |          |       | -0.212** | 0.044 | -0.212*** | 0.044 | -0.212*** | 0.004 |
| Sex - Female (reference)           |                          |       |          |       |          |       |          |       |           |       |           |       |
| Sex - Male                         |                          |       |          |       |          |       | 0.354**  | 0.133 | 0.353**   | 0.133 | 0.329*    | 0.133 |
| Education - None / Other (Ref)     |                          |       |          |       |          |       |          |       |           |       |           |       |
| GCSE                               |                          |       |          |       |          |       | 2.865*** | 0.216 | 2.865***  | 0.216 | 2.853***  | 0.216 |
| A-level                            |                          |       |          |       |          |       | 2.845*** | 0.223 | 2.845***  | 0.222 | 2.844***  | 0.223 |
| Degree                             |                          |       |          |       |          |       | 3.457*** | 0.206 | 3.457***  | 0.206 | 3.454***  | 0.206 |
| NSSEC - Unemployed (Ref)           |                          |       |          |       |          |       |          |       |           |       |           |       |
| NSSEC - Intermediate               |                          |       |          |       |          |       | 3.127*** | 0.206 | 3.127***  | 0.206 | 3.118***  | 0.206 |
| Managerial / professional          |                          |       |          |       |          |       | 3.576*** | 0.187 | 3.576***  | 0.187 | 3.573***  | 0.187 |
| Income - Lowest 80% (Ref)          |                          |       |          |       |          |       |          |       |           |       |           |       |
| Income - Highest 20%               |                          |       |          |       |          |       | 1.772*** | 0.193 | 1.772***  | 0.193 | 1.742***  | 0.193 |
| Household size (no of occupants)   |                          |       |          |       |          |       | -0.981   | 0.079 | -0.982    | 0.079 | -0.178    | 0.085 |
| Variance Partitioning – PSU        | 2.0%                     |       | 2.0%     |       | 2.0%     |       | 1.8%     |       | 1.8%      |       | 1.8%      |       |
| Variance Partitioning – Household  | 28.7%                    |       | 28.7%    |       | 28.2%    |       | 13.6%    |       | 13.6%     |       | 13.5%     |       |
| Variance Partitioning – Individual | 69.3%                    |       | 69.3%    |       | 69.8%    |       | 84.6%    |       | 84.6%     |       | 84.7%     |       |
| Model Fit - AIC                    | 167986.0                 |       | 167991.8 |       | 167915.7 |       | 162967.3 |       | 162969.3  |       | 16296.0   |       |

Note: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ; Coeff = Coefficient; SE = Standard Error; AIC = Akaike Information Criterion.



**Table 3 (continued):** Associations between Household PEBs, Household and Individual PEAs and health and wellbeing outcomes.

| Mental Quality of Life             |          |       |          |       |          |       |          |       |          |        |          |       |
|------------------------------------|----------|-------|----------|-------|----------|-------|----------|-------|----------|--------|----------|-------|
|                                    | Model 0  |       |          |       | Model 1  |       | Model 2  |       | Model 3  |        |          |       |
|                                    | Coeff    | SE    | Coeff    | SE    | Coeff    | SE    | Coeff    | SE    | Coeff    | SE     | Coeff    | SE    |
| Household PEBs                     | 0.634    | 0.346 |          |       |          |       | 0.466    | 0.338 | 0.455    | 0.337  | 0.455    | 0.177 |
| Individual PEAs                    |          |       | -0.519   | 0.278 |          |       |          |       | -0.522   | 0.274  | -0.478   | 0.274 |
| Other Household Members PEAs       |          |       |          |       | 1.708*** | 0.208 |          |       |          |        | 1.389*** | 0.223 |
| Age                                |          |       |          |       |          |       | 0.081*** | 0.004 | 0.081*** | 0.004  | 0.081*** | 0.004 |
| Sex - Female (reference)           |          |       |          |       |          |       |          |       |          |        |          |       |
| Sex - Male                         |          |       |          |       |          |       | 1.487*** | 0.122 | 1.488*** | 0.1217 | 1.437*** | 0.122 |
| Education - None / Other (Ref)     |          |       |          |       |          |       |          |       |          |        |          |       |
| GCSE                               |          |       |          |       |          |       | 1.159*** | 0.202 | 1.155*** | 0.202  | 1.128*** | 0.201 |
| A-level                            |          |       |          |       |          |       | 1.430*** | 0.208 | 1.427*** | 0.208  | 1.424*** | 0.208 |
| Degree                             |          |       |          |       |          |       | 1.451*** | 0.193 | 1.447*** | 0.193  | 1.439*** | 0.193 |
| NSSEC - Unemployed (Ref)           |          |       |          |       |          |       |          |       |          |        |          |       |
| NSSEC - Intermediate               |          |       |          |       |          |       | 0.615**  | 0.192 | 0.615**  | 0.192  | 0.595**  | 0.192 |
| Managerial / professional          |          |       |          |       |          |       | 0.254    | 0.174 | 0.258    | 0.174  | 0.253    | 0.174 |
| Income - Lowest 80% (Ref)          |          |       |          |       |          |       |          |       |          |        |          |       |
| Income - Highest 20%               |          |       |          |       |          |       | 0.960*** | 0.186 | 0.961*** | 0.186  | 0.895*** | 0.186 |
| Household size (no of occupants)   |          |       |          |       |          |       | 0.446*** | 0.077 | 0.447*** | 0.077  | 0.264**  | 0.082 |
| Variance Partitioning – PSU        | 1.9%     |       | 1.9%     |       | 1.9%     |       | 1.1%     |       | 1.1%     |        | 1.1%     |       |
| Variance Partitioning – Household  | 23.8%    |       | 23.9%    |       | 23.6%    |       | 21.5%    |       | 21.5%    |        | 21.4%    |       |
| Variance Partitioning – Individual | 74.3%    |       | 74.2%    |       | 74.5%    |       | 77.4%    |       | 77.4%    |        | 77.5%    |       |
| Model Fit - AIC                    | 160651.6 |       | 160657.5 |       | 160594.0 |       | 160011.6 |       | 160010.0 |        | 159973.3 |       |

Note: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ ; Coeff = Coefficient; SE = Standard Error; AIC = Akaike Information Criterion.