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Abstract

There is renewed interest in the wider societal benefits of health interventions. Estimation of these effects should relate to changes in health rather than cross-sectional differences. We consider the impact of health on net State contributions, which include contributions to tax revenues and receipt of benefits. We subject cross-sectional differences in net contributions across health states to a more rigorous longitudinal analysis using the 1991-2008 British Household Panel Survey. We estimate the effects of 12 self-reported health problems on tax contributions and benefits received, controlling for several confounding factors and individual heterogeneity. We find cross-sectional differences in tax contributions and benefit receipts are substantially larger than those associated with changes in health. Changes in depression have the largest impact on net contributions. Estimates of net resource contributions should be based on longitudinal analysis to avoid overstating the wider societal benefits of health interventions.

1. INTRODUCTION

In 2010 the Department of Health (DH) in England opened a consultation on several adaptations to the way in which appraisals are conducted for health technology assessments (Department of Health, 2010). Value Based Pricing (VBP) was to replace the Pharmaceutical Pricing Regulation Scheme (PPRS) in 2014. VBP aims to improve transparency and access to medicines on the basis of a pricing system that more accurately reflects the value of medicines to society compared to the more stringent NHS and personal and social services perspective adopted in clinical and cost effectiveness analyses. Key suggestions for change included the expansion of assessment criteria beyond the current National Institute for Health and Care Excellence (NICE) technology appraisal scheme (NICE, 2013) to include a tiered threshold system reflected by the burden of illness, innovation, and the wider societal benefit (WSB) offered by interventions.

WSBs measure the effect of an intervention on an individual's production and consumption in society. Previous attempts to measure WSBs have focussed on measuring productivity gains and losses. Two approaches are typically used to measure productivity; the Human Capital (HC) and Friction Cost (FC) approaches. The HC approach values the effects of changes in health by changes in economic production, that is, income losses due to morbidity and mortality (Zhang and Anis, 2014). The FC approach instead looks at the costs of losses where a worker needs to be replaced. Both use wages as measures for marginal productivity and the use of these has been questioned (see Pauly et al. (2002) and Pauly et al. (2008)). There are many concerns about double-counting, equity, and perspective when productivity losses are incorporated (see for example, Zhang et al. (2011); Drummond et al. (2005)).

WSBs go beyond the direct clinical effectiveness for the patient and the NHS and personal and social services perspective undertaken by NICE. The initial proposal from the DH was to apply WSB supplements to the Quality Adjusted Life Year (QALY) gains associated with interventions. This approach was rejected by NICE in 2014, largely because QALY gains may be associated with negative WSBs (for example, for conditions in later life where production is likely to be lower). An alternative approach based on QALY shortfalls has been proposed (NICE, 2014). Raftery (2014) has shown how this can be seen as a loss of quality of life expectancy. This ‘shortfalls’ approach gives higher weight to older ages, thus incorporating special consideration for end-of-life treatments.

Whilst QALY shortfalls has some merit in reducing discrimination of technologies on the basis of age, it does not deal with the main rationale for including WSBs in consideration of the value of health technologies. The shortfall is measured by time until death with and without treatment and WSBs are not explicitly considered. The maintained assumption is that WSBs are proportional to the gains in health.

NICE stated that ‘[as] WSB is a consequence of the difference between consumption and production, some patient characteristics will always result in negative WSBs for patients whose condition means that they have to receive more from society than they are able to give back.’ (NICE, 2014 pg.15). They appear to have neglected to note that evaluations are based on *changes*. It is not the absolute level of consumption or production for a given health state that evaluations should assess, rather the *changes* in consumption and production that interventions generate. On the production side these changes are generally higher for younger individuals and/or those in well paid occupations, but the reverse is true for consumption where reductions are generally larger for older age groups. An intervention could still have a positive WSB effect for individuals who do not work if their use of social services is reduced.

A recent analysis commissioned by the DH to estimate WSBs set out to measure productivity losses for those in work (Ara et al., 2013). The unit of measurement for productivity loss was sickness absence days, used as a proxy for productivity losses in paid work. The report sought to estimate levels of sickness absence associated with health states measured in terms of Health Related Quality of Life (HRQoL) as an appropriate way for applicability in cost-effectiveness analyses. The work built on previous work by Krol et al. (2013) and Mukuria et al. (2013) on hospitalised respondents by using a more representative population.

Using data from the Health Outcomes Data Repository (HODaR) and Understanding Society, Ara et al estimated how sickness absence days and employment probabilities varied by HRQoL, ICD-10 chapter, age, and gender. There are several limitations to what Ara et al could achieve with the available data. First, productivity effects are only observed for those in employment –this favours technologies that benefit those of working age. Second, the use of sickness absence as a proxy for productivity has several drawbacks. The exact costs for absenteeism are not currently known due to differences in instruments and modelling (Schultz et al., 2009). In addition, productivity losses from absence may be flawed, since less prioritised work could be delayed and eventually someone will replace the absent worker. In these cases, the net societal gain is questionable (Drummond et al., 2005). Third, their approach modelled cross-sectional associations between health states and sickness absence.

In this paper we propose approaches to address each of these limitations. First, we model changes in production and consumption for a sample of individuals aged 16 years and over.

Second, our measure of production does not rely on sickness absence alone. Third, we propose a model that assesses how changes in health (rather than cross-sectional associations) are related to changes in production and consumption.

We use a longitudinal dataset, the British Household Panel Study (BHPS), which allows us to estimate how changes in a measure of WSBs are related to changes in health. We argue that this is more pertinent to the evaluation of interventions that seek to improve health or avoid deteriorations in health.

We present a possible alternative approach to measuring financial benefits by adopting the perspective of the State. We model contributions (tax paid net of benefit income received) for individuals for a range of self-reported health conditions in the BHPS. Our measure for contributions thus accounts for the consumption of State benefits and captures production via the level of taxation paid. With this approach we are estimating transfer payments related to employment in a similar vein to the approach suggested by Drummond (2005, pg.84). The State perspective is not, however, a societal perspective as taxes paid and benefit incomes received can be viewed as mere transfer payments (Drummond et al. (2005) pg.55). Nonetheless, expanding the perspective to incorporate a government budget perspective is an extension over traditional evaluation approaches, which focus on the health care payer perspective.

Taxation could be problematic in the sense that increases in tax paid may be the effect of employment for a job that may have been taken by somebody else claiming benefits. Furthermore, these may favour health technologies serving better paid occupations and those of working age. Taxation underestimates the effect of health changes on societal benefit since this ignores consumption possibilities and welfare gains from expenditure of wages of the individual. Benefits are less contentious in the sense that these are non-rival and represent public funds that could have been spent on alternative things by the State.

To our knowledge this is the first study to model State contributions using longitudinal data, and the first to model the financial impacts of health conditions on individual contributions to State finances.

2. METHODS

2.1 Data

We use the BHPS to model contributions to the State over the period 1991-2008. The BHPS was designed as an annual survey of each adult (16+) member of a nationally representative sample of more than 5,000 households (Taylor et al., 2010). Respondents are interviewed from 1st September each year (wave). The same individuals are re-interviewed in successive waves and, if they split-off from original households, all adult members of their new households are also interviewed. Children are interviewed once they reach the age of 16. Thus the sample should remain broadly representative of the population of Britain as it changes through time (Taylor et al., 2010).

To measure State contributions, we use data from the income section of the BHPS. Since contributions can be made at every age we model all ages and all types of State financial payments and taxation paid from employment.

Payments to the State are measured using income tax paid, which is calculated as the difference between gross and net usual monthly pay (variables *paygty* and *paynty*, respectively). *paygty* (*paynty*) measures monthly gross (net) payment of wage or self-employed income at 1st September of the current wave (Taylor et al., 2010, pg.252). Those with jobs starting before this period have their usual monthly wage reported. Those with jobs starting after this date had their previous job (at that date) wage reported. If gross payment is missing, this is estimated from net pay (taking into account marital status, spouse' earnings and pension membership).

To measure payments from the State, we use the derived variable *fimnb* (Taylor et al., 2010, pg.245) which measures the amount of benefit income an individual received from the State in the last month (jointly received benefits are apportioned equally unless otherwise stated). State benefits measured over the BHPS sample period include: retirement pension, widow or war widows pension, widowed mothers allowance, severe disablement allowance, industrial injury allowance, attendance allowance, invalid care allowance, war disability pension, pension credit, incapacity benefit, disability living allowance (care and mobility), income support, child benefit, working family tax credit, maternity allowance, housing benefit, council tax benefit, job seekers allowance, child tax credit, return to work credit, and other state benefit.

Our contribution measure does not represent total individual payments to the State as we only have data on income taxes/National Insurance payments. Income tax and National Insurance averaged 55% of Public Sector receipts over the period 1999-2014 while Value Added Tax was on average 19% (HMRC, 2014), and social benefits averaged 29% of Public Sector expenditure (ONS, 2014a). We deflate contributions by the annual Retail Price Index obtained from the Office of National Statistics (ONS, 2014b).

To measure the effects of different health states on contributions to the State we use information on self-reported health conditions. Respondents are asked: ‘Do you have any of the health problems or disabilities listed on this card…’. The listed conditions are: ‘anxiety, depression etc’, ‘arms, legs, hands etc’, ‘sight’, ‘hearing’, ‘skin conditions/allergy’, ‘chest/breathing’, ‘heart/blood pressure’, ‘stomach or digestion’, ‘diabetes’, ‘epilepsy’, ‘alcohol or drugs’, and ‘migraine’. An additional option, ‘other’, is also recorded and included in our analysis to control for potential confounding on the reported health problems. Cancer and stroke are listed as a health problem but not modelled here since these were only asked from wave 11 onwards.

2.2 Empirical strategy

An individual’s net contribution (C_{it}) to the State at time *t* is:

$$C_{it} = T_{it} - B_{it} \tag{1}$$

in which T_{it} is taxes paid and B_{it} is state benefits received.

We use pooled OLS to estimate the following equation:

$$C_{it} = \beta_k x_{itk} + \beta_j h_{itj} + v_{it} \tag{2}$$

Where C_{it} is monthly contribution per individual, h_{itj} are dummies for each health condition, and x_{itk} is a range of *k* covariates that may affect the amount of contributions made by individuals. These will include factors influencing whether someone is in work (and thus pays taxes) and/or claiming benefits. In order to obtain the full effect of each health condition, the variables in x_{itk} exclude those that may be affected by changes in health (such as occupation type).

x_{itk} includes dummies for age group, region of residence, qualifications, marital status, gender, and the number of children. By including age group and region dummies we obtain the effects of the health conditions conditional on age and region – in other words, the average effect of that health condition across all ages and regions. This reduces the concern of the valuation of the effects of health conditions being directed on the basis of age and region. The inclusion of qualifications may reduce the extent to which the effects of health conditions reflect the types of occupations individuals are in. An alternative approach could be to include occupation dummies, we discount this approach due to concerns that health conditions may cause changes in occupation making estimation of the direct health effect problematic.

To ensure we have reliable estimates, we need to control for potential bias in the model. The first possible source of bias occurs were there to be reverse causality between the dependent variable (contributions) and one of our independent variables. Our primary interest is in the effect of the health conditions. Reverse causality would require the health state to be caused by contributions to the State - we believe this causal pathway is unlikely. The second potential source of bias stems from unobserved heterogeneity; certain individuals may be more or less likely to contribute than others and these unobservable differences may be correlated with other independent variables. To correct for this potential source of bias, we estimate (2) using fixed-effects assuming that the unobserved component is time invariant. Use of fixed-effects also controls for any time-invariant, individual-specific measurement errors:

$$C_{it} = \beta_k x_{itk} + \beta_j h_{itj} + u_i + v_{it} \quad (3)$$

The estimates from (3) provide an indication of the effect of health conditions on contributions. To assess more directly how a technology may impact on contributions requires the modelling of the effect of different types of *changes* in health state. To model the effects of changes in health state we estimate equation (4) via fixed-effects:

$$C_{it} = \beta_k x_{itk} + \beta_l \Delta h_{itj} + u_i + v_{it} \quad (4)$$

Where Δh_{itj} includes 4 dummies for each health condition based on lagged health state and current health state (h_{it-1j}, h_{itj}) – 0,0 (remains not having the condition); 0,1 (obtains the condition this year); 1,0 (condition removed this year); and 1,1 (remains with the condition). Though for many conditions a transition off the condition is unlikely, for several this is plausible (for example, depression). In addition, this approach is one that can be easily adapted to account for changes in the intensity of a health condition (for example, changes in EQ-5D scores).

The linear relationship between contributions, tax paid, and benefits received (1) enables us to disentangle contributions into estimates of tax paid and benefits received. To do this we also model (4) with tax paid (T_{it}) and with state benefits received (B_{it}) as dependent variables.

3. RESULTS

The initial BHPS sample consists of 238,996 person-year observations. Item non-response on the covariates result in a final sample of 222,485 (93.1%) person-year observations, comprised of 30,766 individuals. Our panel is unbalanced and individuals can enter or leave the sample at any wave.

Table I provides the rates of each health condition, and average contributions, tax paid, and benefits received. The most prominent condition was ‘problems with arms, legs or hands’. The unconditional averages in Table I show average contributions in the sample of £18.27 per month, this is comprised of £115.89 taxes paid and £97.61 benefits received. The effects of health conditions on monthly contributions vary, depression reduces contributions by £167.81 per month (£31.34-(-£136.47)) and the largest effect is seen for heart and blood problems (£177.72). The presence of a health condition reduces tax paid and increases benefit income from the State for all health conditions except skin/allergy problems.

[Table I Here]

The cross-section univariate associations between health conditions and contributions in Table I are likely to be biased, picking up age effects and potential co-morbidity. When we include each health condition in a pooled OLS regression of contributions (not reported) we find the effects of each condition reduce (for example, depression leads to £167.81 less contributions in the univariate association dropping to £100.96 lower contributions when all health conditions are controlled for). Including age, region, wave, marital status, qualification, and children dummies (not reported) also change the effects of each health condition (for example, to £89.70 lower contributions for depression). Table II reports the sample sizes for each of the additional covariates in our model.

[Table II Here]

The results from fixed-effects estimation (equation (3)) are provided in Tables III. The effect of depression is now £20.97 lower contributions than those without depression. A similar picture holds for each health condition regardless of whether contributions, tax paid, or benefits received are measured – cross-sectional associations between health states and contributions, tax paid, and benefits received are substantially overestimated.

Approximately half (55%) of the unobserved variation in contributions to the State is explained by the unobserved heterogeneity term (43% for tax paid, and 61% for benefits received). Tests of the null that the unobserved effects are not significant are rejected for each model (p-values <0.0001). The reduced effects on the health conditions when controlling for unobserved variation suggests there are unobservable characteristics that are associated with health conditions and contributions, tax paid, and benefits received.

Our other estimates work in the direction expected. There is an inverted u-shape in contributions by age (the inverted u-shape in taxes more than offsets the u-shape in benefits received). Individuals with degrees are more likely to contribute more than those with other qualifications. Those not married receive higher benefits than married individuals, largely resulting in lower net contributions. More children reduces contributions (reducing tax paid and increasing benefits received). Contributions have decreased over the sample period (1991-2008, estimates not reported), this is driven by increasing benefits received over the period.

[Table III Here]

In order to estimate the effects of a change in health on contributions we estimated the same models but with dummies for transitions on to a health problem, transitions off a health problem, and for remaining on or off a health problem. Sample sizes and average contributions for each health problem are included in Table IV. The use of the previous periods health problem status reduces the sample to 189,738 observations (25,124 individuals).

[Table IV Here]

For all health problems, those who have transited off have lower contributions than those who have remained without the condition. Transitions on to a health condition also have lower contributions than those who remain without the condition. For most conditions those transiting off have greater contributions than those transiting on to a condition. There are several health problems with a small number of transitions (diabetes, alcohol or drugs, and epilepsy). Small sample sizes can lead to inaccurate estimates of the effects of these health conditions but are included to control for potential co-morbidity bias on the other health problem estimates.

Tables V presents the estimates of fixed-effects regressions of contributions on changes in health with additional covariates (equation (4)). Transitions off depression and arms, legs or hands, and diabetes result in higher contributions (compared to the base of remaining with the health problem). Those transiting on to health problems (depression, arms, legs or hands, heart or blood pressure) have higher contributions compared to those remaining with the health problem.

[Table V Here]

4. DISCUSSION

We have modelled the effect of a range of self-reported health problems on State contributions, tax paid, and benefits received. We found that unconditional cross-sectional associations between health problems and State contributions are substantially inflated. Our results suggest any approach to capture correlations between health and a measure for wider societal benefit should ideally utilise longitudinal data and control for several potential confounding effects.

We find reduced monthly contributions to the State for individuals with depression (-£20.97), arms, legs or hands problems (-£12.21), chest or breathing problems (-£10.30), heart or blood pressure problems (-£8.42), stomach or digestion problems (-£7.95), alcohol or drug problems (-£30.96), or epilepsy problems (£38.85). Each is driven by greater benefits received compared to those without the health problem. When assessing the effects of changes in health problems to contributions to the State we find significant increases in contributions for those transiting off depression (£21.44), arms, legs or hands (£19.25), and diabetes (£31.93) problems.

Comparing across health conditions, a consistent picture emerges – depression, diabetes and problems with arms, legs or hands result in reductions in contributions to the State. Interventions that remove these problems would increase an individual’s monthly State contributions by £21.44 (depression) and £19.25 (arms, legs or hand problems) and £31.93 (diabetes).

Interestingly, the key mechanism by which contributions vary appears to be via the effect of health conditions on benefit income received. Our results thus suggest that any approach to capture a wider perspective should consider not only wages (production) but also State benefits received (consumption).

Our approach aimed to show how an expansion of perspective could by assessed. We do not have a WSB measure here, rather; we have one domain of WSB. Nonetheless the methods have implications for any analysis of WSB.

There are a number of limitations to our analyses. First, attrition is likely to be higher amongst individuals with poor health – this has been confirmed in Contoyannis, Jones and Rice (2004) who use the BHPS to analyse health dynamics. Attrition however, was found to have an insignificant impact on the estimated determinants of self-reported health in Contoyannis, Jones and Rice (2004). Nonetheless, we replicated our analysis on only those present in every wave of the BHPS (Supplementary Tables SI and SII). We find similar effects remain for depression and arms, legs, or hands problems (£15.64 and £9.07 fewer contributions in the balanced compared to £20.97 and £12.21 fewer contributions in the unbalanced sample). Contributions for several health conditions change to insignificance in the balanced sample (stomach or digestion problems, alcohol or drugs problems, and epilepsy problems). For transitions off a health condition we find both depression and arms, legs, or hands problems remain significant in the balanced panel although the estimated effect is smaller (£29.69 and £12.92 greater contributions in the balanced and £21.44 and £19.25 greater contributions in the unbalanced sample).

Second, one particular concern when modelling the effects of changes on health is the timing of the main variables. The health measures are current (the date of interview) whilst the benefit income is for the past month, and tax paid is monthly tax as at 1st September. Most respondents are surveyed in September/October, however, a small proportion may be reporting health problems that they were not aware of/ did not have during the period of benefit payment and tax paid.

Third, we estimate State contributions for health problems conditional on age and region, meaning these health effects are less suspect to age and location discrimination. However, there is still potential for health problems concentrated in better paid jobs to be favoured.

Finally, there are a number of ways in which our analysis can be further expanded using the BHPS data. Our measure of contributions to the State contains only financial transactions, but this is not the only means by which individuals contribute to the State. Transfers can occur via taxes on spending and there are substantial transfers in the form of state-financed health care provision. Utilisation of health services could also be modelled. The BHPS reports the use of in-patient stays, GP visits, a health visitor, home help, meals on wheels, social worker, chiropodist, alternative medicine, speech therapy, physiotherapist, consultants, dental and optician, and health checks. These measures could provide a useful extension of the approach taken here to incorporate additional impacts from the State perspective. It is worth noting however, that any costs met by the health care provider should have already been factored into the cost-effectiveness assessment of that intervention.

The BHPS holds several opportunities for further research into WSB. There are several other health measures that could be used, including: health status over the last 12 months (reported at each wave), whether health limits daily activities, the General Health Questionnaire (GHQ), and the SF-36 (two waves). Wailoo (2012) notes the methodological issues with the incorporation of WSB into economic modelling. He notes that cohort modelling can lead to potential issues of bias in the effects of WSB, whilst individual patient studies require the availability of common metrics to enable the addition of the WSB cost per QALY to the model. The use of the SF-36 provides a potential useful avenue for further research, as this can be transformed to the SF-6D which has utility weights (Brazier et al., 2002) for each health profile and mapped across each BHPS wave. The SF-6D could then be mapped as per the approach taken by Ara et al. (2013). The BHPS also asks respondents whether they provide informal care and to whom and how many hours a week they provide this. This information could be also be used to capture elements of WSB.

Whilst informative, these additional avenues potentially add further complications and room for error in our analysis and we abstain from incorporating these in the analysis since the effects would not alter our main finding – that regardless of perspective taken, any analysis of changing health should be assessed using longitudinal data and methods.

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Tables

Table I Average monthly transfer payments by self-reported health problem in the BHPS

		N	%	Mean contribution (£)	Mean tax paid (£)	Mean benefits received (£)
		222,485	100.00	18.27	115.89	97.61
Anxiety, depression	No	205,156	92.21	31.34	120.89	89.54
	Yes	17,329	7.79	-136.47	56.69	193.16
Arms, legs, hands	No	161,996	72.81	61.99	133.62	71.64
	Yes	60,489	27.19	-98.80	68.38	167.18
Sight	No	210,824	94.76	27.51	119.59	92.08
	Yes	11,661	5.24	-148.76	48.95	197.71
Hearing	No	203,798	91.60	31.16	121.10	89.94
	Yes	18,687	8.40	-122.28	59.03	181.30
Skin/allergy	No	196,715	88.42	17.72	115.17	97.45
	Yes	25,770	11.58	22.49	121.32	98.83
Chest, breathing	No	193,207	86.84	33.00	121.77	88.77
	Yes	29,278	13.16	-78.89	77.08	155.97
Heart, blood pressure	No	186,497	83.82	47.02	127.68	80.66
	Yes	35,988	16.18	-130.70	54.79	185.49
Stomach or digestion	No	205,668	92.44	27.43	119.04	91.61
	Yes	16,817	7.56	-93.73	77.36	171.09
Diabetes	No	214,975	96.62	23.74	117.73	93.99
	Yes	7,510	3.38	-138.26	63.00	201.27
Alcohol or drugs	No	221,382	99.50	19.13	116.19	97.05
	Yes	1,103	0.50	-154.76	55.06	209.82
Epilepsy	No	220,708	99.20	19.40	116.25	96.84
	Yes	1,777	0.80	-122.23	71.21	193.44
Migraine	No	204,461	91.90	22.16	117.99	95.84
	Yes	18,024	8.10	-25.79	92.01	117.79
Other	No	212,376	95.46	22.70	117.76	95.06
	Yes	10,109	4.54	-74.83	76.54	151.37

Table II Summary statistics for model covariates

	N	*%*
	222,485	100.00
Age		
16-20 (base)	18,602	8.36
21-25	17,942	8.06
26-30	19,617	8.82
31-35	21,506	9.67
36-40	21,660	9.74
41-45	20,287	9.12
46-50	18,563	8.34
51-55	16,940	7.61
56-61	17,996	8.09
62-66	12,861	5.78
67+	36,511	16.41
Region		
London (base)	14,325	6.44
South East	30,385	13.66
South West	15,107	6.79
East Anglia	7,002	3.15
East Midlands	13,769	6.19
West Midlands	14,223	6.39
North West	17,238	7.75
Yorks. & Humber.	15,334	6.89
North East	10,033	4.51
Wales	29,554	13.28
Scotland	34,141	15.35
Northern Ireland	21,374	9.61
Ethnic Minority		
No (base)	206,427	92.78
Yes	16,058	7.22
Qualifications		
Other (non-degree) (base)	122,922	55.25
Degree	26,347	11.84
No Qualifications	73,216	32.91
Marital Status		
Married (base)	119,843	53.87
Couple	23,378	10.51
Widowed	17,245	7.75
Divorced	12,026	5.41
Single	49,989	22.47
Children		
None (base)	149,289	67.10
1	36,216	16.28
2	26,437	11.88
3+	10,543	4.74
Gender		
Male	101,326	45.54
Female	121,159	54.46

Table III Fixed-effects regression models of contributions to the State

	Contribution		***Tax Paid***		***Benefits received***	
Health Problems						
Anxiety, depression	-20.97**	(2.50)	-3.85	(2.07)	17.12**	(1.31)
Arms, legs, hands	-12.21**	(1.66)	-5.11**	(1.38)	7.10**	(0.87)
Sight	-4.85	(2.80)	0.47	(2.32)	5.32**	(1.47)
Hearing	-5.42	(2.84)	-3.66	(2.35)	1.76	(1.49)
Skin/allergy	-1.40	(2.19)	0.71	(1.82)	2.11	(1.15)
Chest, breathing	-10.30**	(2.39)	-3.21	(1.98)	7.09**	(1.25)
Heart, blood pressure	-8.42**	(2.14)	-1.64	(1.78)	6.78**	(1.12)
Stomach or digestion	-7.95**	(2.46)	-0.02	(2.04)	7.93**	(1.29)
Diabetes	-8.49	(5.16)	2.08	(4.28)	10.57**	(2.71)
Alcohol or drugs	-30.96**	(9.38)	2.91	(7.79)	33.87**	(4.93)
Epilepsy	-38.85**	(11.72)	-2.15	(9.73)	36.71**	(6.16)
Migraine	1.79	(2.56)	1.34	(2.12)	-0.46	(1.34)
Other	-5.13	(2.70)	-2.29	(2.24)	2.84*	(1.42)
Age (base 16-20)						
21-25	32.67**	(3.44)	44.34**	(2.86)	11.67**	(1.81)
26-30	85.13**	(4.56)	92.90**	(3.79)	7.77**	(2.40)
31-35	127.61**	(5.63)	119.72**	(4.68)	-7.88**	(2.96)
36-40	167.28**	(6.70)	140.57**	(5.56)	-26.72**	(3.52)
41-45	206.59**	(7.77)	157.16**	(6.45)	-49.43**	(4.08)
46-50	234.39**	(8.89)	163.14**	(7.38)	-71.25**	(4.67)
51-55	235.72**	(10.06)	145.23**	(8.35)	-90.49**	(5.28)
56-61	203.53**	(11.28)	105.99**	(9.37)	-97.54**	(5.93)
62-66	95.83**	(12.57)	45.95**	(10.44)	-49.89**	(6.60)
67+	40.26**	(14.07)	21.96	(11.68)	-18.30*	(7.39)
Region (base London)						
South East	-29.12**	(6.94)	-26.78**	(5.76)	2.34	(3.65)
South West	-7.08	(9.31)	-5.48	(7.73)	1.59	(4.89)
East Anglia	-99.65**	(11.77)	-90.71**	(9.77)	8.94	(6.18)
East Midlands	-52.80**	(10.18)	-49.20**	(8.45)	3.60	(5.35)
West Midlands	-55.79**	(11.07)	-48.61**	(9.19)	7.18	(5.81)
North West	-57.46**	(10.67)	-53.58**	(8.85)	3.88	(5.60)
Yorks. & Humber.	-73.07**	(11.17)	-68.58**	(9.27)	4.49	(5.87)
North East	-104.97**	(13.83)	-92.89**	(11.48)	12.08	(7.27)
Wales	-71.62**	(12.09)	-66.25**	(10.03)	5.37	(6.35)
Scotland	-86.97**	(12.92)	-75.44**	(10.73)	11.53	(6.79)
Northern Ireland	-17.47	(68.69)	-22.52	(57.02)	-5.05	(36.08)
Ethnic Minority						
Education (base other)						
Degree	93.82**	(4.95)	77.25**	(4.10)	-16.57**	(2.60)
No Qualifications	6.06	(7.61)	3.26	(6.31)	-2.80	(4.00)
Marital Status (base married)						
Couple	-11.61**	(2.96)	3.08	(2.46)	14.69**	(1.56)
Widowed	-65.56**	(4.70)	2.02	(3.90)	67.58**	(2.47)
Divorced	-69.01**	(4.29)	-4.16	(3.56)	64.85**	(2.25)
Single	-65.19**	(3.27)	-19.67**	(2.72)	45.52**	(1.72)
Kids (base none)						
1	-45.16**	(2.03)	-13.71**	(1.68)	31.45**	(1.06)
2	-66.69**	(2.54)	-19.90**	(2.11)	46.78**	(1.34)
3+	-86.43**	(3.82)	-21.32**	(3.17)	65.10**	(2.01)
Constant	-53.37**	(13.70)	79.93**	(11.37)	133.30**	(7.20)
Rho	0.55		0.43		0.61	
N	222,485		222,485		222,485	

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$
Year effects included but not shown. Fixed-effects regression. Test of significance of rho rejected p-value<0.0001. Hausman test supports fixed effects against random effects p-value<0.0001

Table IV Average monthly contributions by change in health state in the BHPS

	Transit off (1,0)		*Remain off (0,0)*		*Transit on (0,1)*		*Remain on (1,1)*	
	£	***N (%)***	**£**	***N (%)***	**£**	***N (%)***	**£**	***N (%)***
Anxiety, depression	-96.84	6,194 (3.26)	36.89	168,452 (88.78)	-94.23	6,714 (3.54)	-173.72	8,378 (4.42)
Arms, legs, hands	-8.58	13,462 (7.10)	73.66	122,520 (64.57)	-17.37	15,348 (8.09)	-133.22	38,408 (20.24)
Sight	-112.17	5,104 (2.69)	32.39	174,644 (92.04)	-119.47	5,336 (2.81)	-198.12	4,654 (2.45)
Hearing	-102.20	4,382 (2.31)	35.93	168,798 (88.96)	-109.21	5,190 (2.74)	-134.20	11,368 (5.99)
Skin/allergy	1.00	8,208 (4.33)	18.93	159,394 (84.01)	-5.85	8,323 (4.39)	39.74	13,813 (7.28)
Chest, breathing	-76.87	6,262 (3.30)	38.44	158,230 (83.39)	-89.08	6,907 (3.64)	-79.61	18,339 (9.67)
Heart, blood pressure	-115.37	6,675 (3.52)	56.84	150,718 (79.43)	-98.41	8,470 (4.46)	-144.01	23,875 (12.58)
Stomach or digestion	-75.32	6,190 (3.26)	31.99	168,719 (88.92)	-76.58	6,814 (3.59)	-110.26	8,015 (4.22)
Diabetes	-197.24	445 (0.23)	24.96	182,488 (96.18)	-144.46	1,064 (0.56)	-137.20	5,741 (3.03)
Alcohol or drugs	-92.33	419 (0.22)	19.68	188,422 (99.31)	-114.54	456 (0.24)	-207.06	441 (0.23)
Epilepsy	-157.39	241 (0.13)	19.96	187,961 (99.06)	-171.00	261 (0.14)	-112.10	1,275 (0.67)
Migraine	-38.13	6,252 (3.30)	24.76	168,065 (88.58)	-36.80	5,977 (3.15)	-18.77	9,444 (4.98)
Other	-76.37	5,796 (3.05)	26.45	175,145 (92.31)	-65.65	5,919 (3.12)	-95.83	2,878 (1.52)

Table V Fixed-effects regression model of contributions to the State (health changes) contributions

	Transit off (1,0)		*Remain off (0,0)*		*Transit on (0,1)*	
Health Problems						
Anxiety, depression	21.44**	(4.49)	37.89**	(4.03)	23.82**	(4.38)
Arms, legs, hands	19.25**	(2.71)	20.59**	(2.47)	16.58**	(2.58)
Sight	6.94	(5.53)	11.37*	(4.99)	11.05*	(5.40)
Hearing	2.75	(4.72)	4.85	(4.22)	-0.48	(4.46)
Skin/allergy	1.00	(3.75)	0.24	(3.42)	0.91	(3.71)
Chest, breathing	4.10	(4.04)	17.44**	(3.56)	7.76*	(3.90)
Heart, blood pressure	8.03*	(3.60)	15.19**	(3.01)	12.40**	(3.30)
Stomach or digestion	3.13	(4.43)	11.16**	(3.92)	5.82	(4.32)
Diabetes	31.93**	(12.26)	7.62	(6.46)	8.09	(8.39)
Alcohol or drugs	28.54	(18.64)	30.47	(16.79)	14.21	(18.20)
Epilepsy	14.60	(20.15)	38.28*	(17.29)	1.00	(19.29)
Migraine	-3.40	(4.38)	-1.57	(4.01)	1.85	(4.40)
Other	10.01	(5.82)	18.56**	(5.35)	16.39**	(5.77)
Rho	0.57					
N	189,738					

Base is ‘Remain on’ (1,1)
Standard errors in parentheses
Additional covariates as per level model (not reported)
* $p < 0.05$, ** $p < 0.01$

Table SI Fixed-effects regression models of contributions to the State – Balanced sample

	Contribution		***Tax Paid***		***Benefits received***	
Health Problems						
Anxiety, depression	-15.64**	(4.72)	3.97	(4.33)	19.61**	(1.63)
Arms, legs, hands	-9.07**	(2.92)	-4.08	(2.68)	4.99**	(1.01)
Sight	-0.75	(5.32)	1.87	(4.89)	2.63	(1.84)
Hearing	-5.46	(5.23)	-2.75	(4.81)	2.71	(1.81)
Skin/allergy	-2.78	(3.98)	-0.23	(3.66)	2.55	(1.38)
Chest, breathing	-11.42*	(4.44)	-1.85	(4.08)	9.57**	(1.53)
Heart, blood pressure	-8.80*	(3.74)	-2.26	(3.44)	6.54**	(1.29)
Stomach or digestion	-4.16	(4.55)	0.40	(4.18)	4.56**	(1.57)
Diabetes	16.89*	(8.54)	15.23	(7.85)	-1.66	(2.95)
Alcohol or drugs	13.59	(23.49)	45.49*	(21.58)	31.90**	(8.12)
Epilepsy	-26.90	(25.33)	5.40	(23.28)	32.30**	(8.76)
Migraine	4.03	(4.59)	3.00	(4.22)	-1.03	(1.59)
Other	-3.27	(4.90)	1.43	(4.50)	4.70**	(1.69)
Age (base 16-20)						
21-25	49.68**	(10.44)	55.38**	(9.59)	5.71	(3.61)
26-30	105.51**	(11.24)	104.10**	(10.33)	-1.40	(3.89)
31-35	148.71**	(12.41)	132.32**	(11.41)	-16.39**	(4.29)
36-40	196.59**	(13.95)	163.06**	(12.82)	-33.53**	(4.82)
41-45	241.37**	(15.48)	185.21**	(14.22)	-56.16**	(5.35)
46-50	279.44**	(17.14)	200.23**	(15.75)	-79.21**	(5.93)
51-55	288.53**	(18.95)	187.84**	(17.41)	-100.69**	(6.55)
56-61	253.37**	(20.88)	146.13**	(19.18)	-107.24**	(7.22)
62-66	132.79**	(22.86)	83.96**	(21.01)	-48.83**	(7.90)
67+	80.27**	(25.48)	65.79**	(23.41)	-14.48	(8.81)
Region (base London)						
South East	-18.55	(11.24)	-17.12	(10.32)	1.44	(3.88)
South West	76.17**	(15.22)	74.51**	(13.98)	-1.66	(5.26)
East Anglia	-160.82**	(20.44)	-134.71**	(18.78)	26.11**	(7.07)
East Midlands	-54.51**	(17.67)	-52.42**	(16.23)	2.08	(6.11)
West Midlands	-49.35**	(18.96)	-41.68*	(17.42)	7.67	(6.55)
North West	-57.97**	(19.11)	-50.87**	(17.56)	7.10	(6.61)
Yorks. & Humber.	-58.61**	(19.52)	-59.67**	(17.93)	-1.06	(6.75)
North East	-75.49**	(23.25)	-73.75**	(21.36)	1.74	(8.04)
Wales	-104.62**	(21.67)	-90.96**	(19.91)	13.67	(7.49)
Scotland	-89.33**	(24.02)	-89.70**	(22.07)	-0.36	(8.30)
Northern Ireland	.	.	.	.	.	.
Ethnic Minority						
Education (base other)						
Degree	87.87**	(9.83)	79.45**	(9.03)	-8.41*	(3.40)
No Qualifications	-4.26	(14.24)	-1.38	(13.08)	2.88	(4.92)
Marital Status (base married)						
Couple	-7.03	(5.53)	3.87	(5.08)	10.90**	(1.91)
Widowed	-63.93**	(7.95)	3.99	(7.30)	67.91**	(2.75)
Divorced	-69.02**	(6.80)	-0.14	(6.25)	68.88**	(2.35)
Single	-63.85**	(6.01)	-18.29**	(5.52)	45.56**	(2.08)
Kids (base none)						
1	-51.41**	(3.62)	-18.75**	(3.32)	32.66**	(1.25)
2	-67.70**	(4.35)	-20.50**	(4.00)	47.20**	(1.50)
3+	-80.32**	(6.51)	-20.08**	(5.98)	60.24**	(2.25)
Constant	-114.48**	(23.20)	31.42	(21.32)	145.89**	(8.02)
Rho	0.48		0.39		0.57	
N	72,096		72,096		72,096	

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$
Year effects included but not shown. Fixed-effects regression. Test of significance of rho rejected p-value<0.0001. Hausman test supports fixed effects against random effects p-value<0.0001

Table SII Fixed-effects regression model of contributions to the State (health changes) contributions – Balanced sample

	Transit off (1,0)		***Remain off (0,0)***		***Transit on (0,1)***	
Health Problems						
Anxiety, depression	29.69**	(8.33)	36.56**	(7.22)	37.33**	(8.16)
Arms, legs, hands	12.92**	(4.66)	14.67**	(4.07)	10.99*	(4.46)
Sight	1.82	(10.23)	2.92	(9.04)	7.62	(10.07)
Hearing	3.41	(8.69)	5.81	(7.27)	0.67	(8.17)
Skin/allergy	4.90	(6.58)	8.05	(5.76)	10.81	(6.50)
Chest, breathing	5.65	(7.53)	15.47*	(6.16)	4.03	(7.18)
Heart, blood pressure	3.81	(6.48)	16.99**	(4.86)	15.51**	(5.76)
Stomach or digestion	2.48	(8.08)	3.02	(6.91)	-2.00	(7.91)
Diabetes	-14.01	(24.63)	-18.73	(10.01)	-5.97	(15.12)
Alcohol or drugs	13.42	(47.09)	46.74	(42.16)	85.06	(46.72)
Epilepsy	20.72	(44.24)	47.59	(33.84)	60.02	(40.59)
Migraine	-3.84	(7.54)	-1.55	(6.60)	4.46	(7.61)
Other	4.25	(10.06)	11.31	(9.02)	13.31	(9.97)
Rho	0.48					
N	67,924					

Base is ‘Remain on’ (1,1)
Standard errors in parentheses
Additional covariates as per level model (not reported)
* $p < 0.05$, ** $p < 0.01$