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THE TRADE-OFF BETWEEN INCOME AND SMOKING AS INFLUENCES ON MORTALITY: EVIDENCE FROM THE BRITISH HOUSEHOLD PANEL SURVEY FOR MEN AND WOMEN AGED SIXTY-FIVE AND OVER

Objectives The purpose of this study is to explore the links between education, income, smoking and mortality of people aged sixty-five and over which can be observed in a general purpose longitudinal survey carried out in the United Kingdom, with the aim of examining any trade-off between income, education and smoking.

The Trade-off between Income and Smoking as Influences on Mortality: Evidence from the British Household Panel Survey for Men and Women aged Sixty-five and Over

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Abstract

Objectives The purpose of this study is to explore the links between education, income, smoking and mortality of people aged sixty-five and over which can be observed in a general purpose longitudinal survey carried out in the United Kingdom, with the aim of examining any trade-off between income, education and smoking.

Design The study uses the data collected by the British Household Panel Survey. This has collected information the people present in an initially randomly -selected sample of households since 1991. Panel members are interviewed once a year and non-response and death are recorded.

Method A bivariate probit equation is fitted to explain jointly mortality and non-response by means of income , educational status and smoking behaviour with controls for previous health status, age and the year of observation.

Results The effect one unit of log income for men is to reduce mortality on average by 0.016 (0.003 to 0.029). For women the effect is found to be 0.004 (0.017 to -0.008) and is not statistically significant. Education is not a significant influence on mortality for either sex. For men an increase in log income by one unit (2.7 times, slightly more than the gap between the median and the 95th percentile) is found to offset 0.45 (0.89 to 0.01) of the average effect of smoking on mortality. An increase in log income of one unit for women offsets only a small and insignificant proportion (0.1; 0.47 to -0.27) of the effect of smoking

Discussion The results show that the effect of smoking on mortality is large compared to that of income and suggest that policies designed to reduce mortality by discouraging smoking are much more powerful than policies designed to influence living standards.

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Competing interest declaration

All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that (1) S.L and M.W. have support from the Economic and Social Research Council for the submitted work; (2) S.L. and M.W. have no relationships with the Economic and Social Research Council that might have an interest in the submitted work in the previous 3 years; (3) their spouses, partners, or children have no financial relationships that may be relevant to the submitted work; and (4) S.L and M.W. have no non-financial interests that may be relevant to the submitted work.

Details of contributors

Silvia Lui and Martin Weale worked jointly on the paper. Lui handled the major part of the data preparation and analysis while Weale was responsible for the major part of the writing up of the research. Both authors were responsible for the design of the study. Weale is the guarantor.

Ethical Issues

The paper draws on an anonymised survey which is made available through the Data Archive at the University of Essex. Ethical approval was not required.

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Data Sharing

Each use of the survey has to be approved by the Data Archive and the researchers are not allowed to forward the data. However *bona fide* researchers requiring access to the data can obtain them directly from the Data Archive.

1 Introduction

The purpose of this study is to explore the links between education, income, smoking and mortality of people aged sixty-five and over which can be observed in a general purpose longitudinal survey carried out in the United Kingdom, with the aim of examining any trade-off between income, education and smoking. It is well established that mortality rates depend on socio-economic variables [1, 2]. The connections between education, income, health and mortality are well-established. However, a meta- analysis of 69 studies [3] includes only five which explicitly look at influences on people aged fifty and over and suggests that, for this group there is only a small and statistically insignificant effect of education in reducing mortality. Similarly, an analysis of the effects of income on mortality in the United States [4] suggests that the effects on people aged under sixty-five are stronger than those in the population as a whole; estimates of the effects on people aged sixty-five and over are not, however, presented. A study of the effects of social security payments, which were lower for men born in 1917 than in 1916 pointed to a negative effect of income on mortality [5], suggesting that this was because lower benefits had encouraged an element of labour force participation with the resulting higher level of socialisation having a favourable influence on survival. So the question of what can be established about the relationship between the relationship between income, education and mortality of people aged sixty-five and over by analysing a reasonably representative general purpose longitudinal survey in the United Kingdom is a pertinent one. And examination of the issue using the longitudinal panel data of the British Household Panel Survey makes it possible to do this in a way which controls for smoking and thus ask what increase in income is needed to offset the effects of smoking, and how far education can compensate.

If links between education, income and mortality are found, there are obvious questions about the pattern of causation. Do education and income have direct effects on health and mortality or are they the consequences of possibly unobserved driving variables which affect both education and health? The problem is very similar to that involved in trying to produce estimates of the effect of education on earnings which are not contaminated by underlying ability. In this latter case the current view [6] is that the biases arising from reporting errors and the omission of ability effects largely offset each other so that estimates of the returns to education generated using ordinary least squares are not subject to significant overall bias. A number of studies have similarly attempted to establish whether education and income have causative power with respect

to health and mortality. Evidence from the impact of lottery winnings on health [7] points to a causative effect. is similar to that of other forms of income, suggesting that income has a causative influence. Another study [8] uses the effect of German unification on the incomes of the people in East Germany to identify a link between an exogenous change in income and health, although this has the drawback that there were many other changes which took place at the same time, and one cannot be sure that the effect identified is that of income. For people aged forty-five to sixty-five, both education and income affect health status [9] after allowing for the possible role of health as a driver of income.

Of course there may be a common causes driving both income and health. Studies of twins [10, 11] find that education plays a separate role as a determinant of adult health while there may also be a role for foetal experience [12] . More generally, childhood circumstances affect adult outcomes [13], with birth-weight and childhood health affecting subsequent career success[14]. A link between IQ at age 11 and the risk of death before the age of 76 [15] raises questions about the relative magnitude of education and income effects; other work [16] finds that the effects of income on mortality are attenuated but not removed if one takes account of respondents' IQ measured at the age of 56. But this, itself, may be a consequence of past education and income. Nevertheless, it seems that the ability of education and income to explain health and mortality is not much affected by the inclusion of childhood IQ as an explanatory variable[17].

2 Data

2.1 The British Household Panel Survey

The British Household Panel Survey (BHPS) started in 1991[1]. It is an annual survey that provides a panel of socio-economic data set over time. Initially each member of a household aged 16 and over was interviewed, in an initial sample of over 5000 households. The same household members are then re-interviewed in the following waves. If a member leaves the original sample household, that person, as well as the other members of the new household (aged 16 and over) are recruited for the panel. New households are also included in the survey each year in order to compensate for attrition. Deaths and non-responses are recorded but there is a risk that, non-response, particularly by

[1]University of Essex. Institute for Social and Economic Research, British Household Panel Survey: Waves 1-17, 1991-2008 [computer file]. 6th Edition. Colchester, Essex: UK Data Archive [distributor], May 2009. SN: 5151.

Level 0	No or minimal qualifications
Level 1	GCSEs or equivalent
Level 2	1 A-level/AS level or equivalent
Level 3	2 or more A levels/ONC/BTEC General Certificate
Level 4	HNC/Nursing or teaching qualification/university diploma or degree

Table 1: The Classification of Qualifications

old people, is a consequence of unidentified death.

The survey asks people to rate their health as very poor, poor, fair, good or excellent relative to other people of a similar age; in 1999 a variant on the question was used. Wide-ranging information on qualifications is collected. In this study that information is consolidated so as to place respondents in one of five distinct educational levels; classification is based on the highest qualifications reported. This classification is summarised in table 1. Full details of the classification are available on request.

The survey also collects information on income and household structure. This study has used measures of income net of taxes and adjusted for household size from the raw data computed by the Institute of Social and Economic Research, University of Essex (see [18]). A logarithmic transformation is applied to income adjusted for household size. The adjustment for household size is made using the modified OECD scale which treats a couple as 1.5 adults. Finally, respondents are asked whether they smoke cigarettes; as with health, in 1999 a variant of the question was asked.

The pattern of mortality represented in the sample is presented in tables 2 and 3. The relationship between education and income can be seen in table 4.

3 Methods

The statistical analysis is structured around a bivariate probit model of mortality and non-response. The advantage of this over the Cox proportional hazards model employed by [16] and others is that this offers a means of dealing with the problems caused by the fact that non-response may be a consequence of unreported death. The ability to address these is very important given the non-response rates shown in tables 2 and **??**.

As with the standard probit model, the risk of death is assumed to be driven by an unobserved variable which is, in turn explained by a number of observed variables, such as age and year dummy variables and a random, normally distributed term. Death is assumed to take place if this unobserved variable is positive. The risk of non-response is

	Non	Education		Smoking		Income	
Age	-response	Up to GCSE	>GCSE	No	Yes	< median	≥ median
65-69	0.048	0.023	0.013	0.017	0.035	0.027	0.016
	(0.004)	(0.003)	(0.004)	(0.003)	(0.008)	(0.005)	(0.003)
n=	2,833	1,869	828	2,178	519	1,038	1,659
70-74	0.034	0.045	0.030	0.034	0.073	0.035	0.045
	(0.004)	(0.005)	(0.007)	(0.004)	(0.014)	(0.006)	(0.006)
n=	2,121	1,423	626	1,708	341	992	1,057
75-79	0.026	0.058	0.035	0.044	0.101	0.060	0.040
	(0.004)	(0.007)	(0.009)	(0.006)	(0.022)	(0.008)	(0.008)
n=	1,491	1,026	426	1,264	188	820	632
80-84	0.042	0.088	0.040	0.067	0.164	0.098	0.039
	(0.006)	(0.011)	(0.012)	(0.009)	(0.045)	(0.013)	(0.010)
n=	965	648	276	857	67	540	384
85+	0.061	0.145	0.119	0.141	0.108	0.141	0.135
	(0.010)	(0.017)	(0.029)	(0.015)	(0.051)	(0.019)	(0.024)
n=	576	415	126	504	37	341	200

Table 2: Non-response and Influences on Men's Mortality Rates (standard errors in brackets)

	Non-	Education		Smoking		Income	
Age	response	Up to GCSE	>GCSE	No	Yes	< median	≥ median
65-69	0.039	0.019	0.009	0.012	0.034	0.020	0.014
	(0.003)	(0.003)	(0.003)	(0.002)	(0.007)	(0.004)	(0.003)
n=	3,342	2,363	850	2,622	591	1,123	2,090
70-74	0.029	0.023	0.023	0.020	0.038	0.025	0.021
	(0.003)	(0.003)	(0.006)	(0.003)	(0.009)	(0.004)	(0.004)
n=	2,775	2,039	655	2,241	453	1,331	1,363
75-79	0.037	0.036	0.028	0.029	0.076	0.033	0.037
	(0.004)	(0.004)	(0.008)	(0.004)	(0.016)	(0.005)	(0.006)
n=	2,305	1759	460	1943	276	1,161	1,058
80-84	0.056	0.059	0.038	0.052	0.085	0.054	0.057
	(0.006)	(0.007)	(0.011)	(0.006)	(0.023)	(0.007)	(0.009)
n=	1,710	1301	313	1473	141	944	670
85+	0.088	0.131	0.097	0.126	0.107	0.129	0.118
	(0.009)	(0.012)	(0.022)	(0.011)	(0.041)	(0.014)	(0.016)
n=	1055	776	186	906	56	573	389

Table 3: Non-response and Influences on Women's Mortality Rates (standard errors in brackets)

	Men		Women	
Level	Number	£ p.a.	Number	£ p.a.
0	3,740	10,396	6,712	9,509
		(99)		(77)
1	1,641	12,263	1,526	11,306
		(187)		(143)
2	768	15,959	905	13,114
		(391)		(265)
3	451	14,130	181	13,594
		(314)		(529)
4	1063	18,846	1,378	15,473
		(307)		(205)

Table 4: Education and Mean Income (standard errors of means in brackets)

similarly explained by observed variables and a separate random term with zero mean and unit variance.

The distinguishing feature of the bivariate model as compared to the estimation of two probit models independently is that the possibility is entertained that the two random terms may be correlated. A positive correlation indicates that unobserved circumstances likely to lead to death are also likely to lead to non-response, while a negative correlation indicates the opposite. The statistical significance of the estimated correlation coefficient indicates whether such effects are statistically significant or not. The command, *biprobit,* in the statistical package, *STATA version 11,* was used to estimate this.

The issue of endogeneity of both education and income is addressed in the following way. An ordered probit was estimated to explain educational status as a function of year of birth, with a dummy included for those leaving school in 1947 or later, for whom the school leaving age was fifteen rather than fourteen. The generalised residuals, referred to as *Edres,* associated with this ordered probit model, along with educational status itself, were used as explanatory variables. An equation was then estimated explaining income by educational status, health status at age sixty-five (or when first recorded if later), age, year and the residual of the probit model described above. The residuals, *Incres,* of this equation computed at age sixty-five (or when first observed if later) were then also used as explanatory variables in the bivariate probit model.

The analysis is carried out separately for men and for women. This allows for the possibility that the structure of influences on men's mortality might be different from that of women. Use of a dummy variable to indicate gender in an analysis which did not

otherwise differentiate men from women would risk obscuring important differences.

4 Results

So as to illustrate the interplay of education and income the analysis is performed with four different combinations of explanatory variables. In the first case (A) the influence on mortality of smoking behaviour and education is examined. Secondly (B), we control for income in the previous period Thirdly, (C) controls are also introduced for previously-reported health state. Finally with specification (D) the controls for education are removed, which were highly insignificant in specification (C), are removed. Roles were examined for both linear and quadratic terms in age; for men, however, the terms in age^2 were found to be insignificant and were suppressed. Dummy variables for calendar year (not shown) are included in all cases so as to address the change in mortality rates over time. Dummies for excellent health and education to level 0 are omitted so as to identify the other parameters.

These different structures make it possible to explore whether the variables of particular interest, income and educational status have a direct effect on mortality even after we take account of each respondent's previously-reported health at age sixty-five. The importance of this is that, while connections between income, education, health status and mortality are well-established, there is a reasonable question how far they are present once one controls for health status in the previous period and thus for any past relationship between these and health.

The equation for non-response, not shown here but available on request, includes the same explanatory variables as the second case above, but also includes indicators region of residence. Some of the regional dummies are found significant for both men and women; this serves to identify the bivariate model. .

A feature of the probit model, unlike the proportional hazard model, is that the incremental effect of each variable on the probability of the event depends on the initial probability of the event, and thus on the magnitudes of the other variables. The interpretation of the parameter is facilitated by transforming them to show the marginal impact on the probability of mortality risk for someone whose mortality risk is the average of the population in question; this is done in table 5 for the variables of interest. For men aged sixty-five and over, the average morality rate, computed from official life tables for the years in question, is 0.060 while for women it is 0.049. For the income variable the table shows the incremental mortality risk of an increase in log income by

	Men				Women			
	A	B	C	D	A	B	C	D
Log Inc		-0.012	-0.011	-0.016		-0.005	-0.003	-0.004
p-value		0.098	0.125	0.018		0.374	0.593	0.511
Smoke	0.037	0.034	0.033	0.035	0.032	0.031	0.029	0.029
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health Age 65 V. Poor			0.117	0.120			0.055	0.055
p-value			0.000	0.000			0.000	0.000
Health Age 65 Poor			0.055	0.057			0.059	0.059
p-value			0.000	0.000			0.000	0.000
Health Age 65 Fair			0.034	0.035			0.031	0.032
p-value			0.001	0.000			0.000	0.000
Health Age 65 Good			0.005	0.006			0.016	0.016
p-value			0.567	0.543			0.053	0.047
Qual Level 1	-0.013	-0.010	-0.010		0.032	-0.013	-0.015	
p-value	0.518	0.634	0.645		0.000	0.514	0.461	
Qual Level 2	-0.023	-0.016	-0.018		-0.014	-0.022	-0.021	
p-value	0.438	0.594	0.565		0.482	0.419	0.451	
Qual Level 3	-0.019	-0.013	-0.017		-0.023	-0.035	-0.044	
p-value	0.568	0.699	0.628		0.388	0.344	0.249	
Qual Level 4	-0.050	-0.038	-0.017		-0.037	-0.018	-0.019	
p-value	0.246	0.382	0.414		0.326	0.625	0.605	
Age	0.005	0.005	0.006	0.006	-0.020	-0.011	-0.012	-0.012
p-value	0.000	0.000	0.000	0.000	0.578	0.087	0.067	0.066
$\text{Age}^2/100$					-0.010	0.010	0.010	0.011
p-value					0.101	0.013	0.010	0.010
Selection Effect p-value	4.5%	4.6%	23.0%	17.2%	5.8%	7.1%	28.7%	25.6%

Table 5: Marginal Probabilities of Influences on Survival Rates

one unit, while for the other variables it shows the effects of the dummy variables for these taking values of one rather than zero. The p-values associated with the underlying coefficients are also shown. The table also shows the p-value of a χ^2_1 statistic which examines whether the selection effects allowed for in the bivariate model are statistically significant or not; the full results of the bivariate probit analysis are available on request.

The table indicates much clearer effects for men than for women, although the deleterious effects of smoking stand out in both cases. However, this influence may reflect health status rather than have a positive effect in its own right. Model (C) which controls for health as reported at the age of sixty-five (or when first observed in the survey if later) shows that this is a very powerful influence on mortality risk.

As table 4 shows there is a clear relationship between education and income. The relationship between work and wage rates has been written about by many authors

	Men	Women
No education or income effects χ^2_7	0.031	0.775
No education effects χ^2_5	0.62	0.8
No income effects χ^2_2	0.011	0.458

Table 6: Tests for the Significance of Education and Income Effects

(e.g. [19]). It is not surprising that this continues into retirement, because pension entitlements often depend on earnings during working life. But the education dummies are highly insignificant in all specifications. Table 6 shows, however, that for men, while individually none of the income or education terms is significant, a joint test for their significance including the significance of the two residuals, *Edres* and *Incres* suggests that collectively they cannot be dismissed. Testing separately for the significance of the four education terms and *Edres,* and the income term and *Incres* indicates that, while the former play little role, the latter are in fact significant. Removing the education terms, to give model (D) has the effect of increasing the precision with which the effect of income is determined. Analogous results for women do not point to significant roles for either education or income and table 6 and the results for model (D) make clear. The effect of smoking for women is, however, much the same as it is for men; the impact of self-reported health, while significant, is appreciably weaker, indicating that the self-reported health of women as an indicator of mortality risk, is much less clear-cut for women than for men.

The aim of this paper is to explore the trade-off between education, income and smoking. The very weak education effects suggest little point in suggesting how far this can offset the damage wrought by smoking. But how much of the effect of smoking is offset by one extra unit of income? This is given as minus the ratio of the coefficient on log income to that on smoking in model (D). That is estimated as 0.45 (0.89 to 0.01). The central estimate indicates that one extra log unit of income, an increase of 2.7 times offsets only 45% of the effect of smoking on mortality. Since the income of a man at the ninety-fifth percentile is 0.96 log units above that of the median, this indicates that, even for men so high up the income distribution, less than half of the effect of smoking is offset. A coefficient of 0.96 would be required for it to be fully offset; this is outside the 95% confidence interval for the ratio. Similar conclusions apply to an increase in income from the bottom percentile to the median; that is a range of 1.08 log units. The small and insignificant coefficient on income for women means that the analogous ratio is both small (0.1 0.47 to -0.27) and poorly determined, i.e. quite possibly zero or negative.

Since the terms on income as shown in table 6 are not statistically significant it is not surprising that there is no evidence that income can compensate women for the effects of smoking.

5 Conclusion

The general pattern of the results is consistent with the view that the links between income and mortality are stronger for men than for women. Despite some suggestions that they are also less prominent for old people than for younger people, the British Household Panel Survey points to a clear connection between income and mortality for men aged sixty-five and over. It was possible to accept the hypothesis that education had no influence despite the data showing that the mortality rates of both women and men decline with educational attainment. However the most interesting conclusions are those found from the relationship between the effects of income and the effects of smoking on men. Despite the clear evidence of a negative relationship between income and mortality, a large movement in a man's income, from median to the ninety-fifth percentile would offset less than half of the average effect of smoking on men's mortality rates; for women the effect is much smaller and statistically insignificant. This, together with the large effects of smoking on mortality rates, highlights the importance of public health measures to reduce smoking relative to the likely consequences of other measures designed to improve living standards of elderly people.

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