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Utilisation of Preventative Health Check-Ups in UK: Findings from individual-level repeated cross-sectional data from 1992 to 2008

Alexander Labeit*

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

Frank Peinemann

FOM University of Applied Science for Economics & Management, 45141 Essen, Germany

Richard Baker

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

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ABSTRACT

Objectives: To investigate the determinants of screening uptake for NHS health check-ups in the UK.

Design: Individual-level analysis of repeated cross-sectional surveys with balanced panel data.

Setting: UK.

Participants: Individuals taking part in the British Household Panel Survey (BHPS), 1992 - 2008.

Outcome measure: Uptake of NHS health check-ups for cervical cancer screening, breast cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.

Methods: Dynamic panel data models (random effects panel probit with initial conditions).

Results: Having had a health check-up one year before, and previously in accordance with the recommended schedule, was associated with higher uptake of health check-ups. Individuals who visited a General Practitioner (GP) had also a higher uptake of all health check-ups. Uptake was highest in the recommended age group for breast and cervical cancer screening. For all health check-ups, age had a nonlinear relationship. The effects of socioeconomic and health related variables (education, employment status, living with a partner, health status, smoking) differed for the different health check-ups. Ethnicity did not have a significant influence on any of the health check-ups. Permanent household income had an influence only on eyesight tests and dental screening, and transitory income only on the cholesterol test.

Conclusions: Common determinants for all health check-ups are age, previous screening history and a GP visit. Policy interventions to increase uptake should consider the central role of the GP in promoting screening examinations and in preserving a high level of uptake. Possible economic barriers to access for prevention exist for dental screening and eyesight tests, and could be a target for policy intervention.

Trial registration: This observational study was not registered.

ARTICLE SUMMARY

Article focus

- To identify common determinants of the uptake of different preventive health check-ups delivered by the NHS: breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.
- To investigate the effect of past screening behaviour, age, GP visits, household income and other socioeconomic variables on the uptake of each of these health check-ups.

Key messages

- Past screening behaviour and GP visits explained recent screening behaviour for each of the health check-ups: taking part in past screening examinations and visiting a GP visit increased actual uptake.
- Permanent household income had a positive significant effect only on eyesight tests and dental screening, but not on the other health check-ups.

Strengths and limitations of this study

- Our study used consistent individual-level repeated cross-sectional data from a panel survey over a period of 18 years for the different health check-ups.

- Our estimation used a balanced panel which considered also attrition effects.
- Information about results from previous screening examinations was not available, and linking with other data sources could improve our analysis.

INTRODUCTION

Individuals are offered different health check-ups in the NHS. These include breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental check-ups and eyesight tests. There is no charge for the health check-ups, other than for dental check-ups and eyesight tests. Taking part in health check-ups is important, because screening examinations promote early detection of diseases and are potentially cost saving.

For each health check-up a detailed recommendation exists on how often an individual should attend a specific health check-up depending on age limits, comorbidities and previous health check-ups. The first female specific analysed prevention programme is the NHS Breast Screening Programme (NHSBSP) which offers mammography to women at different time intervals depending on age.[1] Women between age 50 and 64 are invited, and from 2003 there has been an extension of the age range for these programme and women between age 65 and 70 years are also invited. The second female specific analysed prevention programme is the NHS Cervical Screening Programme (NHSCSP) which offers women a smear test at different time intervals depending on age.[2] The intervals for screening are: age 20 (England) or 25 (Scotland and Wales) for first invitation, and between age 20 or 25 and 49 for a 3 yearly recall period since 2003 (5 yearly before 2003). The recall interval is 5 years between age 50 and 64; for women of age 65 and older, screening is offered only to those not screened since age 50 or who

have had recent abnormal tests. Blood pressure can be checked by a GP or another healthcare professional and it is recommended that adults with aged over 40 are checked at least every 5 years.[3] For individuals with increased risk of hypertension or with comorbidities (e.g. diabetes) blood pressure should be checked every year. A cholesterol test is recommended for individuals aged over 40 and especially for individuals who have a family history of early cardiovascular disease or who have high blood pressure or diabetes.[4]

For dental screening the national guidelines recommend at least one check-up every two years, unless the dentist recommends a different interval based on the patient's current dental health.[5] The national guidelines changed in 2004, the previous recommendation being every 6 months. Dental screening incurs a charge to the patient, and is only free for those under the age of 18 or on income support. An eyesight test is recommended every two years, or more frequently if necessary.[6] It is especially advised for individuals aged 60 years and older, individuals from certain ethnic groups, for example, Afro-Caribbeans, and for those with diseases such as diabetes. There is a charge for the eyesight test, but it is free for individuals of age 60 and older, or who are registered blind or partially sighted, or who have diabetes or glaucoma.

Economic models of the demand of health care in general and preventative care in particular are based on human capital models.[7] This framework has also been used for the modelling of demand for primary and secondary prevention.[8] These categories of prevention are self-protection measures that improve early detection and health outcomes.[9] The problem with economic models of prevention is that two important

aspects are typically not considered at the same time in detail: the distinction between acute and preventative care, and uncertainty. Some dynamic economic models for the demand of health care take only uncertainty into consideration, however there is no distinction made between acute and preventative care.[10] Acute care describes the consumption aspect of health whereas preventative care describes the investment aspect. The (simplified) Grossman model makes the distinction between acute and preventative care, but as a confinement no uncertainty is considered in this model.[11] There is only one economic model which explicitly takes the demand for preventative health care and uncertainty in a stochastic dynamic framework into consideration.[12] However, in this article no non-economic factors were considered. Our conceptual framework is based on a human capital approach[12] and as an extension, non-economic factors such as non-monetary barriers are included. Our approach is also supported by previous research which has investigated determinants of different types of screening examinations.[13]

Information about the uptake of these different health check-ups over a period of nearly 20 years is available in the British Household Panel Survey (BHPS). There is only one study which compares these different NHS health check-ups from 1991 to 2003.[14] However, this study estimated random effects panel probit models only with unbalanced panels, with the potential problem of attrition bias, and as a consequence selection bias in the estimates can occur.[15] The influence of household and individual characteristics on uptake is analysed in our study and also the effects of transitory and permanent household income on uptake. Also in our analysis the effect of policy changes on the uptake for three health check-ups (cervical cancer screening, breast cancer screening and dental

screening) are additionally considered. Therefore, our analysis compares how past screening behaviour, individual and household characteristics, policy changes and changes in transitory and permanent household income affect the uptake on these different health check-ups.

Previous screening behaviour was shown to be an important predictor for recent screening behaviour.[13 16 17] Age have different effects on the demand for prevention.[18 19] On one hand, health depreciates at an increasing rate at older ages, and the necessity to maintain health increases and as a consequence also demand for prevention activities increase. On the other hand, older individuals have a shorter life span and pay-off period of their investment in prevention activities, and therefore the effect of increasing age on uptake cannot be predicted. Empirical studies often find a negative relationship between age and uptake of health check-ups.[19 20] Females have a higher utilization of health care services[21] and also a higher use of preventative care services including blood pressure checks, cholesterol tests and dental screening.[22] Higher educational level may be expected to lead to an increase in the demand for prevention services, because individuals with a higher education may have higher efficiency in the production of health and also increased self-efficacy, higher confidence and motivation.[8 16 19 20] Females living in a partnership have a higher propensity for screening examinations.[23 24] A higher number of children in the household can influence screening behaviour through time constraints.[16 25] Household income may be expected to lead to an increase in the demand for prevention services, because higher income leads to an increase in demand for time in perfect health.[7 11] In some studies, increasing household income increased uptake of preventive

care,[18 19 26] although the effect may be weaker in the UK compared to other countries, because most preventative services are free in UK. Employed women had a higher uptake of cervical cancer screening and in some studies it was a stronger predictor of non-attendance for screening uptake than income and education.[23 24] The predictive value of employment status for uptake of cervical cancer screening held in the United States, but not for uptake of mammography.[27] The GP plays a role as gatekeeper in the UK health care system and can give advice and information about health check-ups and so enhance uptake of prevention services.[28 29] Self-rated health status is used as a proxy for the health stock of an individual and individuals with low health stock can increase their stock by taking part in prevention activities.[18] However, poor health status can make it more difficult to visit prevention services. There are contradicting results for the effect of poor health status on the uptake of health check-ups, with increased uptake of cholesterol checks and a lower uptake of mammograms and pap smears.[30] Smoking is typically associated with risk taking behaviour[31] and can serve as an indicator for the weakened preference of an individual for health in comparison to other goods and services and so the individual should have a lower demand for prevention activities.[19] For individuals with non-white ethnic origin cultural barriers may exist, and can be especially important for breast and cervical cancer screening. For cervical cancer screening ethnicity was the most important predictor, with white British women having the highest uptake.[32] In order to receive an invitation for breast and cervical cancer screening women have to be registered with a GP. For women who had changed residence and address, lower uptake for cervical cancer screening was found in one study,[25] however not in another one.[16]

METHODS

A dynamic random effects (RE) panel probit model was used to estimate the uptake of NHS health check-ups over the panel period from 1992 to 2008. The advantage of such a specification is that actual uptake of health check-ups is not only explained by individual and household characteristics, but also by past screening behaviour and therefore persistence in screening behaviour (state dependence) can be analysed. One possibility for estimating a dynamic random effects (RE) panel probit is the Mundlak-Wooldridge estimator which specifies a relationship between the unobserved time-invariant individual effect and the observed characteristics and initial conditions,[33] and the econometric model is given by the following 3 equations (1), (2), (3).

$$y^*_{it} = \gamma_1 y_{it-1} + \gamma_2 y_{it-2} + \gamma_3 y_{it-3} + x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (1)$$

In the first equation y^*_{it} indicates the unobserved latent variable of an individual i at a given time t for taking part in a specific screening exam, y_{it-1}, y_{it-2}, y_{it-3} are the screening examination decisions of the individual i 1, 2 and 3 periods before t and γ_1, γ_2, γ_3 are the related coefficients for these variables, x is a vector of time variant and time invariant covariates, β is the vector of coefficients associated with these covariates, ε_{it} is the random error term and α_i indicates the individual specific term for time invariant unobserved variables which is modelled according to equation (2) as individual specific random effect:

$$\alpha_i = \delta_1 S_{i1} + \delta_2 S_{i2} + \delta_3 S_{i3} + + \delta_4 \overline{X}_i^{'} + \upsilon_i \quad (2)$$

A normal density for the individual specific random effect is assumed and the first three terms are the initial conditions with the uptake of the specific health check-up for an individual *i* in the first three periods of the panel: S_{i1}, S_{i2} , S_{i3} .The fourth term allows correlation between the time-varying variables household income and health status of an individual by including the average $\overline{X}_i^{'}$ of over the whole panel observation period and the individual specific random effect,[34] which divides both variables into a transitory and permanent component for the estimation. ν_i is the error term assumed normally distributed with zero mean and standard deviation σ_α. This specification has the advantage that time-invariant unobserved variables which are correlated to household income and health status are captured by the mean of these variables and give a less biased estimate of the transitory component of these variables. The third equation gives the observed binary outcome y_{it} of taking part in a specific health check-up for individual *i* in period *t*.

$$y_{it} = \begin{cases} 1, if \;\; y_{it}^{*} > 0 \\ 0, otherwise \end{cases} \quad (3)$$

The chosen Mundlak-Wooldridge specification has the advantage that under certain assumptions the bias which is caused by the persistence of screening behaviour is removed. Crucial assumptions for the estimation of the dynamic random effect model are that the relationship between the unobserved time-invariant individual effect and the mean of the observed characteristics is correctly specified and also the distributional assumptions on the initial conditions are correct. For an unbiased estimation with regard

to initial conditions it is also necessary to fulfil the assumption that unobserved past screening behaviour is uncorrelated with observed screening behaviour, i.e. that unobserved specific health check-ups that happened prior to our observation period (first wave) are not correlated with the observed health check-up and if this assumption is violated the estimation can be biased.[35] Estimation of a balanced panel was preferred in comparison to an unbalanced panel, because estimation of unbalanced panels with ad hoc treatments of initial problems has unfavourable estimation properties and could result in biased estimation because of the selection bias caused by attrition effects in the panel and the estimation results of balanced panels are more reliable, because balanced panels satisfy the assumptions of the Mundlak-Wooldridge estimator.[36 37] An alternative to the Mundlak-Wooldridge estimator would be for the balanced model the maximum likelihood estimator proposed by Heckman,[35] however for balanced panels with more than 5 to 8 periods the finite sample properties of the Mundlak-Wooldridge estimator are better.[15]

The decision to take part in a health check-up is dependent on the result of the specific health check-up one year ago. Individuals with an inconclusive result of the specific health check-up from the previous screening one year ago have a higher chance of being invited again to a health check-up in the recent year and this is especially relevant for breast and cervical cancer screening. Unfortunately, the results from previous health check-ups are not available in the BHPS. Our chosen dynamic specification with 1-year, 2-year, 3-year lagged dependent variables as explaining variables takes into consideration, that the health check-up from the previous year could have an inconclusive

result and takes also into consideration the institutional setting that specific medical recommendations exist for each health check-up.

For our analysis the BHPS is used which is an annual survey of households in UK. It is a nationally representative sample of more than 5,000 households and individuals with age 16 and over are interviewed.[38] The first wave of the data collection for this survey started in 1991 and all the original individuals were also interviewed each succeeding year unless they dropped out. Questions about taking part in NHS health checks-up have been in every wave from the start of the panel survey in 1991 until 2008. For the analysis of breast and cervical cancer screening, only females were included, for all other types of health check-ups both males and females were included. In our analysis and construction of the balanced sample only individuals from England, Wales and Scotland were selected, because data collection started in Northern Ireland from wave 11 and not from the first wave. For the construction of the balanced panel 17 years of information were used: from 1992 to 2008, because in the first wave only few individuals were interviewed in 1991, most in 1992. For an individual to be included in our analysis provision of the specific health check-up had to be from NHS, private provision being excluded. The dependent variable takes the value of 1 in a specific year if the specific health check-up (breast cancer screening, cervical cancer screening, blood pressure check, cholesterol test, dental test, eyesight test) was done through NHS provision and 0 if the specific health check-up had not been utilised or through NHS provision.

The balanced panel included for breast cancer screening 855 women with 11,970

observations, for cervical cancer screening 860 women with 12,040 observations, for blood pressure checks 1,412 individuals with 19,768 observations, for cholesterol tests 1,578 individuals with 22,092 observations, for dental screening 701 individuals with 9,814 observations and for eyesight tests 616 individuals with 8,624 observations.

In our analysis, for cervical cancer screening we used the age groups of the screening guidelines: 16 to 24 (reference group), 25 to 49, 50 to 64, and aged 65 and older. For breast cancer screening, we followed also the age groups of the screening guidelines: 16 to 49 (reference group), 50 to 64, 65 to 69, and aged 70 and older. For all other screening checks, the following groups were used: 16 to 39 (reference group), 40 to 49, 50 to 59, 60 to 69, 70 to 79 and 79 and older. For blood pressure checks and cholesterol tests, we included information on whether the person had diabetes or also heart/blood pressure/blood circulation problems, and for eyesight tests, information on eyesight problems was used. Transitory income was defined as the total equivalised and deflated household annual income divided by 100 and permanent household was defined as annual household income over the 17 years between 1992 and 2008. Household income was deflated and transformed in per capita income using the modified OECD scale to allow for household size and needs.[39] The International Standard Classification of Education (ISCED) was used for the categorisation of educational levels with tertiary, secondary and primary education (reference category). Household income was deflated and transformed in per capita income using the modified OECD scale to allow for household size and needs.[39] Health status was self-rated from excellent (1) to very poor (5).

RESULTS

Table 1 presents descriptive statistics for the variables used in our estimation for the balanced panels for the different health check-ups.

Table 1: Sample characteristics for the balanced panels of different health check-ups in UK

For the period 1992 to 2008 there were the following uptake rates within one year for individuals for the unbalanced panel: 14.0% for breast cancer screening, 20.4% for cervical cancer screening, 51.1% for the blood pressure check, 19.6% for the cholesterol test, 57.7% for dental screening and 34.3% for the eyesight test.

Table 2 provides the dynamic random effects (RE) probit estimates with initial conditions for the balanced panel (BP) for the different health check-ups.

Table 2: Parameter estimates and standard errors for the uptake of health check-ups in UK

For all health check-ups, taking part in past screening examinations showed a strong influence on the current screening examination. The effect of having the same screening

examination one year ago was strongest for dental screening and the marginal effect resulted in an increase of 18.4% (table not shown). The effect of having the same screening examination three years ago was strongest for cervical cancer screening and the marginal effect resulted in an increase in uptake of 12.9%). For individuals who visited their GP in the last year, there was an increase in the uptake, the increase being highest for blood pressure (27.3% increase) and lowest for dental screening (2.9% increase). Women aged between 50 and 64 had an increased uptake of 11.0% for breast cancer screening and women aged between 25 and 49 had an increased uptake of 7.1% for cervical cancer screening in comparison to the reference groups. Also for the other four health check-ups there was a nonlinear relationship between age and uptake. For blood pressure check, cholesterol test and eyesight test uptake increased nonlinear with age and for dental screening uptake was highest for individuals between 40 and 49. Women aged between 25 and 49 had a 2.4% decreased uptake of cervical cancer screening after 2003. Women between aged 65 and 69 had an increased uptake of breast cancer screening after 2002 (an increase of 4.6% for this age group in comparison to the years before). Individuals who had a dental screening after 2004 had an increased uptake of 1.6% in comparison to the years before.

Females had an increase in the uptake in three of the four analysed health check-ups which are not sex-specific (blood pressure check, dental screening, eyesight test) and a decrease in the uptake of the cholesterol test. The increase in uptake for females was highest for eyesight test with an increase of 4.5%, and there was a decrease of 1.8% in uptake for females for the cholesterol test. The marginal effects for education,

employment status, household income, living with a partner, poor health status, smoking, changed residence status were non-uniform for the different health check-ups. The effect of tertiary education was strongest for uptake of blood pressure checks (4.2% increase). Being employed decreased the uptake for breast cancer screening by about 2.5% and decreased the uptake of eyesight tests by about 3.2%. Increasing transitory household income led to an increase of uptake for the cholesterol test by 0.3%. Living with a partner increased the uptake of breast and cervical cancer about 2.2% and 2.8%. Poor self-rated health status increased the uptake of the blood pressure checks about 7.8% and cholesterol tests about 3.0%. Smoking decreased the uptake of breast cancer screening about 0.9%, blood pressure checks about 2.8% and dental screening about 3.9%. An additional child in the household decreased the uptake of breast cancer screening and blood pressure checks by 3.8% and 2.1%. Change of residence decreased the uptake of dental screening by 2.5%; however, it increased the uptake of blood pressure checks by 4.0%. Individuals with existing blood pressure problems or diabetes had increased uptake of blood pressure checks by 25.5% and 14.3% and also individuals with blood pressure or diabetes problems had an increased uptake for cholesterol tests by 9.0% and 11.1% Individuals with existing eyesight problems had an increased uptake for eyesight tests of 11.0%. Permanent equivalised household income increased the uptake of dental screening and eyesight tests by 2.0% and 1.6%. An increase of one unit in the average self-rated health status led to an increase in the uptake of eyesight tests by 2.5%.

DISCUSSION

Our analysis of the BHPS estimated for the first time the uptake of health check-ups with a balanced panel over a period for 17 years from 1992 to 2008 in the UK (excluding Northern Ireland). We concentrated on balanced samples for the period from 1992 to 2008 for the different health check-ups, because the estimation of balanced panels has advantages over unbalanced panels.[33] Our empirical investigation showed the importance of taking the past screening behaviour into account, the relevance of age and visiting a GP. The effects of socioeconomic and health related variables such as education, employment status, living with a partner, health status, and smoking differ for the different health check-ups. Permanent household income decreased the uptake for dental screening and eyesight tests. The advantage of our analysis which used panel data rather than the cross-sectional data as used by most other studies is that individual heterogeneity and state dependence can be considered in a dynamic panel data model which is not possible in a model for cross-sectional data.

The strong positive significant effect of past screening behaviour shows that past behaviour influences actual behaviour and can be interpreted as persistence in screening behaviour in the sense of state dependence.[40 41] Reasons for the strong positive state dependence are the adherence to the medical guidelines in UK, i.e. recommendation of checking in certain time intervals, and controlling results from previous screening examinations with unclear results. Initial conditions show a high relevance in all analysed screening examinations and so persistence of screening behaviour is caused by unobserved characteristics. For women the uptake of breast and cervical cancer screening

is highest in the age group for which it is recommended. There is a lower uptake of dental screening for older ages in comparison to persons of middle age group and this result is in accordance with another study.[42] The finding of decreasing screening uptake with increasing age is in accordance with the shorter pay-off period for older individuals from the human capital theory approach. For blood pressure check, cholesterol test and eyesight test the uptake increases with age and our results can be explained by the increasing prevalence of hypertension, high cholesterol and eyesight problems with age and the necessity to check these specific health problems.

The significance of a GP visit in the year before the actual wave, for all the included health check-ups, can be explained by the fact that the GP plays an important role as gatekeeper in the UK and also an important role in access to prevention by giving advice to accept a health check-up or by doing the screening examination.[29] Our results reflect those in an Italian study which analysed the uptake of cervical cancer screening with a recursive probit. The regulations for having a smear test are very similar in Italy and UK with respect to the role of GP in cervical cancer screening. In both countries a visit of the GP is not an essential condition for the provision of a smear test and this test can also be done in specialized institutions.[20] Estimations from the Italian study showed that GP visits led to an increased uptake of cervical screening.

For women, uptakes were higher for blood pressure checks, dental screening and eyesight tests, and these results were in agreement with a recent study from the United States; however there was a negative effect on the uptake of cholesterol tests and the explanation

of this result remains unclear.[22] Health status related variables such as a poorer self-rated health status had both a significant influence on the uptake of blood pressure checks and cholesterol tests. For both health check-ups the interpretation as health stock proxy is probably most valid and so it is understandable that individuals with a low health stock have a high demand for preventative services. For the other health check-ups there was no such influence. However, health status related variables such as poor self-rated health status can be also be interpreted in another way: poor health can influence also perceptions on the preventability of health problems; individuals who were found in a poorer health status also expressed less interest in receiving prevention information in a study[43] and this fact could explain why a poor health status can also be associated with low uptake for prevention services. Smoking had only an influence on the uptake of breast cancer screening, blood pressure screening and dental screening, but not the other health check-ups. Reduced uptake for breast cancer screening has also been found for current smokers in another study.[44]

Education had only an influence on the uptake of the blood pressure checks and dental screening. Education has often to be found an important predictor in uptake for health check-ups, but not always.[13] Education is correlated with other socioeconomic variables (e.g. employment status, socioeconomic status) and the inclusion of further socioeconomic variables explains why education had an influence in only in one of the health check-ups. Non-uniform results were also found for other socioeconomic variables for the different analysed health check-ups: employment status had only a significant positive effect on breast cancer screening and eyesight test, living with a partner only a

significant positive effect for breast, cervical cancer and dental screening and number of children in the household led to a significant negative effect for breast cancer screening and blood pressure check. In a systematic review which analysed the determinants of screening uptake for different cancer screenings and other different health check-ups, none of the socioeconomic variables were significant in all screening examinations and there were diverging results for a specific socioeconomic variable for a specific health check-up.[13] Our results confirm that for different screening examinations different socioeconomic variables are of relevance. Ethnicity had no significant influence on any of the health check-ups, suggesting that ethnicity is not a cultural barrier for access to preventative services. In comparison to our results, another study with the BHPS which analysed an unbalanced panel found for cervical cancer screening a lower uptake for Asian women in comparison to women of other ethnic origin.[16] Women who had changed residence and address within the UK did not have lower uptake for breast and cervical cancer screening and so the effectiveness of the invitation letters are questionable. In contrast changed residence led to an increase in the uptake of blood pressure check which could be explained that after moving to a new location and GP registration, the new GP often measured blood pressure if an individual appears for the first time in their practice. There was no regional effect on uptake of check-ups, so use of prevention services differed not in different parts of UK.

Transitory household income had an effect on the uptake of the cholesterol test and permanent household income had a significant influence on the uptake for dental screening and eyesight tests. This result for the permanent income for these health check-

ups is important in comparison to the other analysed free health check-ups, because income effects exist for the access to preventative health services for which a charge has to be paid in comparison to preventative services for which no charge exist. Another study which estimated the uptake of the health check-ups with unbalanced panels with the BHPS from 1991 until 2003 confirmed our results only in part, because a transitory income effect was found for the blood pressure check and a permanent income effect was found for dental screening.[14] An advantage of our analysis was that we have controlled for attrition bias by estimating a balanced sample. Income effects such as transitory income effects could also be caused by unobserved time-varying factors (e.g. motivation) which have an influence on uptake and income and similar permanent income effects could also be caused by unobserved time-invariant factors.

Only the policy change to extend breast cancer screening had the intended effect. For breast cancer screening there was a higher uptake after 2002 in the age group of 65 to 69. The recommendation of shortening the time interval from 5 to 3 years for women of age 25 to 49 after 2003 for cervical cancer screening failed to have the intended effect of increased uptake in the relevant age group and also the recommendation of extending the time interval from 6 months to 1 or 2 years for dental screening after 2004 did not have the intended effect. The reason why only the changed recommendations for breast cancer screening had the intended effect remains unclear and should be the focus of further research. Individuals with blood pressure or diabetes problems had a higher propensity for the blood pressure checks and cholesterol tests and also individuals with eyesight problems had a higher propensity for the eyesight tests, in accordance with the medical

guidelines.

There are some differences comparing our results for the uptake of cervical cancer screening with another study which had used the BHPS. In our analysis previous screening, age and a GP visit were significant for cervical cancer screening in the UK and our results were confirmed by this study which analysed uptake of cervical cancer screening uptake in England with an unbalanced panel for the first 12 waves of the BHPS until 2003.[16] The coefficients for education, smoking and changed residence status were not significant in our analysis. The differences in results for the variable education and smoking are remarkable, because in our analysis they had not been significant. However, also some other studies have found no influence of education[13] and smoking status on screening behaviour.[45]

One study with the BHPS found in a descriptive analysis that females reported a higher uptake than males for dental check-ups under NHS provision.[42] Individuals between age 46 and 55 years had the highest proportion of dental check-ups with 72% in 2000 and the lowest participation rate was for individuals of age 66 years and older with 43% in 2000. These results are confirmed by our study. Another study which analysed with the BHPS the probability of making a dental check-up visit in 1, 3, 5 and 10 years in comparison to the baseline period of 1991 found that in each of these time periods from 1991 to 2001 females, more educated and non-smokers had a higher uptake which is in accordance with own results. However, in contrast with our own results persons below age 40 had the highest rate of uptake and this result could be explained by the fact that only a distinction

between individuals below age 40 and above age 40 was made.[46]

A first limitation of our study is there is no information about results from previous screening examinations available and it is not possible to differentiate between preventative health check-ups, or taking part after following the advice of a GP or consultant and follow-up tests which are in response to previous inconclusive results. A second limitation of our study is that no information was available about level of trust in the NHS or in the GP, because it has been shown that taking part in screening examinations can be dependent on trust.[20] A third limitation exists, because there was no information available about the characteristics of the primary care factors that have been shown to be associated with the uptake of screening examinations in England.[47] Characteristics of the professional performing of the screening test, structure and organization of medical services can influence the uptake rate. A fourth limitation of our study comes from not using detailed microgeographic information, because uptake rates for a specific health check-up can be higher in affluent and less deprived areas.[48]

CONCLUSIONS

The innovative feature of our study is the analysis of the uptake of different health check-ups with a random effects panel probit model with initial conditions (Mundlak-Wooldridge estimator) with a balanced sample. Our research shows the high importance of past screening behaviour for each of the analysed health check-ups for recent screening behaviour and it is important, therefore, to maintain a high level of prevention

uptake. The GP plays a central role in the uptake of screening examinations and this role in prevention in the UK health care system should not be weakened. Income barriers could be removed for health check-ups such as dental screening and eyesight test to increase the uptake for individuals with lower socioeconomic status. Future research could use information about results from previous screening examinations and microgeographic information by linking with other data sources and this linking with other datasets would give the possibility to analyse additional determinants of uptake.

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Contributions

AL performed statistical analyses. AL, RB and FP discussed the results, and contributed to the text of the manuscript. All three authors reviewed the manuscript.

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Competing financial interests

The authors declare no competing financial interests.

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Table 1: Sample characteristics for the balanced panels of different health check-ups in UK

Health check-up	Breast cancer screening	Cervical cancer screening	Blood pressure check	Cholesterol test	Dental screening	Eyesight test
Health check-up in actual period t	0.140	0.204	0.511	0.196	0.577	0.343
Health check-up in 1992	0.151	0.297	0.419	0.0938	0.492	0.229
Health check-up in 1993	0.145	0.299	0.421	0.111	0.506	0.237
Health check-up in 1994	0.126	0.270	0.421	0.0982	0.529	0.217
Average health status (mean/sd)	2.218/0.666	2.222	2.198(0.650)	2.182(0.645)	2.298(0.674)	2.257(0.691)
Average HH income (mean/sd)	3.077/1.411	3.062(1.408)	2.997(1.344)	3.095(1.426)	2.802(1.292)	2.766(1.363)
Health check-up one year before (t-1)	0.138	0.213	0.499	0.179(0.383)	la0.572	0.328
Health check-up two years before (t-2)	0.137	0.222	0.487	0.164	0.566	0.314
Health check-up three years before (t-3)	0.136	0.231	0.475	0.149	0.559	0.302
HH income (mean/sd)	3.132/1.849	3.120(1.853)	3.058(1.810)	3.160(1.896)	2.860(1.766)	2.813(1.823)
Living with partner	0.728	0.732	0.760	0.769	0.736	0.734
Number of children in HH (mean/sd)	0.526/0.916	0.522(0.913)	0.535(0.923)	0.545(0.924)	0.540(0.944)	0.599(0.982)
Secondary education (ISCED)	0.430	0.432	0.424	0.426	0.400	0.432
Tertiary education (ISCED)	0.324	0.321	0.338	0.349	0.306	0.276
Employed	0.525	0.524	0.562	0.588	0.505	0.518
GP visit during last 12 months	0.810	0.810	0.765	0.754	0.763	0.747
Health status self rated poor	0.0909	0.090	0.0853	0.0829	0.106	0.101
Smoking	0.164	0.166	0.176	0.171	0.215	0.220
Scotland	0.079	0.079	0.0791	0.0764	0.0905	0.0762
Wales	0.052	0.052	0.0504	0.0508	0.0454	0.0633
Ethnic origin non-white	0.012	0.011	0.00997	0.0108(0.103)	0.0101	0.0147
Moved residence	0.048	0.047	0.0524	0.0532	0.0492	0.0550
Age (mean/sd)	52.54/15.26	52.63(15.23)	52.40/15.61	51.87(15.34)	53.60(15.63)	52.11(15.92)
Female sex			0.593	0.566	0.573	0.546
Health problem blood pressure			0.231	0.220		
Health problem diabetes			0.049	0.0453		
Health problem sight						0.049

Source: BHPS. Balanced panels consisted for breast cancer screening of 855 women from 11,970 observations, for cervical cancer screening of 860 women from 12,040 observations, for blood pressure test of 1,412 individuals and from 19,768 observations, for cholesterol test of 1,578 individuals from 22,092 observations, for dental screening of 701 individuals from 9,814 observations and for the eyesight test of 616 individuals from 8,624 observations.

Table 2: Parameter estimates and standard errors for the uptake of health check-ups in UK

Health check-up	Breast cancer screening	Cervical cancer screening	Blood pressure check	Cholesterol test	Dental screening	Eyesight test
Health check-up in 1992	0.185***(0.064)	0.223***(0.043)	0.113***(0.034)	0.180***(0.044)	0.495***(0.078)	0.347***(0.065)
Health check-up in 1993	0.140**(0.065)	0.194***(0.044)	0.094***(0.035)	0.095**(0.043)	0.231***(0.084)	0.354***(0.064)
Health check-up in 1994	0.269***(0.067)	0.150***(0.046)	0.214***(0.035)	0.144***(0.043)	0.598***(0.088)	0.288***(0.067)
Average health status	0.045(0.040)	-0.024(0.036)	0.038(0.028)	0.005(0.025)	-0.029(0.051)	0.090**(0.045)
Average HH income	-0.006(0.024)	0.009(0.020)	-0.008(0.016)	0.011(0.013)	0.110***(0.033)	0.058**(0.027)
Health check-up one year before (t-1)	0.130***(0.049)	0.242***(0.038)	0.521***(0.027)	0.925***(0.031)	1.016***(0.051)	0.300***(0.041)
Health check-up two years before (t-2)	-0.005(0.048)	-0.280***(0.039)	0.240***(0.027)	0.382***(0.032)	0.400***(0.052)	0.395***(0.040)
Health check-up three years before (t-3)	0.820***(0.044)	0.576***(0.036)	0.187***(0.027)	0.257***(0.033)	0.262***(0.052)	0.141***(0.041)
HH income	-0.002(0.014)	0.005(0.012)	0.005(0.010)	0.017**(0.008)	-0.018(0.017)	-0.020(0.016)
Living with partner	0.139**(0.055)	0.125**(0.049)	0.053(0.034)	0.038(0.032)	0.157**(0.062)	0.013(0.055)
Number of children in HH	-0.243***(0.033)	0.026(0.022)	-0.082***(0.018)	-0.003(0.019)	0.030(0.033)	0.015(0.029)
Secondary education (ISCED)	-0.022(0.060)	0.044(0.058)	0.124***(0.041)	0.038(0.037)	0.134*(0.077)	0.065(0.066)
Tertiary education (ISCED)	0.024(0.068)	0.071(0.065)	0.166***(0.045)	0.065(0.040)	0.176**(0.087)	0.056(0.075)
Employed	-0.159***(0.049)	0.067(0.043)	-0.015(0.035)	0.018(0.035)	-0.098(0.064)	-0.114**(0.053)
GP visit during last 12 months	0.246***(0.052)	0.408***(0.044)	1.079***(0.032)	0.585***(0.034)	0.161***(0.051)	0.217***(0.046)
Health status self rated poor	-0.063(0.069)	-0.005(0.065)	0.311***(0.049)	0.191***(0.043)	-0.065(0.073)	0.037(0.065)
Smoking	-0.182***(0.064)	0.041(0.051)	-0.110***(0.037)	-0.058(0.037)	-0.216***(0.063)	-0.089(0.058)
Scotland	0.014(0.088)	0.030(0.073)	0.045(0.054)	0.019(0.051)	0.032(0.102)	0.049(0.098)
Wales	0.103(0.098)	-0.125(0.092)	-0.066(0.067)	0.065(0.057)	-0.111(0.141)	-0.032(0.107)
Ethnic origin non-white	0.090(0.200)	-0.184(0.184)	0.136(0.147)	0.007(0.121)	-0.356(0.292)	0.079(0.215)
Moved residence	-0.022(0.087)	-0.023(0.067)	0.158***(0.049)	-0.025(0.054)	-0.180**(0.084)	-0.087(0.079)
Age 50-64	0.708***(0.045)	0.147**(0.059)				
Age 65-69	-0.311***(0.079)					
Age 70 and older	-0.654***(0.080)					
Age 25-49		0.316***(0.064)				
Age 65 and older		-0.908***(0.077				
Age 40-49			0.013(0.036)	0.352***(0.040)	0.101(0.069)	0.337***(0.062)
Age 50-59			0.091**(0.045)	0.482***(0.046)	0.006(0.085)	0.460***(0.078)
Age 60-69			0.173***(0.053)	0.682***(0.053)	-0.130(0.098)	0.579***(0.088)
Age 70-79			0.253***(0.062)	0.635***(0.062)	-0.321***(0.111)	0.798***(0.100)
Age 80 and older			0.340***(0.087)	0.706***(0.083)	-0.581***(0.153)	0.844***(0.132)
Female sex			0.096***(0.031)	-0.153***(0.028)	0.193***(0.060)	0.162***(0.053)
Health problem blood pressure			1.009***(0.040)	0.576***(0.031)		
Health problem diabetes			0.567***(0.080)	0.711***(0.061)		
Health problem sight						0.397***(0.083)
Breast cancer screening policy change	0.293***(0.094)					
Cervical cancer screening policy change		-0.106**(0.046)				
Dental policy change					0.091*(0.048)	

Source: BHPS. (*),(**),(***): significance at 10%, 5%, 1% level. Balanced panels consisted for breast cancer screening of 855 women from 11,970 observations, for cervical cancer screening of 860 women from 12,040 observations, for blood pressure test of 1,412 individuals and from 19,768 observations, for cholesterol test of 1,578 individuals from 22,092 observations, for dental screening of 701 individuals from 9,814 observations and for the eyesight test of 616 individuals from 8,624 observations.

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Utilisation of Preventative Health Check-Ups in the UK: Findings from individual-level repeated cross-sectional data from 1992 to 2008

Alexander Labeit*

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

Frank Peinemann

FOM University of Applied Science for Economics & Management, 45141 Essen, Germany

Richard Baker

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

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ABSTRACT

Objectives: To analyse and compare the determinants of screening uptake for different NHS health check-ups in the UK.

Design: Individual-level analysis of repeated cross-sectional surveys with balanced panel data.

Setting: UK.

Participants: Individuals taking part in the British Household Panel Survey (BHPS), 1992 - 2008.

Outcome measure: Uptake of NHS health check-ups for cervical cancer screening, breast cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.

Methods: Dynamic panel data models (random effects panel probit with initial conditions).

Results: Having had a health check-up one year before, and previously in accordance with the recommended schedule, was associated with higher uptake of health check-ups. Individuals who visited a General Practitioner (GP) had a significantly higher uptake in 5 of the 6 health check-ups. Uptake was highest in the recommended age group for breast and cervical cancer screening. For all health check-ups, age had a nonlinear relationship. Lower self-rated health status was associated with increased uptake of blood pressure checks and cholesterol tests; smoking was associated with decreased uptake of 4 health check-ups. The effects of socioeconomic variables differed for the different health check-ups. Ethnicity did not have a significant influence on any health check-up. Permanent household income had an influence only on eyesight tests and dental screening.

Conclusions: Common determinants for having health check-ups are age, previous screening history and a GP visit. Policy interventions to increase uptake should consider the central role of the GP in promoting screening examinations and in preserving a high level of uptake. Possible economic barriers to access for prevention exist for dental screening and eyesight tests, and could be a target for policy intervention.

Trial registration: This observational study was not registered.

ARTICLE SUMMARY

Article focus

- To identify and compare determinants of the uptake of different preventive health check-ups delivered by the NHS: breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.
- To compare the effect of past screening behaviour, age, GP visits, health status and socioeconomic variables on the uptake of each of these health check-ups.

Key messages

- Past screening behaviour and GP visits explained recent screening behaviour for each of the health check-ups: taking part in past screening examinations and visiting a GP visit increased recent uptake.
- Lower self-rated health status increased the uptake of blood pressure checks and cholesterol tests, but smoking decreased the uptake of 4 health check-ups.
- Permanent household income had a positive significant effect only on eyesight tests and dental screening, but not on the other health check-ups.

Strengths and limitations of this study

- Our study used consistent individual-level repeated cross-sectional data from a panel survey over a period of 17 years for the different health check-ups.

- Our estimation used a balanced panel which considered also attrition effects.
- Medical information about results from previous screening examinations was not available, and linking with other data sources could improve our analysis.

INTRODUCTION

Individuals are offered different health check-ups in the NHS. These include breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental check-ups and eyesight tests. There is no charge for the health check-ups, other than for dental check-ups and eyesight tests. Taking part in health check-ups is important, because screening examinations promote early detection of diseases and are potentially cost saving. There are only few national and international analyses that analyse how different health check-ups are affected by socioeconomic determinants, and typically such studies have been cross-sectional surveys.[1 2] One analysis using UK data has shown that the socioeconomic determinants of breast and cervical cancer screening differ. Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, existing health problems and health status for these six different health check-ups. Can certain determinants explain the uptake of these six health check-ups, and especially what is the influence of health related variables on the uptake? In the next sections the institutional regulations of the six different health check-ups are introduced, followed by the theoretical framework for our analysis and a discussion of relevant previous empirical prevention research which is related to our own work.

For each health check-up a detailed recommendation exists on how often an individual should attend a specific health check-up depending on age limits, comorbidities and previous health check-ups. The national NHS Breast Screening Programme (NHSBSP)

offers mammography to women at different time intervals depending on age.[3] Women between age 50 and 64 are invited, and from 2003 there has been an extension of the age range for these programme and women between age 65 and 70 years are also invited. The national NHS Cervical Screening Programme (NHSCSP) offers women a smear test at different time intervals depending on age.[4] The age for the first invitation and the age of the last invitation to cervical cancer screening is dependent on country in the UK: age 25 in England since 2003, or 20 in Scotland, Wales and in England before 2003.[5 6] Between the age of the first invitation and 49 is a 3 yearly recall period in all parts of UK since 2003 and before 2003 there was a 3 to 5 yearly recall period policy depending on the Primary Care Trust, with the majority of Primary Care Trusts following a 3-year policy.[7] The policy of a uniform 3 yearly recall period for women between age and 25-49 was implemented after a recommendation by Cancer Research UK, because a 3-year recall policy seemed most effective after analysis of UK data.[8] No information was available for us how quickly each Primary Care Trust in England implemented the changes to the recall policy. Cervical cancer screening is offered to women aged 50 and over every three years until age 60 in Scotland and until age 64 in Wales, and every 5 years in England until age 64 from 2003.[5] Before 2003 a majority of women were screened every 3 years.[7] Women above the age limits are excluded from the recall system and no longer invited unless they need ongoing surveillance or follow up, for example because of an abnormal result in any of the three most recent tests. For breast and cervical cancer screening examination there are sent out routine periodic invitations to women by their GP. Blood pressure can be checked by a GP or another healthcare professional, and it is recommended that adults aged over 40 are checked at least every 5 years.[9] For

individuals with increased risk of hypertension or with comorbidities (e.g. diabetes), blood pressure should be checked every year. A cholesterol test is recommended for individuals aged over 40 and especially for individuals who have a family history of early cardiovascular disease or who have high blood pressure or diabetes.[10] The cholesterol test is implemented as an invitational programme. For dental screening the national guidelines recommend at least one check-up every two years, unless the dentist recommends a different interval based on the patient's current dental health.[11] The national guidelines changed in 2004, the previous recommendation being every 6 months. Dental screening incurs a charge to the patient, and is only free for those under the age of 18 or on income support. Dental screening has been free in Scotland since 2006[12] and in Wales it is free for individuals under age 25 and aged 60 or over since 2006.[13] An eyesight test is recommended every two years, or more frequently if necessary.[14] It is especially advised for individuals aged 60 years and older, individuals from certain ethnic groups, for example, Afro-Caribbeans, and for those with selected diseases predisposing to eye disorders, for example diabetes. There is a charge for the eyesight test, but it is free for individuals aged 60 and older, or who are registered blind or partially sighted, or who have diabetes or glaucoma. Eyesight tests have been free in Scotland since 2006.[15] For dental screening and eyesight tests the individual dental or optometry practices can decide on sending invitation letters.

Economic models of the demand of health care in general, and preventative care in particular, are based on human capital models.[16] This framework has also been used for the modelling of demand for primary and secondary prevention.[17] These categories of

prevention are self-protection measures that improve early detection and health outcomes.[18] The problem with economic models of prevention is that two important aspects are typically not considered at the same time in detail: the distinction between acute and preventative care, and uncertainty. Some dynamic economic models for the demand of health care take only uncertainty into consideration, no distinction being made between acute and preventative care.[19] Acute care describes the consumption aspect of health whereas preventative care describes the investment aspect. The (simplified) Grossman model makes the distinction between acute and preventative care, but uncertainty is not considered in this model.[20] Only one economic model explicitly considers both the demand for preventative health care, using a stochastic dynamic framework.[21] However, in this article no non-economic factors were considered. Our conceptual framework is based on a human capital approach[21] and as an extension, non-economic factors such as non-monetary barriers are included. Our approach is also supported by previous research which has investigated determinants of different types of screening examinations.[22]

Information about the uptake of these different health check-ups over a period of nearly 20 years is available in the British Household Panel Survey (BHPS). Only one study has compared these different NHS health check-ups from 1991 to 2003.[23] However, this study analysed not the influence of health related and socioeconomic characteristics on the uptake and estimated random effects panel probit models only with unbalanced panels, with the potential problem of attrition bias, and as a consequence selection bias in the estimates can occur.[24] The influence of household and individual characteristics on

uptake is analysed in our study and also the effects of transitory and permanent household income on uptake. Also in our analysis the effect of changes in the medical screening guidelines on the uptake for three health check-ups (cervical cancer screening, breast cancer screening and dental screening) are additionally considered. Therefore, our analysis compares how past screening behaviour, individual and household characteristics and changes of medical screening guidelines affect uptake of these different health check-ups.

Participation in breast or cervical cancer screening examinations in past periods has predictive value for the uptake in the actual period, i.e. past screening behaviour is correlated with current behaviour.[22 25 26] Age can have different effects on the demand for prevention.[27 28] For breast and cervical cancer screening examinations, medical guidelines exist with explicit recommendations on how often screening should be done in certain time intervals, and for the recommended age intervals uptake should be higher than for non-recommended age intervals. However, on one hand according to the Grossman model health depreciates at an increasing rate at older ages, and the necessity to maintain health increases and as a consequence the demand for preventive activities increases. On the other hand, older individuals have a shorter life span and pay-off period for their investment in prevention activities. Therefore the effect of increasing age on uptake cannot be predicted with confidence. Empirical studies often find a negative relationship between age and uptake of health check-ups.[28 29] Studies which analysed possible gender differences in the utilization of health care services found that females have a higher utilization of health care services[30] and also a higher use of preventative services

including blood pressure checks, cholesterol tests and dental screening.[31] Higher educational level may be expected to lead to an increase in the demand for prevention services, because individuals with a higher education may have higher efficiency in the production of health and also increased self-efficacy, higher confidence and motivation.[17 25 28 29] Individuals who live in a partnership have a higher propensity for screening examinations and living in a partnership may be a proxy for having a more dense social support network that encourages individuals to take part in prevention activities and some empirical studies have confirmed this hypothesis.[32 33] A higher number of children in the household can influence screening behaviour through time constraints.[25 34] Household income may be expected to lead to an increase in the demand for prevention services, because higher income leads to an increase in demand for time in perfect health.[16 20] In some studies, increasing household income increased uptake of preventive care,[27 28 35] although the effect may be weaker in the UK compared to other countries, because most preventative services are free in the UK. Employment was added as a further control variable, because individuals who work may have higher opportunity costs in comparison to unemployed and retired individuals. In a systematic review of the influence of different determinants on the uptake of health check-ups, influence of employment for the uptake of different health check-ups was found to be inconsistent. The GP plays a role as gatekeeper in the UK health care system and can give advice and information about the importance of health check-ups for the early detection of diseases, and therefore uptake may be enhanced by previous GP visits.[36 37] Cervical cancer screening, blood pressure checks and cholesterol tests can be done in a GP practice. Poor self-rated health status and existing general health problems could encourage people to think about their health

in general and therefore to invest in health and to increase participation in screening examinations, and this seems to be the case for general health check-ups such as blood pressure check and cholesterol test, but not for female specific cancer screenings such as the mammography and the smear test.[27] Psychological factors such as fear and anxiety about receiving a cancer diagnosis may deter some women from attending one of these health check-ups. Furthermore, individuals in a poor health state may not be able to visit the screening location such as the GP, family clinic or mammography unit, the dentist or the optometrist, because of physical limitations. There are contradicting findings on the effect of poor health status on the uptake of health check-ups, with increased uptake of cholesterol checks and a lower uptake of mammograms and pap smears.[38] Smoking can serve as an indicator for the weakened preference of an individual for health in comparison to other goods and smoking individuals show risk taking behaviour.[39] Individuals who smoke have poorer preventative health habits such as a reduced level of physical activity in comparison to non-smoking women.[40] The predicted influence of smoking on uptake was empirically confirmed for breast cancer screening with a lower uptake for smoking women.[28] For individuals with non-white ethnic origin cultural barriers may exist, and this is especially the case for breast and cervical cancer screening. In an empirical investigation ethnicity was the most important predictor for cervical cancer screening, with white British women having a higher uptake than women of other ethnicity. Registration with a GP is a necessary condition for receiving an invitation letter for breast and cervical cancer screening and routine periodic invitations are sent from the GP according to the recommended interval for breast and cervical cancer screening. A changed residence and address of a woman lowers the chance to receive an invitation

letter. A lower uptake of cervical cancer screening was found in one study for women in UK who had changed residence and address,[34] but not in another one.[25]

METHODS

It is sensible for our estimation to consider how screening behaviour was in the past time and the recommended time interval for a screening examination (e.g. for breast and cervical cancer screening examinations the recommended 3 year intervals), because there is an increased likelihood of participating in a screening examination after the recommended time interval. Additionally, there exists also the possibility that screening examinations are recommended in shorter time intervals if an individual belongs to a high risk population such as in the female cancer screening examinations with close relatives with a history of breast or cervical cancer. Also there exists for all the different health check-ups the possibility that an inconclusive check-up in the actual year has a consequence a control follow check-up in the next year. With the BHPS it is not possible to differentiate between routine check-ups according to the screening guidelines or as a response to an inconclusive result from a health check-up in the previous year or as an advice to do a health check-up from a GP. To include these different possibilities for the analysis of uptake behaviour a dynamic specification with lags for the last 3 years was chosen for the different health check-ups. To model the dynamic nature of screening examinations and because uptake is a binary variable, a dynamic random effects (RE) panel probit model was used to estimate the uptake of NHS health check-ups over the panel period from 1992 to 2008. The advantage of such a specification is that the uptake of health check-ups is not only explained by individual and household characteristics, but

also at the same time by past screening behaviour and therefore persistence in screening behaviour (state dependence). A further advantage of this econometric specification which uses panel data and not cross-sectional data is that both individual heterogeneity and state dependence can be considered in a dynamic panel data model, which is not possible in a model for cross-sectional data. One possibility for estimating a dynamic random effects (RE) panel probit is the Mundlak-Wooldridge estimator that specifies a relationship between the unobserved time-invariant individual effect and the observed characteristics and initial conditions,[41] and the econometric model is given by the following 3 equations (1), (2), (3).

$$y^*_{it} = \gamma_1 y_{it-1} + \gamma_2 y_{it-2} + \gamma_3 y_{it-3} + x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (1)$$

In the first equation y^*_{it} indicates the unobserved latent variable of an individual i at a given time t for taking part in a specific screening exam, y_{it-1}, y_{it-2}, y_{it-3} are the screening examination decisions of the individual i 1, 2 and 3 periods before t and γ_1, γ_2, γ_3 are the related coefficients for these variables, x is a vector of time variant and time invariant covariates, β is the vector of coefficients associated with these covariates, ε_{it} is the random error term and α_i indicates the individual specific term for time invariant unobserved variables which is modelled according to equation (2) as individual specific random effect:

$$\alpha_i = \delta_1 S_{i1} + \delta_2 S_{i2} + \delta_3 S_{i3} + + \delta_4 \overline{X}_i^{'} + \upsilon_i \quad (2)$$

A normal density for the individual specific random effect is assumed and the first three terms are the initial conditions with the uptake of the specific health check-up for an individual *i* in the first three periods of the panel: S_{i1}, S_{i2} , S_{i3}.The fourth term allows correlation between the time-varying variables of an individual by including the average $\overline{X}_i^{'}$ over the whole panel observation period and the individual specific random effect,[42] which divides the time-varying variables into a transitory and permanent component for the estimation. ν_i is the error term assumed normally distributed with zero mean and standard deviation σ_α. This specification has the advantage that time-invariant unobserved variables which are correlated to time-varying variables are captured by the mean of these variables and give a less biased estimate of the transitory component of these variables. The third equation gives the observed binary outcome y_{it} of taking part in a specific health check-up for individual *i* in period *t*.

$$y_{it} = \begin{cases} 1, if \;\; y_{it}^* > 0 \\ 0, otherwise \end{cases} \quad (3)$$

The chosen Mundlak-Wooldridge specification has the advantage that under certain assumptions the bias which is caused by the persistence of screening behaviour is removed. Crucial assumptions for the estimation of the dynamic random effect model are that the relationship between the unobserved time-invariant individual effect and the mean of the observed characteristics is correctly specified and also the distributional

assumptions on the initial conditions are correct. The breast cancer screening programme (NHSBSP) and cervical cancer screening programme (NHSCSP) were introduced in 1988 before the beginning of the BHPS and also the four other health check-ups had been available to individuals before the BHPS had started. For our estimation technique it is assumed that the health check-ups that had been undertaken before the first wave of the BHPS are uncorrelated with the health check-ups recorded in the BHPS. If this assumption is violated, the inclusion of initial conditions of health check-ups for the years 1992 to 1994 could result in biased estimates for our regressions. An advantage of our statistical approach is that some previous analyses have investigated the uptake of health check-ups with cross-sectional data and therefore could not control for unobserved heterogeneity, and other analyses used unbalanced panel data sets for their estimation.[23 25] Estimation of unbalanced panels with ad hoc treatments of initial problems has unfavourable estimation properties and could result in biased estimation as has been shown by simulation studies.[24] The estimation results of balanced panels are more reliable, because balanced panels satisfy the assumptions of the Mundlak-Wooldridge estimator.[43 44] Therefore, estimation of balanced panels for the different health check-ups was preferred over unbalanced panels. An alternative to the Mundlak-Wooldridge estimator would be the maximum likelihood estimator proposed by Heckman,[45] however for balanced panels with more than 5 to 8 periods the finite sample properties of the Mundlak-Wooldridge estimator are better.[24]

We used the BHPS, which is an annual survey of households in UK. It is a nationally representative sample of more than 5,000 households and individuals aged 16 and over.[46]

The first wave of the data collection for this survey started in 1991 and all the original individuals were interviewed in each succeeding year unless they dropped out. Questions about taking part in NHS health checks-up have been in every wave from the start of the panel survey in 1991 until 2008. For the analysis of breast and cervical cancer screening, only females were included, for all other types of health check-ups both males and females were included. In our analysis and construction of the balanced sample only individuals from England, Wales and Scotland were selected, because data collection started in Northern Ireland from wave 11 and not from the first wave. For the construction of the balanced panel 17 years of information were used: from 1992 to 2008, because in the first wave only a small number of individuals were interviewed in 1991. For an individual to be included in our analysis, provision of the specific health check-up had to be from the NHS; individuals with private provision or with NHS and private provision for a specific health check-up have been excluded from the analysis. The dependent variable takes the value of 1 in a specific year if the specific health check-up (breast cancer screening, cervical cancer screening, blood pressure check, cholesterol test, dental test, eyesight test) was done and 0 if not. For analysing the changes in the medical screening guidelines for 3 different health check-ups (breast cancer screening, cervical cancer screening, dental screening) a dummy coding was chosen: for breast cancer screening and age group 65-70, all years before and including 2002 were coded with 0 and all the following years with 1; for cervical cancer screening and age group 25-49 all years before and including 2003 were coded with 0 and all the following years with 1; for dental screening all years before and including 2004 were coded with 0 and all the following years with 1.

The balanced panel included for breast cancer screening 861 women with 12,054 observations, for cervical cancer screening 867 women with 12,138 observations, for blood pressure checks 1,405 individuals with 19,670 observations, for cholesterol tests 1,568 individuals with 21,952 observations, for dental screening 706 individuals with 9,884 observations and for eyesight tests 613 individuals with 8,582 observations.

In our analysis, for cervical cancer screening we used the age groups of the screening guidelines: 16 to 19 (reference group), 20 to 24, 25 to 49, 50 to 64, and aged 65 and older. For breast cancer screening, we followed also the age groups of the screening guidelines: 16 to 49 (reference group), 50 to 64, 65 to 69, and aged 70 and older. For all other screening checks, the following groups were used: 16 to 39 (reference group), 40 to 49, 50 to 59, 60 to 69, 70 to 79 and 80 and older. For blood pressure checks and cholesterol tests, we included information on whether the person had diabetes or also heart/blood pressure/blood circulation problems, and for eyesight tests, information on eyesight problems was used. Actual (transitory) income was defined as the total equivalised and deflated household annual income divided by 100 and permanent household income was defined as annual household income over the 17 years between 1992 and 2008. Household income was deflated and transformed in per capita income using the modified OECD scale to allow for household size and needs.[47] The International Standard Classification of Education (ISCED) was used for the categorisation of educational levels with tertiary, secondary and primary education (reference category). Household income was deflated and transformed into per capita income using the modified OECD scale to

allow for household size and needs.[47] Health status was self-rated and included in our analysis with categories from excellent (1) as reference category in regressions, good (2) fair (3), poor (4) to very poor (5).[48]

RESULTS

Table 1 presents descriptive statistics for the variables used in our estimation for the balanced panels for the different health check-ups.

Table 1: Sample characteristics for the balanced panels of different health check-ups in UK

For the period 1992 to 2008 there were the following uptake rates within one year for individuals for the balanced panel: 13.9% for breast cancer screening, 20.4% for cervical cancer screening, 51.2% for the blood pressure check, 19.5% for the cholesterol test, 57.6% for dental screening and 34.4% for the eyesight test.

Table 2 provides the estimated coefficients for the dynamic random effects (RE) probit model with initial conditions for the balanced panel (BP) for the different health check-ups.

Table 2: Parameter estimates and standard errors for the uptake of health check-ups in

UK

For all health check-ups, taking part in past screening examinations showed a strong influence on the current screening examination. The effect of having the same screening examination one year ago was strongest for dental screening. The magnitude of the effects, the marginal effects, are shown in table 3 and for dental screening examinations there was an increase of 18.2% if there has been a visit one year before.

Table 3: Marginal effects and standard errors for main predictors of uptake for health check-ups in UK

The effect of having the same screening examination three years ago was similar for breast and cervical cancer screening and the marginal effects resulted in an increase in uptake of 12.3% and 12.6% %. For individuals who visited their GP in the last year, there was an increase for 5 of the 6 analysed health check-ups with only the eyesight test not significant, the increase being highest for blood pressure with a 25.9% increase and lowest for dental screening with a 1.7% increase. Poor self-rated health status increased the uptake of blood pressure checks by about 12.6% and cholesterol tests about 4.5% and for the eyesight test poor health status increased the uptake by 5.4%. For breast and cervical cancer screening there was no significant influence of poor health status on uptake. Women aged between 50 and 64 had an increased uptake of 9.9% for breast cancer screening and women aged between 25 and 49 had an increased uptake of 7.3% for cervical cancer screening in comparison to the reference categories. Also for the other

four health check-ups there was a nonlinear relationship between age and uptake. For blood pressure check, cholesterol test and eyesight test uptake increased nonlinearly for the different age categories. Women aged between 65 and 70 had a higher uptake of breast cancer screening after 2002; an increase of 7.9% for this age group in comparison to the years before. Women aged between 25 and 49 had a 2.5% lower uptake of cervical cancer screening after 2003 in comparison to women of this age group before 2003. Individuals who had a dental screening after 2004 did not have a significant changed uptake in comparison to the years before.

Females had a higher uptake in three of the four analysed health check-ups that are not sex-specific (blood pressure check, dental screening, eyesight tests), but the influence on the uptake of the cholesterol tests was non-significant. The increase in uptake for females was highest for eyesight tests with an increase of 4.4%. The marginal effects for education, employment status, household income, living with a partner, smoking, changed residence status were non-uniform for the different health check-ups. The effect of secondary and tertiary education was strongest for the uptake of dental screening (30.5% and 28.3% increase). Being employed decreased the uptake for breast cancer screening by 3.1%, for blood pressure checks by 2.5% and cholesterol test by 2.2%. Increasing actual household income had no significant effect on any of the uptakes. Living with a partner increased the uptake of dental screening by 3.8%. Smoking decreased the uptake of breast cancer screening by 3.3%, blood pressure checks by 6.3%, cholesterol tests by 2.9% and dental screening by 3.2%. An additional child in the household decreased the uptake of breast cancer screening examinations and blood

pressure checks by 2.1% and 2.4%. Change of residence decreased the uptake of dental screening by 3.5%; however, it increased the uptake of blood pressure checks by 3.6%. Individuals with existing blood pressure problems or diabetes had increased uptake of blood pressure checks by 22.5% and 11.1% and for cholesterol tests by 8.9% and 13.2%. Individuals with existing eyesight problems and diabetes health problems had an increased uptake for eyesight tests of 11.1% and 29.4%. Permanent equivalised household income increased the uptake of dental screening and eyesight tests by 2.5% and 1.8%. Initial conditions show significance for all health-check-ups.

DISCUSSION

Our analysis compared the determinants of the uptake of six health check-ups in UK using the BHPS from 1992 to 2008 (excluding Northern Ireland). We investigated which determinants were the same for all health check-ups and which determinants differed for determining uptake with a focus on the importance of past screening behaviour on actual screening behaviour and health related variables.

The strong positive significant effect of past screening behaviour shows that past behaviour influences current behaviour and this result can be interpreted as persistence in screening behaviour in the sense of state dependence.[49 50] Reasons for the strong positive state dependence are the adherence to the medical screening guidelines in UK such as the NHS Breast and Cervical Screening Programme with explicit recommendations for the time interval between screening examinations. The relevance of these screening

guidelines on current behaviour can be seen in the high predictive value of these coefficients for these specific health check-ups 3 years before. Also the coefficient for the same specific health check-up one year before was significantly positive for all the different health check-ups. Persistence in screening behaviour, control follow-ups to check unclear test results from the previous health check-up and shorter recommended time intervals for some of the analysed health check-up (blood pressure check, cholesterol test, dental screening, eyesight test) could explain our results. However, with data from the BHPS it is not possible to differentiate between these different possibilities. Initial conditions show relevance in all analysed screening examinations. If initial conditions for the first three years had not been taken into account, the influence of past screening behaviour on actual behaviour would have been overestimated. For women the uptake of breast and cervical cancer screening is higher in the age group for which it is recommended than in the reference groups. There is a lower uptake of dental screening for older ages in comparison to persons of middle age, and this result is in accordance with another study.[51] The finding of decreasing screening uptake with increasing age is in accordance with the shorter pay-off period for older individuals from the human capital theory approach. For blood pressure checks, cholesterol tests and eyesight tests uptake increases with age and our results can be explained by the increasing prevalence of hypertension, high cholesterol and eyesight problems with age and the necessity to check these specific health problems.

The significance of a GP visit in the year before the actual wave, for all the included health check-ups with the exception of non-significance for the eyesight test, can be

explained by the fact that the GP plays an important role as gatekeeper in the UK and also an important role in access to prevention by giving advice about accepting a health check-up or by doing the screening examination[37] as it the case for cervical cancer screening, blood pressure check or cholesterol test. However, the importance of the GP is also significant for the health check-ups which are done outside of practice: breast cancer and dental screening. Our results reflect those in an Italian study which analysed the uptake of cervical cancer screening with a recursive probit. The regulations for having a smear test are very similar in Italy and UK with respect to the role of the GP in cervical cancer screening. In both countries a visit to the GP is not an essential condition for the provision of a smear test and this test can also be done in specialized services.[29] Estimations from the Italian study showed that GP visits led to an increased uptake of cervical screening. The effect of self-assessed health status is dependent on the specific health check-up. The uptake of blood pressure checks and cholesterol tests increased with a deteriorating self-assessed health status and was highest for individuals in a very poor health state. Both these health check-ups are often included in a general health check-up for the health status of an individual. The interpretation of health status as a proxy for health stock is most valid for these two health check-ups in comparison to the other health check-ups as individuals in a poor health status have a high demand for these two health check-ups in order to increase their health stock. However, poor self-assessed health status can influence uptake also in other ways such as changed perceptions on the preventability of health problems and diseases. Individuals with poorer health status also expressed less interest in receiving prevention information in another study.[52] Psychological factors such as fear and anxiety about confirmation of a disease can be

related to a poor health status and this correlation could be especially relevant for the both analysed female cancer screening examinations. Also individuals with a poor health status could be less able to visit the screening location and these interpretations could explain why such individuals have a lower uptake such as for cervical cancer screening. Individuals with blood pressure or diabetes problems had a higher propensity for the blood pressure checks and cholesterol tests and also individuals with eyesight problems had a higher propensity for the eyesight tests, in accordance with the medical guidelines. This is to our knowledge the first analysis that compares the uptake rates of blood pressure checks and cholesterol tests for individuals who have blood pressure and diabetes problems with individuals without having these diseases in a longitudinal setting for UK. Smoking had an influence on the uptake of breast cancer screening, blood pressure screening, cholesterol tests and dental screening, but not the other 2 health check-ups. These results are in accordance with the interpretation that smokers have a risk taking behaviour, however the effect of smoking with a reduced uptake on health-check is not found in all studies as a systematic review has shown.[22]

Only the change of medical screening guidelines to extend breast cancer for women of age 65 to 70 screening had the intended effect. For breast cancer screening there was a higher uptake after 2002 in the age group of 65 to 70. Comparing the uptake rates for cervical cancer screening before and after changing the recommended time interval in 2003 from 5 to 3 years for women of age 25 to 49 shows a decrease in uptake rates. This result can be explained by a comparison of our result with official statistics data for the coverage rate of the target age groups for cervical cancer screening, because official

statistics data show a declining uptake rate over time and this time trend is especially visible in the age group 25-49.[53] The recommendation of extending the time interval from 6 months to 1 to 2 years for dental screening after 2004 did not have an effect on uptake. The reason why the change in the medical screening guidelines for breast cancer screening had the intended effect could be based on the fact that timed appointments are made and it has a strictly policed screening interval.

The results for the socioeconomic variables are mixed for the different health check-ups. For women, uptakes were higher for blood pressure checks, dental screening and eyesight tests, and lower for of cholesterol tests and these results were in agreement with a recent study from the United States.[31] Education to secondary or tertiary levels had a positive significant influence on the uptake of dental screening. Education has often been found to be an important predictor of uptake of health check-ups, but not always.[22] The hypothesised influence of higher education is only visible in one health check-up (dental screening). This result is in part explained by education being correlated with other socioeconomic variables and the inclusion of further socioeconomic variables could explain why the effect on education disappears in other regressions. Non-uniform results were also found for other socioeconomic variables for the different analysed health check-ups: employment status as a proxy for opportunity costs of time had a significant negative effect on breast cancer screening, blood pressure checks and cholesterol tests, living with a partner as a proxy for social support and network had only a significant positive effect for dental screening and number of children as a proxy for a possible time constraint led to a significant negative effect for breast cancer screening and blood

pressure checks. In a systematic review which analysed the determinants of screening uptake for different cancer screenings and other different health check-ups, none of the socioeconomic variables were significant in all screening examinations.[22] Our results confirm the result of this systematic review that for different screening examinations different socioeconomic variables are of relevance. Ethnicity had no significant influence on any of the health check-ups, suggesting that ethnicity is not a cultural barrier for access to preventative services. In comparison with our results, another study using the BHPS that analysed an unbalanced panel found for cervical cancer screening a lower uptake for Asian women in comparison to women of other ethnic origin.[25] Changed residence and address with a higher chance for not receiving an invitation letter has influenced the uptake rate of the various health check-ups unequally: women who had changed residence and address within the UK did not have a lower uptake for breast and cervical cancer screening and so the effectiveness of sending invitation letters for these both female screening examinations is questionable. In opposite to these both female cancer screening examinations it was found that for dental screening a changed residence resulted in a lower uptake for dental screening. The implementation for the different health check-ups with sending routine periodic invitation letters to individual women for breast and cervical cancer screening, with the decision about invitation left for individual practices for eyesight test and dental screening and as an invitational programme for blood pressure check and cholesterol test could have influenced the uptake rates for the different health check-ups in different ways, however there is no information in the BHPS available how the invitational programmes are implemented on an individual practice level. There was no regional effect on uptake of health check-ups.

Averaged (permanent) household income had a significant influence only on the uptake for dental screening and eyesight tests and actual (transitory) household income had no effect on any of the analysed health check-ups. This result is important in comparison with the other analysed free health check-ups, because income effects exist for access to preventative health services for which a charge has to be paid in comparison to preventative services for which no charge exist. Permanent income effects could also be caused by unobserved time-invariant factors that have an influence on income and uptake. Another study which estimated the uptake of the health check-ups with unbalanced panels using the BHPS from 1991 until 2003 confirmed our results only in part, because a transitory income effect was found for the blood pressure check and a permanent income effect was found for dental screening.[23] The averaged value of a GP visit during the last 12 months variable was correlated in five of the six health check-ups with the individual specific term for time invariant unobserved heterogeneity.

There are some differences when comparing our results on the uptake of breast and cervical cancer screening with other studies which had analysed the uptake behaviour for UK and used the BHPS as sample. Analysis of breast cancer screening uptake with the BHPS was done in one analysis with a balanced sample.[26] Identical results were found for the relevance of previous screening history, a GP visit, age and self-assessed health status, however results were different to own results for smoking status, education level, marital status and the averaged income term, because they were significant in this analysis. The different results for the latter mentioned variables are best explained by

choosing different specifications in the two empirical analyses. Analysis of cervical cancer screening uptake with the BHPS was done in a further analysis with a balanced sample. In our analysis previous screening history, age and a GP visit were significant for cervical cancer screening in the UK and our results were confirmed by this study which analysed uptake of cervical cancer screening uptake in England with an unbalanced panel for the first 12 waves of the BHPS until 2003.[25] The coefficients for education, smoking and changed residence status were not significant in our analysis. The differences in results for the variable education and smoking are remarkable, because in our analysis they had not been significant. However, also some other studies have found no influence of education[22] and smoking status[54] on screening behaviour. Only one analysis compared the sociodemographic determinants for the uptake of breast and cervical cancer screening at the same time for UK with a cross-sectional survey.[2] Results for the effects of determinants on the uptake of both female cancer screening examinations were different, because for mammography level of education, occupational classification and ethnicity were not significant and only indicators for wealth were positively significant. For having a smear test a higher educational level, and white British ethnicity were positively significant, but not indicators for wealth or occupational classification. This is one of the few studies that compared the determinants of the uptake of breast and cervical screening and found different determinants to be responsible for the uptake of both screening examinations. An advantage of this analysis was that is used the same estimation sample for the analysis, however unobserved heterogeneity and state dependency could not be taken into account with cross-sectional data in this analysis and this could explain the different results to the results of our own study. One study with the BHPS found in a

descriptive analysis that females reported a higher uptake than males for dental check-ups under NHS provision.[51] Individuals between age 46 and 55 years had the highest proportion of dental check-ups with 72% in 2000 and the lowest participation rate was for individuals of age 66 years and older with 43% in 2000. These results are confirmed in our analysis. Another study which used the BHPS to investigate the probability of making a dental check-up visit in 1, 3, 5 and 10 years in comparison to the baseline period of 1991 found that in each of these time periods from 1991 to 2001 females, more educated and non-smokers had a higher uptake which is in accordance with own results. However, in contrast with our own results persons below age 40 had the highest rate of uptake and this result could be explained by the fact that only a distinction between individuals below age 40 and above age 40 was made.[55]

A first limitation of our study is there is no information about results from previous screening examinations available and it is not possible to differentiate between types of health check-ups: preventative health check-ups according to screening guidelines, health check-ups following the advice of a GP or consultant to do a test, or health check-ups which are in response to previous inconclusive results. A second limitation of our study is that no information was available about level of trust in the NHS or in the GP, because it has been shown that taking part in screening examinations can be dependent on trust.[29] A third limitation exists, because there was no information available about the characteristics of the primary care factors that have been shown to be associated with the uptake of screening examinations in England.[56] Characteristics of the professional performing of the screening test, structure and organization of medical services can

influence the uptake rate. A fourth limitation of our study comes from not using detailed microgeographic information, because uptake rates for a specific health check-up can be higher in affluent and less deprived areas.[57]

CONCLUSIONS

Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, health status, and existing health problems for these six different health check-ups. A further innovative feature of our study is the analysis of the uptake of different health check-ups with a random effects panel probit model with initial conditions (Mundlak-Wooldridge estimator) and a balanced sample, because some other analyses have used cross-sectional data and unbalanced panels with the possible problem of an attrition bias. Our research shows the high importance of past screening behaviour for each of the analysed health check-ups for recent screening behaviour and it is important, therefore, to maintain a high level of prevention uptake. The GP plays a central role in the uptake of screening examinations and this role in prevention in the UK health care system should not be weakened. Existing diseases are as expected important predictors for the specific health check-up. Income barriers could be removed for health check-ups such as dental screening and eyesight tests to increase the uptake for individuals with limited financial possibilities. Future research could use information about results from previous screening examinations and microgeographic information by linking with other data sources.

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Contributions

AL performed statistical analyses. AL, RB and FP discussed the results, and contributed to the text of the manuscript. All three authors reviewed the manuscript.

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Competing financial interests

The authors declare no competing financial interests.

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Table 1: Descriptive statistics with proportions for the balanced panels of different health check-ups in UK

Health check-up	Breast cancer screening	Cervical cancer screening	Blood pressure check	Cholesterol test	Dental screening	Eyesight test
Health check-up in actual period t	0.139	0.204	0.512	0.195	0.576	0.344
Health check-up in 1992	0.150	0.295	0.419	0.095	0.492	0.227
Health check-up in 1993	0.144	0.296	0.421	0.112	0.506	0.238
Health check-up in 1994	0.127	0.296	0.425	0.100	0.528	0.217
Health check-up one year before (t-1)	0.137	0.213	0.500	0.178	0.572	0.329
Health check-up two years before (t-2)	0.136	0.222	0.488	0.164	0.562	0.316
Health check-up three years before (t-3)	0.135	0.231	0.475	0.149	0.558	0.303
HH income (mean/sd)	3.134/1.857	3.124(1.862)	3.062(1.819)	3.158(1.900)	2.856(1.762)	2.812(1.823)
Living with partner	0.727	0.732	0.760	0.768	0.735	0.735
Number of children in HH (mean/sd)	0.531/0.919	0.526(0.916)	0.540(0.927)	0.547(0.926)	0.545(0.948)	0.601(0.984)
Secondary education (ISCED)	0.430	0.433	0.424	0.427	0.399	0.434
Tertiary education (ISCED)	0.324	0.320	0.338	0.349	0.306	0.274
Employed	0.524	0.522	0.562	0.588	0.504	0.520
GP visit during last 12 months	0.810	0.811	0.765	0.756	0.764	0.747
Health status self-rated good	0.477	0.482	0.475	0.479	0.479	0.462
Health status self-rated fair	0.236	0.237	0.238	0.233	0.254	0.248
Health status self-rated poor	0.072	0.072	0.070	0.068	0.083	0.080
Health status self-rated very poor	0.020	0.020	0.016	0.016	0.024	0.023
Smoking	0.164	0.166	0.176	0.172	0.215	0.221
Moved residence	0.049	0.048	0.053	0.054	0.050	0.056
Scotland	0.080	0.078	0.079	0.076	0.090	0.077
Wales	0.052	0.052	0.050	0.051	0.045	0.064
Ethnic origin non-white	0.012	0.011	0.001	0.012	0.011	0.015
Age (mean/sd)	52.51/15.29	52.62(15.27)	52.35(15.65)	51.83(15.37)	53.58(15.67)	52.08(15.90)
Female sex			0.593	0.567	0.575	0.544
Health problem blood pressure			0.232	0.221		
Health problem diabetes			0.049	0.045		0.069
Health problem sight						0.049

Source: BHPS. Balanced panels consisted for breast cancer screening of 861 women from 12,054 observations, for cervical cancer screening of 867 women from 12,138 observations, for blood pressure check of 1,405 individuals from 19,670 observations, for cholesterol test of 1,568 individuals from 21,952 observations, for dental screening of 706 individuals from 9,884 observations and for the eyesight test of 613 individuals from 8,582 observations.

Table 2: Parameter estimates and standard errors for the uptake of health check-ups in UK

Health check-up	Breast cancer screening	Cervical cancer screening	Blood pressure check	Cholesterol test	Dental screening	Eyesight test
Health check-up in 1992	0.092(0.064)	0.229***(0.044)	0.107***(0.035)	0.139**(0.055)	0.488***(0.079)	0.373***(0.065)
Health check-up in 1993	0.044(0.065)	0.195***(0.045)	0.102***(0.036)	0.115**(0.054)	0.223***(0.085)	0.343***(0.064)
Health check-up in 1994	0.175***(0.066)	0.142***(0.047)	0.202***(0.037)	0.233***(0.054)	0.591***(0.089)	0.290***(0.067)
Averaged HH income	-0.015(0.026)	0.008(0.022)	-0.014(0.018)	0.003(0.019)	0.134***(0.037)	0.068**(0.029)
Averaged living with partner	0.117(0.135)	0.017(0.107)	-0.007(0.076)	0.102(0.090)	-0.115(0.129)	0.064(0.115)
Averaged number of children in HH	0.032(0.064)	0.022(0.046)	0.012(0.037)	-0.064(0.044)	0.084(0.068)	0.063(0.058)
Averaged secondary education (ISCED)	-0.604(0.423)	-0.169(0.383)	-0.005(0.213)	0.466(0.323)	-1.691***(0.453)	-0.244(0.339)
Averaged tertiary education (ISCED)	-0.498(0.517)	-0.245(0.427)	0.030(0.241)	0.716**(0.351)	-1.495***(0.479)	-0.143(0.371)
Average status employed	0.384***(0.105)	-0.041(0.093)	0.173**(0.075)	0.152*(0.081)	-0.073(0.141)	-0.038(0.117)
Averaged GP visit during last 12 months	0.460***(0.141)	-0.037(0.120)	0.240***(0.090)	0.243**(0.098)	0.587***(0.164)	0.840***(0.143)
Averaged health status self-rated good	0.006(0.127)	-0.029(0.107)	-0.086(0.082)	0.052(0.094)	-0.101(0.174)	-0.118(0.145)
Averaged health status self-rated fair	-0.021(0.151)	-0.131(0.136)	-0.217**(0.100)	-0.194*(0.109)	-0.225(0.200)	-0.303*(0.171)
Averaged health status self-rated poor	0.207(0.247)	0.189(0.235)	-0.293(0.187)	-0.022(0.179)	-0.315(0.313)	-0.306(0.283)
Averaged health status self-rated very poor	-0.353(0.432)	0.129(0.378)	-0.420(0.333)	0.078(0.294)	-0.471(0.456)	-0.420(0.438)
Averaged status smoking	0.118(0.141)	-0.154(0.118)	0.188**(0.081)	0.195**(0.091)	-0.113(0.128)	-0.042(0.119)
Averaged status moved residence	-0.487(0.379)	0.121(0.293)	-0.003(0.211)	-0.418*(0.248)	0.069(0.427)	0.021(0.354)
Averaged age	0.029***(0.004)	-0.006(0.004)	-0.016***(0.003)	-0.030***(0.003)	-0.006(0.006)	0.000(0.005)
Averaged Health Problems Blood Pressure			0.317***(0.083)	0.001(0.075)		
Averaged Health Problems Diabetes			0.166(0.162)	-0.264*(0.144)		-0.254(0.192)
Averaged Health Problems Sight						-0.046(0.232)
Health check-up one year before (t-1)	0.115**(0.048)	0.233***(0.039)	0.501***(0.027)	0.950***(0.035)	1.014***(0.051)	0.247***(0.041)
Health check-up two years before (t-2)	-0.030(0.048)	-0.286***(0.039)	0.215***(0.028)	0.352***(0.037)	0.385***(0.053)	0.350***(0.041)
Health check-up three years before (t-3)	0.814***(0.044)	0.570***(0.036)	0.158***(0.028)	0.238***(0.038)	0.265***(0.052)	0.101**(0.041)
HH income	0.006(0.015)	0.005(0.013)	0.002(0.010)	0.009(0.011)	-0.024(0.017)	-0.023(0.016)
Living with partner	0.034(0.116)	0.136(0.086)	0.065(0.060)	-0.040(0.076)	0.215**(0.097)	-0.061(0.087)
Number of children in HH	-0.135***(0.048)	-0.001(0.031)	-0.095***(0.025)	-0.007(0.033)	-0.002(0.042)	-0.008(0.038)
Secondary education (ISCED)	0.645(0.418)	0.180(0.377)	0.094(0.209)	-0.467(0.319)	1.715***(0.445)	0.247(0.332)
Tertiary education (ISCED)	0.581(0.511)	0.278(0.419)	0.115(0.235)	-0.662*(0.346)	1.585***(0.467)	0.160(0.360)
Employed	-0.205***(0.065)	0.055(0.056)	-0.098**(0.045)	-0.144***(0.054)	-0.040(0.078)	-0.094(0.064)
GP visit during last 12 months	0.169***(0.058)	0.419***(0.048)	1.036***(0.034)	0.664***(0.046)	0.096*(0.055)	0.070(0.050)
Health status self-rated good	0.075(0.063)	-0.039(0.050)	0.079**(0.038)	0.046(0.048)	-0.036(0.070)	0.066(0.061)
Health status self-rated fair	0.031(0.076)	-0.031(0.062)	0.303***(0.046)	0.184***(0.056)	-0.057(0.081)	0.140*(0.073)
Health status self-rated poor	0.014(0.101)	-0.048(0.089)	0.505***(0.066)	0.288***(0.072)	-0.156(0.106)	0.203**(0.095)
Health status self-rated very poor	0.048(0.152)	-0.253*(0.144)	0.669***(0.122)	0.448***(0.111)	0.262*(0.154)	0.076(0.142)
Smoking	-0.218*(0.123)	0.131(0.100)	-0.251***(0.067)	-0.184**(0.079)	-0.186*(0.099)	-0.059(0.093)
Moved residence	0.051(0.092)	-0.063(0.070)	0.146***(0.051)	0.023(0.066)	-0.207**(0.086)	-0.075(0.081)
Scotland	0.013(0.088)	0.028(0.075)	0.050(0.056)	0.026(0.059)	0.046(0.104)	0.020(0.098)
Wales	0.147(0.098)	-0.129(0.093)	-0.063(0.070)	-0.039(0.070)	-0.114(0.144)	-0.030(0.107)
Ethnic origin non-white	0.195(0.199)	-0.242(0.188)	0.143(0.146)	-.074(0.146)	-0.207(0.271)	-0.249(0.221)
Age 50-64	0.644***(0.046)					
Age 65-70	-0.645***(0.093)					
Age 71 and older	-1.149***(0.099)					
Age 20-24		0.472***(0.173)				
Age 25-49		0.327***(0.087)				

Age 65 and older		0.189***(0.066)			
Age 40-49			0.137***(0.042)	0.660***(0.059)	0.130(0.084)	0.319***(0.070)
Age 50-59			0.376***(0.065)	1.083***(0.082)	0.090(0.129)	0.454***(0.104)
Age 60-69			0.608***(0.086)	1.544***(0.107)	0.014(0.172)	0.544***(0.132)
Age 70-79			0.830***(0.109)	1.709***(0.132)	-0.152(0.213)	0.703***(0.162)
Age 80 and older			1.034***(0.137)	1.966***(0.160)	-0.400(0.267)	0.718***(0.197)
Female sex			0.094***(0.033)	-0.152***(0.034)	0.100(0.064)	0.164***(0.055)
Health problem blood pressure			0.901***(0.047)	0.568***(0.042)		
Health problem diabetes			0.446***(0.118)	0.847***(0.104)		1.095***(0.126)
Health problem sight						0.415***(0.091)
Breast cancer screening policy change	0.499***(0.103)					
Cervical cancer screening policy change		-0.113**(0.045)				
Dental policy change					0.068(0.053)	

Source: BHPS. (*),(**),(***): significance at 10%, 5%, 1% level. Balanced panels consisted for breast cancer screening of 861 women from 12,054 observations, for cervical cancer screening of 867 women from 12,138 observations, for blood pressure check of 1,405 individuals from 19,670 observations, for cholesterol test of 1,568 individuals from 21,952 observations, for dental screening of 706 individuals from 9,884 observations and for the eyesight test of 613 individuals from 8,582 observations. Reference categories: not living in a partnership, primary education, no employment, no GP visit during last 12 months, health status self-rated excellent, non-smoking status, non-moved residence, region England, ethnic origin white, age 16-49 for breast cancer screening, age 16-19 for cervical cancer screening, age 16-39 for all other health check-ups, male sex.

Breast cancer screening policy change: age group 65-70 all years before and inclusive 2002 were coded with 0 and all the following years with 1. Cervical cancer screening policy change: age group 25-49 all years before and inclusive 2003 were coded with 0 and all the following years with 1. Dental policy change: all years before and inclusive 2004 were coded with 0 and all the following years with 1.

Table 3: Marginal effects and standard errors for main predictors of uptake for health check-ups in UK

Health check-up	Breast cancer screening	Cervical cancer screening	Blood pressure check	Cholesterol test	Dental screening	Eyesight test
Health check-up one year before (t-1)	0.017(0.007)	0.051(0.009)	0.125(0.007)	0.149(0.006)	0.182(0.009)	0.066(0.011)
Health check-up two years before (t-2)	-0.004(0.007)	-0.065(0.009)	0.054(0.007)	0.055(0.006)	0.070(0.009)	0.094(0.011)
Health check-up three years before (t-3)	0.123(0.007)	0.126(0.008)	0.040(0.007)	0.037(0.006)	0.047(0.009)	0.027(0.011)
HH income	0.001(0.002)	0.001(0.003)	0.001(0.003)	0.001(0.002)	-0.004(0.003)	-0.006(0.004)
Living with partner	0.006(0.018)	0.028(0.019)	0.016(0.015)	-0.006(0.012)	0.038(0.017)	-0.016(0.023)
Number of children in HH	-0.021(0.007)	-0.000(0.007)	-0.024(0.006)	-0.001(0.005)	0.000(0.008)	-0.002(0.010)
Secondary education (ISCED)	0.099(0.064)	0.040(0.084)	0.024(0.052)	-0.073(0.050)	0.305(0.080)	0.066(0.089)
Tertiary education (ISCED)	0.088(0.079)	0.053(0.093)	0.029(0.059)	-0.103(0.054)	0.283(0.084)	0.043(0.097)
Employed	-0.031(0.010)	0.013(0.012)	-0.025(0.011)	-0.022(0.009)	-0.010(0.014)	-0.025(0.017)
GP visit during last 12 months	0.029(0.009)	0.095(0.011)	0.259(0.008)	0.104(0.007)	0.017(0.010)	0.019(0.013)
Health status self-rated good	0.010(0.010)	-0.009(0.011)	0.020(0.009)	0.007(0.008)	-0.006(0.012)	0.018(0.016)
Health status self-rated fair	0.003(0.012)	-0.008(0.014)	0.076(0.012)	0.029(0.009)	-0.012(0.014)	0.038(0.019)
Health status self-rated poor	-0.000(0.015)	-0.012(0.020)	0.126(0.016)	0.045(0.011)	-0.033(0.019)	0.054(0.025)
Health status self-rated very poor	0.005(0.023)	-0.057(0.032)	0.167(0.030)	0.070(0.017)	0.044(0.028)	0.020(0.038)
Smoking	-0.033(0.019)	0.030(0.022)	-0.063(0.017)	-0.029(0.012)	-0.032(0.018)	-0.016(0.025)
Moved residence	0.007(0.014)	-0.012(0.015)	0.036(0.013)	0.004(0.010)	-0.035(0.015)	-0.020(0.022)
Scotland	0.002(0.013)	0.006(0.017)	0.012(0.014)	0.004(0.009)	0.005(0.018)	0.005(0.026)
Wales	0.024(0.015)	-0.029(0.021)	-0.016(0.017)	-0.006(0.011)	-0.021(0.026)	-0.008(0.029)
Ethnic origin non-white	0.030(0.031)	-0.055(0.042)	0.036(0.037)	-0.012(0.023)	-0.036(0.048)	-0.067(0.059)
Age 50-64	0.099(0.007)	0.042(0.015)				
Age 65-70	-0.101(0.014)					
Age 71 and older	-0.177(0.015)					
Age 20-24		0.104(0.039)				
Age 25-49		0.073(0.019)				
Age 65 and older		-0.180(0.019)				
Age 40-49			0.036(0.011)	0.070(0.006)	0.025(0.015)	0.081(0.017)
Age 50-59			0.099(0.017)	0.142(0.010)	0.018(0.023)	0.120(0.027)
Age 60-69			0.159(0.023)	0.247(0.018)	0.002(0.031)	0.147(0.036)
Age 70-79			0.215(0.028)	0.292(0.026)	-0.028(0.040)	0.195(0.047)
Age 80 and older			0.264(0.034)	0.366(0.037)	-0.074(0.052)	0.200(0.058)
Female sex			0.023(0.008)	-0.024(0.005)	0.020(0.011)	0.044(0.015)
Health problem blood pressure			0.225(0.012)	0.089(0.007)		
Health problem diabetes			0.111(0.030)	0.132(0.016)		0.294(0.033)
Health problems eyesight						0.111(0.024
Breast cancer screening policy change	0.079(0.016)					
Cervical cancer screening policy change		-0.025(0.010)				
Dental policy change					0.013(0.010)	

Source: BHPS. Balanced panels consisted for breast cancer screening of 861 women from 12,054 observations, for cervical cancer screening of 867 women from 12,138 observations, for blood pressure check of 1,405 individuals from 19,670 observations, for cholesterol test of 1,568 individuals from 21,952 observations, for dental screening of 706 individuals from 9,884 observations and for the eyesight test of 613 individuals from 8,582 observations. Breast cancer screening policy change: age group 65-70 all years before and inclusive 2002 were coded with 0 and all the following years with 1. Cervical cancer screening policy change: age group 25-49 all years before and inclusive 2003 were coded with 0 and all the following years with 1. Dental policy change: all years before and inclusive 2004 were coded with 0 and all the following years with 1.

Technical appendix table: Parameter estimates and standard errors for the uptake of two different specifications for cervical cancer screening in UK

Variable	Cervical cancer screening Specification 1	Cervical cancer screening Specification 2
Health check-up in 1992	0.229***(0.044)	0.222***(0.044)
Health check-up in 1993	0.195***(0.045)	0.191***(0.044)
Health check-up in 1994	0.142***(0.047)	0.142***(0.046)
Averaged HH income	0.008(0.022)	0.012(0.022)
Averaged living with partner	0.017(0.107)	0.037(0.107)
Averaged number of children in HH	0.022(0.046)	0.029(0.046)
Averaged secondary education (ISCED)	-0.169(0.383)	-0.169(0.382)
Averaged tertiary education (ISCED)	-0.245(0.427)	-0.179(0.423)
Average status employed	-0.041(0.093)	-0.055(0.092)
Averaged GP visit during last 12 months	-0.037(0.120)	-0.044(0.120)
Averaged health status self rated good	-0.029(0.107)	-0.023(0.106)
Averaged health status self rated fair	-0.131(0.136)	-0.132(0.135)
Averaged health status self rated poor	0.189(0.235)	0.210(0.232)
Averaged health status self rated very poor	0.129(0.378)	0.122(0.376)
Averaged status smoking	-0.154(0.118)	-0.174(0.117)
Averaged status moved residence	0.121(0.293)	0.119(0.287)
Averaged age	-0.006(0.004)	-0.010***(0.003)
Health check-up one year before (t-1)	0.233***(0.039)	0.236***(0.038)
Health check-up two years before (t-2)	-0.286***(0.039)	-0.285***(0.039)
Health check-up three years before (t-3)	0.570***(0.036)	0.568***(0.036)
HH income	0.005(0.013)	0.004(0.012)
Living with partner	0.136(0.086)	0.108(0.085)
Number of children in HH	-0.001(0.031)	-0.005(0.031)
Secondary education (ISCED)	0.180(0.377)	0.170(0.377)
Tertiary education (ISCED)	0.278(0.419)	0.202(0.416)
Employed	0.055(0.056)	0.073(0.055)
GP visit during last 12 months	0.419***(0.048)	0.426***(0.047)
Health status self rated good	-0.039(0.050)	-0.040(0.050)
Health status self rated fair	-0.031(0.062)	-0.030(0.062)
Health status self rated poor	-0.048(0.089)	-0.050(0.088)
Health status self rated very poor	-0.253*(0.144)	-0.248*(0.143)
Smoking	0.131(0.100)	0.146(0.099)
Moved residence	-0.063(0.070)	-0.047(0.069)
Scotland	0.028(0.075)	0.030(0.074)
Wales	-0.129(0.093)	-0.135(0.093)
Ethnic origin non-white	-0.242(0.188)	-0.239(0.187)
Age 50-64	0.189***(0.066)	0.118*(0.060)
Age 20-24	0.472***(0.173)	
Age 25-49	0.327***(0.087)	0.203***(0.073)
Age 65 and older	-0.803***(0.083)	-0.810***(0.082)
Cervical cancer screening policy change	-0.113**(0.045)	-0.121***(0.044)

Source: BHPS. (*),(**),(***): significance at 10%, 5%, 1% level. Estimation sample consisted for cervical cancer screening of 867 women of age 16 and older from 12,138 observations for the first specification. Estimation sample consisted for cervical cancer screening of 867 women of age 20 and older from 12,135 observations for the second specification. Cervical cancer screening policy change: for cervical cancer screening and age group 25-49 all years before and inclusive 2003 were coded with 0 and all the following years with 1.

Utilisation of Preventative Health Check-Ups in the UK: Findings from individual-level repeated cross-sectional data from 1992 to 2008

Alexander Labeit*

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

Frank Peinemann

FOM University of Applied Science for Economics & Management, 45141 Essen, Germany

Richard Baker

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

Keywords: Dynamic panel data models, Mass screening/utilization, Utilization Review/statistics & numerical data, Utilization Review/statistics & numerical data, Health Behaviour, Preventive Medicine

Word Count: 7259

ABSTRACT~~5585~~

~~ABSTRACT~~**Objectives:** To ~~investigate~~analyse and compare the determinants of screening uptake for different NHS health check-ups in the UK.

Design: Individual-level analysis of repeated cross-sectional surveys with balanced panel data.

Setting: UK.

Participants: Individuals taking part in the British Household Panel Survey (BHPS), 1992 - 2008.

Outcome measure: Uptake of NHS health check-ups for cervical cancer screening, breast cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.

Methods: Dynamic panel data models (random effects panel probit with initial conditions).

Results: Having had a health check-up one year before, and previously in accordance with the recommended schedule, was associated with higher uptake of health check-ups. Individuals who visited a General Practitioner (GP) had ~~also a~~a significantly higher uptake in 5 of ~~all~~the 6 health check-ups. Uptake was highest in the recommended age group for breast and cervical cancer screening. For all health check-ups, age had a nonlinear relationship. Lower self-rated health status was associated with increased uptake of blood pressure checks and cholesterol tests; smoking was associated with decreased uptake of 4 health check-ups. The effects of socioeconomic ~~and health related~~ variables ~~(education, employment status, living with a partner, health status, smoking)~~ differed for the different health check-ups. Ethnicity did not have a significant influence

on any ~~of the~~ health check-~~ups~~up. Permanent household income had an influence only on eyesight tests and dental screening~~, and transitory income only on the cholesterol test~~.

Conclusions: Common determinants for ~~all~~having health check-ups are age, previous screening history and a GP visit. Policy interventions to increase uptake should consider the central role of the GP in promoting screening examinations and in preserving a high level of uptake. Possible economic barriers to access for prevention exist for dental screening and eyesight tests, and could be a target for policy intervention.

Trial registration: This observational study was not registered.

ARTICLE SUMMARY
~~ARTICLE SUMMARY~~

Article focus

- To identify ~~common~~and compare determinants of the uptake of different preventive health check-ups delivered by the NHS: breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.
- To ~~investigate~~compare the effect of past screening behaviour, age, GP visits, ~~household income~~health status and ~~other~~ socioeconomic variables on the uptake of each of these health check-ups.

Key messages

- Past screening behaviour and GP visits explained recent screening behaviour for each of the health check-ups: taking part in past screening examinations and visiting a GP visit increased ~~actual~~recent uptake.
- Lower self-rated health status increased the uptake of blood pressure checks and cholesterol tests, but smoking decreased the uptake of 4 health check-ups.
- Permanent household income had a positive significant effect only on eyesight tests and dental screening, but not on the other health check-ups.

Strengths and limitations of this study

- Our study used consistent individual-level repeated cross-sectional data from a panel survey over a period of ~~18~~17 years for the different health check-ups.
- Our estimation used a balanced panel which considered also attrition effects.
- ~~Information~~Medical information about results from previous screening examinations was not available, and linking with other data sources could improve our analysis.

INTRODUCTION

Individuals are offered different health check-ups in the NHS. These include breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental check-ups and eyesight tests. There is no charge for the health check-ups, other than for dental check-ups and eyesight tests. Taking part in health check-ups is important, because screening examinations promote early detection of diseases and are potentially cost saving. There are only few national and international analyses that analyse how different health check-ups are affected by socioeconomic determinants, and typically such studies have been cross-sectional surveys.[1 2] One analysis using UK data has shown that the socioeconomic determinants of breast and cervical cancer screening differ. Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, existing health problems and health status for these six different health check-ups. Can certain determinants explain the uptake of these six health check-ups, and especially what is the influence of health related variables on the uptake? In the next sections the institutional regulations of the six different health check-ups are introduced, followed by the theoretical framework for our analysis and a discussion of relevant previous empirical prevention research which is related to our own work.

For each health check-up a detailed recommendation exists on how often an individual should attend a specific health check-up depending on age limits, comorbidities and previous health check-ups. The national NHS Breast Screening Programme (NHSBSP)

offers mammography to women at different time intervals depending on age.[3] Women between age 50 and 64 are invited, and from 2003 there has been an extension of the age range for these programme and women between age 65 and 70 years are also invited. The national NHS Cervical Screening Programme (NHSCSP) offers women a smear test at different time intervals depending on age.[4] The age for the first invitation and the age of the last invitation to cervical cancer screening is dependent on country in the UK: age 25 in England since 2003, or 20 in Scotland, Wales and in England before 2003.[5 6] Between the age of the first invitation and 49 is a 3 yearly recall period in all parts of UK since 2003 and before 2003 there was a 3 to 5 yearly recall period policy depending on the Primary Care Trust, with the majority of Primary Care Trusts following a 3-year policy.[7] The policy of a uniform 3 yearly recall period for women between age and 25-49 was implemented after a recommendation by Cancer Research UK, because a 3-year recall policy seemed most effective after analysis of UK data.[8] No information was available for us how quickly each Primary Care Trust in England implemented the changes to the recall policy. Cervical cancer screening is offered to women aged 50 and over every three years until age 60 in Scotland and until age 64 in Wales, and every 5 years in England until age 64 from 2003.[5] Before 2003 a majority of women were screened every 3 years.[7] Women above the age limits are excluded from the recall system and no longer invited unless they need ongoing surveillance or follow up, for example because of an abnormal result in any of the three most recent tests. For breast and cervical cancer screening examination there are sent out routine periodic invitations to women by their GP. Blood pressure can be checked by a GP or another healthcare professional, and it is recommended that adults aged over 40 are checked at least every 5 years.[9] For

individuals with increased risk of hypertension or with comorbidities (e.g. diabetes), blood pressure should be checked every year. A cholesterol test is recommended for individuals aged over 40 and especially for individuals who have a family history of early cardiovascular disease or who have high blood pressure or diabetes.[10] The cholesterol test is implemented as an invitational programme. For dental screening the national guidelines recommend at least one check-up every two years, unless the dentist recommends a different interval based on the patient's current dental health.[11] The national guidelines changed in 2004, the previous recommendation being every 6 months. Dental screening incurs a charge to the patient, and is only free for those under the age of 18 or on income support. ~~The first female specific analysed prevention programme is the NHS Breast Screening Programme (NHSBSP) which offers mammography to women at different time intervals depending on age.[1] Women between age 50 and 64 are invited, and from 2003 there has been an extension of the age range for these programme and women between age 65 and 70 years are also invited. The second female specific analysed prevention programme is the NHS Cervical Screening Programme (NHSCSP) which offers women a smear test at different time intervals depending on age.[2] The intervals for screening are: age 20 (England) or 25 (Scotland and Wales) for first invitation, and between age 20 or 25 and 49 for a 3 yearly recall period since 2003 (5 yearly before 2003). The recall interval is 5 years between age 50 and 64; for women of age 65 and older, screening is offered only to those not screened since age 50 or who have had recent abnormal tests. Blood pressure can be checked by a GP or another healthcare professional and it is recommended that adults with aged over 40 are checked at least every 5 years.[3] For individuals with increased risk of hypertension or with~~

~~comorbidities (e.g. diabetes) blood pressure should be checked every year. A cholesterol test is recommended for individuals aged over 40 and especially for individuals who have a family history of early cardiovascular disease or who have high blood pressure or diabetes.~~[4]Dental screening has been free in Scotland since 2006[12] and in Wales it is free for individuals under age 25 and aged 60 or over since 2006.[13] An eyesight test is recommended every two years, or more frequently if necessary.[14] It is especially advised for individuals aged 60 years and older, individuals from certain ethnic groups, for example, Afro-Caribbeans, and for those with selected diseases predisposing to eye disorders, for example diabetes. There is a charge for the eyesight test, but it is free for individuals aged 60 and older, or who are registered blind or partially sighted, or who have diabetes or glaucoma. Eyesight tests have been free in Scotland since 2006.[15] For dental screening and eyesight tests the individual dental or optometry practices can decide on sending invitation letters.

Economic models of the demand of health care in general~~For dental screening the national guidelines recommend at least one check-up every two years, unless the dentist recommends a different interval based on the patient's current dental health.[5] The national guidelines changed in 2004, the previous recommendation being every 6 months.~~ , and preventative care in particular, are based on human capital models.[16] This framework has also been used for the modelling of demand for primary and secondary prevention.[17] These categories of prevention are self-protection measures that improve early detection and health outcomes.[18] The problem with economic models of prevention is that two important aspects are typically not considered at the same time in detail: the distinction

between acute and preventative care, and uncertainty. Some dynamic economic models for the demand of health care take only uncertainty into consideration, no distinction being made between acute and preventative care.[19] Acute care describes the consumption aspect of health whereas preventative care describes the investment aspect. The (simplified) Grossman model makes the distinction between acute and preventative care, but uncertainty is not considered in this model.[20] Only one economic model explicitly considers both the demand for preventative health care, using a stochastic dynamic framework.[21] However, in this article no non-economic factors were considered. Our conceptual framework is based on a human capital approach[21] and as an extension, non-economic factors such as non-monetary barriers are included. Our approach is also supported by previous research which has investigated determinants of different types of screening examinations.[22]

~~Dental screening incurs a charge to the patient, and is only free for those under the age of 18 or on income support. An eyesight test is recommended every two years, or more frequently if necessary.[6] It is especially advised for individuals aged 60 years and older, individuals from certain ethnic groups, for example, Afro Caribbeans, and for those with diseases such as diabetes. There is a charge for the eyesight test, but it is free for individuals of age 60 and older, or who are registered blind or partially sighted, or who have diabetes or glaucoma.~~

~~Economic models of the demand of health care in general and preventative care in particular are based on human capital models.[7] This framework has also been used for the modelling of demand for primary and secondary prevention.[8] These categories of~~

~~prevention are self protection measures that improve early detection and health outcomes.[9] The problem with economic models of prevention is that two important aspects are typically not considered at the same time in detail: the distinction between acute and preventative care, and uncertainty. Some dynamic economic models for the demand of health care take only uncertainty into consideration, however there is no distinction made between acute and preventative care.[10] Acute care describes the consumption aspect of health whereas preventative care describes the investment aspect. The (simplified) Grossman model makes the distinction between acute and preventative care, but as a confinement no uncertainty is considered in this model.[11] There is only one economic model which explicitly takes the demand for preventative health care and uncertainty in a stochastic dynamic framework into consideration.[12] However, in this article no non-economic factors were considered. Our conceptual framework is based on a human capital approach[12] and as an extension, non-economic factors such as non-monetary barriers are included. Our approach is also supported by previous research which has investigated determinants of different types of screening examinations.[13]~~

Information about the uptake of these different health check-ups over a period of nearly 20 years is available in the British Household Panel Survey (BHPS). ~~There is only one study which compares these different NHS health check-ups from 1991 to 2003.[14] However, this study~~Only one study has compared these different NHS health check-ups from 1991 to 2003.[23] However, this study analysed not the influence of health related and socioeconomic characteristics on the uptake and estimated random effects panel probit models only with unbalanced panels, with the potential problem of attrition bias, and as a

consequence selection bias in the estimates can occur.[15][24] The influence of household and individual characteristics on uptake is analysed in our study and also the effects of transitory and permanent household income on uptake. Also in our analysis the effect of ~~policy~~ changes in the medical screening guidelines on the uptake for three health check-ups (cervical cancer screening, breast cancer screening and dental screening) are additionally considered. Therefore, our analysis compares how past screening behaviour, individual and household characteristics~~, policy changes~~ and changes ~~in transitory and permanent household income~~of medical screening guidelines affect ~~the~~ uptake ~~on~~of these different health check-ups.

~~Previous screening behaviour was shown to be an important predictor for recent screening behaviour.[13] [16] [17] Age have different effects on the demand for prevention.[18] [19] On one hand, health depreciates at an increasing rate at older ages, and the necessity to maintain health increases and as a consequence also demand for prevention activities increase. On the other hand, older individuals have a shorter life span and pay-off period of their investment in prevention activities, and therefore the effect of increasing age on uptake cannot be predicted. Empirical studies often find a negative relationship between age and uptake of health check-ups.[19] [20] Females have a higher utilization of health care services[21] and also a higher use of preventative care services including blood pressure checks, cholesterol tests and dental screening.[22] Higher educational level may be expected to lead to an increase in the demand for prevention services, because individuals with a higher education may have higher efficiency in the production of health and also increased self-efficacy, higher confidence and motivation.[8] [16]~~ Participation in breast or

cervical cancer screening examinations in past periods has predictive value for the uptake in the actual period, i.e. past screening behaviour is correlated with current behaviour.[22 25 26] Age can have different effects on the demand for prevention.[27 28] For breast and cervical cancer screening examinations, medical guidelines exist with explicit recommendations on how often screening should be done in certain time intervals, and for the recommended age intervals uptake should be higher than for non-recommended age intervals. However, on one hand according to the Grossman model health depreciates at an increasing rate at older ages, and the necessity to maintain health increases and as a consequence the demand for preventive activities increases. On the other hand, older individuals have a shorter life span and pay-off period for their investment in prevention activities. Therefore the effect of increasing age on uptake cannot be predicted with confidence. Empirical studies often find a negative relationship between age and uptake of health check-ups.[28 29] Studies which analysed possible gender differences in the utilization of health care services found that females have a higher utilization of health care services[30] and also a higher use of preventative services including blood pressure checks, cholesterol tests and dental screening.[31] Higher educational level may be expected to lead to an increase in the demand for prevention services, because individuals with a higher education may have higher efficiency in the production of health and also increased self-efficacy, higher confidence and motivation.[17 25 ~~19 20~~28 29] ~~Females living in a partnership have a higher propensity for screening examinations.[23 24] A higher number of children in the household can influence screening behaviour through time constraints.[16 25] Household income may be expected to lead to an increase in the demand for prevention services, because higher income leads to an increase in demand for time in perfect~~

health.[7 11] In some studies, increasing household income increased uptake of preventive care,[18 19 26] although the effect may be weaker in the UK compared to other countries, because most preventative services are free in UK. Employed women had a higher uptake of cervical cancer screening and in some studies it was a stronger predictor of non-attendance for screening uptake than income and education.[23 24] The predictive value of employment status for uptake of cervical cancer screening held in the United States, but not for uptake of mammography.[27] The GP plays a role as gatekeeper in the UK health care system and can give advice and information about health check-ups and so enhance uptake of prevention services.[28 29] Self rated health status is used as a proxy for the health stock of an individual and individuals with low health stock can increase their stock by taking part in prevention activities.[18] However, poor health status can make it more difficult to visit prevention services. There are contradicting results for the effect of poor health status on the uptake of health check-ups, with increased uptake of cholesterol checks and a lower uptake of mammograms and pap smears.[30] Smoking is typically associated with risk taking behaviour[31] and can serve as an indicator for the weakened preference of an individual for health in comparison to other goods and services and so the individual should have a lower demand for prevention activities.[19] For individuals with non white ethnic origin cultural barriers may exist, and can be especially important for breast and cervical cancer screening. For cervical cancer screening ethnicity was the most important predictor, with white British women having the highest uptake.[32] In order to receive an invitation for breast and cervical cancer screening women have to be registered with a GP. For women who had changed residence and address, lower uptake for cervical cancer screening was found in one study,[25] however not in another one.[16]

Individuals who live in a partnership have a higher propensity for screening examinations and living in a partnership may be a proxy for having a more dense social support network that encourages individuals to take part in prevention activities and some empirical studies have confirmed this hypothesis.[32 33] A higher number of children in the household can influence screening behaviour through time constraints.[25 34] Household income may be expected to lead to an increase in the demand for prevention services, because higher income leads to an increase in demand for time in perfect health.[16 20] In some studies, increasing household income increased uptake of preventive care,[27 28 35] although the effect may be weaker in the UK compared to other countries, because most preventative services are free in the UK. Employment was added as a further control variable, because individuals who work may have higher opportunity costs in comparison to unemployed and retired individuals. In a systematic review of the influence of different determinants on the uptake of health check-ups, influence of employment for the uptake of different health check-ups was found to be inconsistent. The GP plays a role as gatekeeper in the UK health care system and can give advice and information about the importance of health check-ups for the early detection of diseases, and therefore uptake may be enhanced by previous GP visits.[36 37] Cervical cancer screening, blood pressure checks and cholesterol tests can be done in a GP practice. Poor self-rated health status and existing general health problems could encourage people to think about their health in general and therefore to invest in health and to increase participation in screening examinations, and this seems to be the case for general health check-ups such as blood pressure check and cholesterol test, but not for female specific cancer screenings such as

the mammography and the smear test.[27] Psychological factors such as fear and anxiety about receiving a cancer diagnosis may deter some women from attending one of these health check-ups. Furthermore, individuals in a poor health state may not be able to visit the screening location such as the GP, family clinic or mammography unit, the dentist or the optometrist, because of physical limitations. There are contradicting findings on the effect of poor health status on the uptake of health check-ups, with increased uptake of cholesterol checks and a lower uptake of mammograms and pap smears.[38] Smoking can serve as an indicator for the weakened preference of an individual for health in comparison to other goods and smoking individuals show risk taking behaviour.[39] Individuals who smoke have poorer preventative health habits such as a reduced level of physical activity in comparison to non-smoking women.[40] The predicted influence of smoking on uptake was empirically confirmed for breast cancer screening with a lower uptake for smoking women.[28] For individuals with non-white ethnic origin cultural barriers may exist, and this is especially the case for breast and cervical cancer screening. In an empirical investigation ethnicity was the most important predictor for cervical cancer screening, with white British women having a higher uptake than women of other ethnicity. Registration with a GP is a necessary condition for receiving an invitation letter for breast and cervical cancer screening and routine periodic invitations are sent from the GP according to the recommended interval for breast and cervical cancer screening. A changed residence and address of a woman lowers the chance to receive an invitation letter. A lower uptake of cervical cancer screening was found in one study for women in UK who had changed residence and address,[34] but not in another one.[25]

METHODS

~~A~~It is sensible for our estimation to consider how screening behaviour was in the past time and the recommended time interval for a screening examination (e.g. for breast and cervical cancer screening examinations the recommended 3 year intervals), because there is an increased likelihood of participating in a screening examination after the recommended time interval. Additionally, there exists also the possibility that screening examinations are recommended in shorter time intervals if an individual belongs to a high risk population such as in the female cancer screening examinations with close relatives with a history of breast or cervical cancer. Also there exists for all the different health check-ups the possibility that an inconclusive check-up in the actual year has a consequence a control follow check-up in the next year. With the BHPS it is not possible to differentiate between routine check-ups according to the screening guidelines or as a response to an inconclusive result from a health check-up in the previous year or as an advice to do a health check-up from a GP. To include these different possibilities for the analysis of uptake behaviour a dynamic specification with lags for the last 3 years was chosen for the different health check-ups. To model the dynamic nature of screening examinations and because uptake is a binary variable, a dynamic random effects (RE) panel probit model was used to estimate the uptake of NHS health check-ups over the panel period from 1992 to 2008. The advantage of such a specification is that ~~actual~~the uptake of health check-ups is not only explained by individual and household characteristics, but also at the same time by past screening behaviour and therefore persistence in screening behaviour (state dependence~~)~~). A further advantage of this econometric specification which uses panel data and not cross-sectional data is that both

individual heterogeneity and state dependence can be ~~analysed~~considered in a dynamic panel data model, which is not possible in a model for cross-sectional data. One possibility for estimating a dynamic random effects (RE) panel probit is the Mundlak-Wooldridge estimator ~~which~~that specifies a relationship between the unobserved time-invariant individual effect and the observed characteristics and initial conditions,[33] ~~and the econometric model is given by the following 3 equations (1), (2), (3).~~[41] and the econometric model is given by the following 3 equations (1), (2), (3).

~~$y_{it}^{*} = \gamma_1 y_{it-1} + \gamma_2 y_{it-2} + \gamma_3 y_{it-3} + x'_{it}\beta + \alpha_i + \varepsilon_{it}$~~

$$y_{it}^{*} = \gamma_1 y_{it-1} + \gamma_2 y_{it-2} + \gamma_3 y_{it-3} + x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (1)$$

In the first equation ~~y_{it}^{*}~~ y_{it}^{*} indicates the unobserved latent variable of an individual i at a given time t for taking part in a specific screening exam, y_{it-1}, y_{it-2}, y_{it-3} are the screening examination decisions of the individual i 1, 2 and 3 periods before t and γ_1, γ_2, γ_3 are the related coefficients for these variables, x is a vector of time variant and time invariant covariates, ~~β~~ β is the vector of coefficients associated with these covariates, ~~ε_{it}~~ ε_{it} is the random error term and ~~α_i~~ α_i indicates the individual specific term for time invariant unobserved variables which is modelled according to equation (2) as individual specific random effect:

~~$\alpha_i = \delta_1 S_{i1} + \delta_2 S_{i2} + \delta_3 S_{i3} + + \delta_4 \overline{X}'_i + \upsilon_i$~~

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$$\alpha_i = \delta_1 S_{i1} + \delta_2 S_{i2} + \delta_3 S_{i3} + +\delta_4 \overline{X}_i' + \upsilon_i \quad (2)$$

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A normal density for the individual specific random effect is assumed and the first three terms are the initial conditions with the uptake of the specific health check-up for an individual i in the first three periods of the panel: S_{i1}, S_{i2} , S_{i3}.The fourth term allows correlation between the time-varying variables ~~household income and health status~~ of an individual by including the average ~~$\overline{X}_i'$ of~~ $\overline{X}_i'$ over the whole panel observation period and the individual specific random effect,[34] ~~which divides both~~[42] which divides the time-varying variables into a transitory and permanent component for the estimation. ν_i is the error term assumed normally distributed with zero mean and standard deviation σ_α. This specification has the advantage that time-invariant unobserved variables which are correlated to ~~household income and health status~~time-varying variables are captured by the mean of these variables and give a less biased estimate of the transitory component of these variables. The third equation gives the observed binary outcome y_{it} of taking part in a specific health check-up for individual i in period t.

Field Code Changed

~~$y_{it} = \begin{cases} 1, if \ \ y_{it}^* > 0 \\ 0, otherwise \end{cases}$~~

$$y_{it} = \begin{cases} 1, if \ \ y_{it}^* > 0 \\ 0, otherwise \end{cases} \quad (3)$$

Field Code Changed

~~The chosen Mundlak Wooldridge specification has the advantage that under certain assumptions the bias which is caused by the persistence of screening behaviour is removed. Crucial assumptions for the estimation of the dynamic random effect model are~~

that the relationship between the unobserved time invariant individual effect and the mean of the observed characteristics is correctly specified and also the distributional assumptions on the initial conditions are correct. For an unbiased estimation with regard to initial conditions it is also necessary to fulfil the assumption that unobserved past screening behaviour is uncorrelated with observed screening behaviour, i.e. that unobserved specific health check-ups that happened prior to our observation period (first wave) are not correlated with the observed health check up and if this assumption is violated the estimation can be biased.[35] Estimation of a balanced panel was preferred in comparison to an unbalanced panel, because estimation of unbalanced panels with ad hoc treatments of initial problems has unfavourable estimation properties and could result in biased estimation because of the selection bias caused by attrition effects in the panel and the estimation results of balanced panels are more reliable, because balanced panels satisfy the assumptions of the Mundlak-Wooldridge estimator.[36 37] An alternative to the Mundlak Wooldridge estimator would be for the balanced model the maximum likelihood estimator proposed by Heckman,[35] however for balanced panels with more than 5 to 8 periods the finite sample properties of the Mundlak-Wooldridge estimator are better.[15]

The decision to take part in a health check up is dependent on the result of the specific health check up one year ago. Individuals with an inconclusive result of the specific health check up from the previous screening one year ago have a higher chance of being invited again to a health check up in the recent year and this is especially relevant for breast and cervical cancer screening. Unfortunately, the results from previous health

~~check-ups are not available in the BHPS. Our chosen dynamic specification with 1 year, 2 year, 3 year lagged dependent variables as explaining variables takes into consideration, that the health check-up from the previous year could have an inconclusive result and takes also into consideration the institutional setting that specific medical recommendations exist for each health check-up.~~

~~For our analysis the BHPS is used~~

The chosen Mundlak-Wooldridge specification has the advantage that under certain assumptions the bias which is caused by the persistence of screening behaviour is removed. Crucial assumptions for the estimation of the dynamic random effect model are that the relationship between the unobserved time-invariant individual effect and the mean of the observed characteristics is correctly specified and also the distributional assumptions on the initial conditions are correct. The breast cancer screening programme (NHSBSP) and cervical cancer screening programme (NHSCSP) were introduced in 1988 before the beginning of the BHPS and also the four other health check-ups had been available to individuals before the BHPS had started. For our estimation technique it is assumed that the health check-ups that had been undertaken before the first wave of the BHPS are uncorrelated with the health check-ups recorded in the BHPS. If this assumption is violated, the inclusion of initial conditions of health check-ups for the years 1992 to 1994 could result in biased estimates for our regressions. An advantage of our statistical approach is that some previous analyses have investigated the uptake of health check-ups with cross-sectional data and therefore could not control for unobserved heterogeneity, and other analyses used unbalanced panel data sets for their estimation.[23 25]

Estimation of unbalanced panels with ad hoc treatments of initial problems has unfavourable estimation properties and could result in biased estimation as has been shown by simulation studies.[24] The estimation results of balanced panels are more reliable, because balanced panels satisfy the assumptions of the Mundlak-Wooldridge estimator.[43 44] Therefore, estimation of balanced panels for the different health check-ups was preferred over unbalanced panels. An alternative to the Mundlak-Wooldridge estimator would be the maximum likelihood estimator proposed by Heckman,[45] however for balanced panels with more than 5 to 8 periods the finite sample properties of the Mundlak-Wooldridge estimator are better.[24]

We used the BHPS, which is an annual survey of households in UK. It is a nationally representative sample of more than 5,000 households and individuals ~~with age 16 and over are interviewed.[38]~~aged 16 and over.[46] The first wave of the data collection for this survey started in 1991 and all the original individuals were ~~also~~ interviewed in each succeeding year unless they dropped out. Questions about taking part in NHS health checks-up have been in every wave from the start of the panel survey in 1991 until 2008. For the analysis of breast and cervical cancer screening, only females were included, for all other types of health check-ups both males and females were included. In our analysis and construction of the balanced sample only individuals from England, Wales and Scotland were selected, because data collection started in Northern Ireland from wave 11 and not from the first wave. For the construction of the balanced panel 17 years of information were used: from 1992 to 2008, because in the first wave only ~~few~~ a small number of individuals were interviewed in 1991~~, most in 1992.~~. For an individual to be

included in our analysis, provision of the specific health check-up had to be from the NHS~~,~~; individuals with private provision ~~being~~or with NHS and private provision for a specific health check-up have been excluded from the analysis. The dependent variable takes the value of 1 in a specific year if the specific health check-up (breast cancer screening, cervical cancer screening, blood pressure check, cholesterol test, dental test, eyesight test) was done ~~through NHS provision and 0 if the specific health check-up had not been utilised or through NHS provision.~~ and 0 if not. For analysing the changes in the medical screening guidelines for 3 different health check-ups (breast cancer screening, cervical cancer screening, dental screening) a dummy coding was chosen: for breast cancer screening and age group 65-70, all years before and including 2002 were coded with 0 and all the following years with 1; for cervical cancer screening and age group 25-49 all years before and including 2003 were coded with 0 and all the following years with 1; for dental screening all years before and including 2004 were coded with 0 and all the following years with 1.

The balanced panel included for breast cancer screening ~~855~~861 women with ~~11,970~~12,054 observations, for cervical cancer screening ~~860~~867 women with 12,~~040~~138 observations, for blood pressure checks 1,~~412~~405 individuals with 19,~~768~~670 observations, for cholesterol tests 1,~~578~~568 individuals with ~~22,092~~21,952 observations, for dental screening ~~701~~706 individuals with 9,~~814~~884 observations and for eyesight tests ~~616~~613 individuals with 8,~~624~~582 observations.

In our analysis, for cervical cancer screening we used the age groups of the screening

guidelines: 16 to ~~24~~19 (reference group), 20 to 24, 25 to 49, 50 to 64, and aged 65 and older. For breast cancer screening, we followed also the age groups of the screening guidelines: 16 to 49 (reference group), 50 to 64, 65 to 69, and aged 70 and older. For all other screening checks, the following groups were used: 16 to 39 (reference group), 40 to 49, 50 to 59, 60 to 69, 70 to 79 and ~~79~~80 and older. For blood pressure checks and cholesterol tests, we included information on whether the person had diabetes or also heart/blood pressure/blood circulation problems, and for eyesight tests, information on eyesight problems was used. ~~Transitory~~Actual (transitory) income was defined as the total equivalised and deflated household annual income divided by 100 and permanent household income was defined as annual household income over the 17 years between 1992 and 2008. Household income was deflated and transformed in per capita income using the modified OECD scale to allow for household size and needs.[~~39~~47] The International Standard Classification of Education (ISCED) was used for the categorisation of educational levels with tertiary, secondary and primary education (reference category). Household income was deflated and transformed ~~in~~into per capita income using the modified OECD scale to allow for household size and needs.[39] ~~Health status was self-rated from excellent (1) to very poor (5).~~[47] Health status was self-rated and included in our analysis with categories from excellent (1) as reference category in regressions, good (2) fair (3), poor (4) to very poor (5).[48]

RESULTS

Table 1 presents descriptive statistics for the variables used in our estimation for the balanced panels for the different health check-ups.

Table 1: Sample characteristics for the balanced panels of different health check-ups in UK

For the period 1992 to 2008 there were the following uptake rates within one year for individuals for the ~~unbalanced~~balanced panel: ~~14.0~~13.9% for breast cancer screening, 20.4% for cervical cancer screening, 51.~~1~~2% for the blood pressure check, 19.~~6~~5% for the cholesterol test, 57.~~7~~6% for dental screening and 34.~~3~~4% for the eyesight test.

Table 2 provides the estimated coefficients for the dynamic random effects (RE) probit ~~estimates~~model with initial conditions for the balanced panel (BP) for the different health check-ups.

Table 2: Parameter estimates and standard errors for the uptake of health check-ups in UK

For all health check-ups, taking part in past screening examinations showed a strong influence on the current screening examination. The effect of having the same screening examination one year ago was strongest for dental screening ~~and~~ . The magnitude of the effects, the marginal ~~effect resulted in an increase of 18.4% (~~effects, are shown in table ~~not shown).~~ 3 and for dental screening examinations there was an increase of 18.2% if

there has been a visit one year before.

Table 3: Marginal effects and standard errors for main predictors of uptake for health check-ups in UK

The effect of having the same screening examination three years ago was ~~strongest~~similar for breast and cervical cancer screening and the marginal ~~effect~~effects resulted in an increase in uptake of 12.~~9%).~~3% and 12.6% %. For individuals who visited their GP in the last year, there was an increase ~~in the uptake~~for 5 of the 6 analysed health check-ups with only the eyesight test not significant, the increase being highest for blood pressure ~~(27.3~~with a 25.9% increase~~)~~ and lowest for dental screening ~~(2.9~~with a 1.7% increase~~).~~. Poor self-rated health status increased the uptake of blood pressure checks by about 12.6% and cholesterol tests about 4.5% and for the eyesight test poor health status increased the uptake by 5.4%. For breast and cervical cancer screening there was no significant influence of poor health status on uptake. Women aged between 50 and 64 had an increased uptake of ~~11.0~~9.9% for breast cancer screening and women aged between 25 and 49 had an increased uptake of 7.~~1~~3% for cervical cancer screening in comparison to the reference ~~groups~~categories. Also for the other four health check-ups there was a nonlinear relationship between age and uptake. For blood pressure check, cholesterol test and eyesight test uptake increased ~~nonlinear with~~nonlinearly for the different age ~~and for dental screening uptake was highest for individuals between 40 and 49. Women aged between 25 and 49 had a 2.4% decreased uptake of cervical cancer screening after 2003. Women between aged~~ categories. Women aged between 65 and

~~69~~70 had ~~an increased~~a higher uptake of breast cancer screening after 2002~~ (~~; an increase of ~~4.6~~7.9% for this age group in comparison to the years before~~).~~. Women aged between 25 and 49 had a 2.5% lower uptake of cervical cancer screening after 2003 in comparison to women of this age group before 2003. Individuals who had a dental screening after 2004 ~~had an increased~~did not have a significant changed uptake ~~of 1.6%~~ in comparison to the years before.

Females had ~~an increase in the~~a higher uptake in three of the four analysed health check-ups ~~which~~that are not sex-specific (blood pressure check, dental screening, eyesight ~~test) and a decrease in~~tests), but the influence on the uptake of the cholesterol ~~test.~~tests was non-significant. The increase in uptake for females was highest for eyesight ~~test~~tests with an increase of 4.~~5%, and there was a decrease of 1.8% in uptake for females for the cholesterol test.~~4%. The marginal effects for education, employment status, household income, living with a partner, ~~poor health status,~~ smoking, changed residence status were non-uniform for the different health check-ups. The effect of secondary and tertiary education was strongest for the uptake of ~~blood pressure checks (4.2~~dental screening (30.5% and 28.3% increase). Being employed decreased the uptake for breast cancer screening by ~~about~~ 3.1%, for blood pressure checks by 2.5% and ~~decreased the uptake of eyesight tests~~cholesterol test by ~~about 3~~2.2%. Increasing ~~transitory~~actual household income ~~led to an increase of uptake for the cholesterol test by 0.3%.~~had no significant effect on any of the uptakes. Living with a partner increased the uptake of ~~breast and cervical cancer about 2.2% and 2.8%. Poor self-rated health status increased the uptake of the blood pressure checks about 7.8% and cholesterol tests about 3.0%.~~dental screening

by 3.8%. Smoking decreased the uptake of breast cancer screening ~~about 0.9%, blood pressure checks about 2.8% and dental screening about~~ by 3.~~9%.~~3%, blood pressure checks by 6.3%, cholesterol tests by 2.9% and dental screening by 3.2%. An additional child in the household decreased the uptake of breast cancer screening examinations and blood pressure checks by ~~3.8% and~~ 2.1% and 2.4%. Change of residence decreased the uptake of dental screening by ~~2~~3.5%; however, it increased the uptake of blood pressure checks by ~~4.0~~3.6%. Individuals with existing blood pressure problems or diabetes had increased uptake of blood pressure checks by ~~25~~22.5% and ~~14.3% and also individuals with blood pressure or diabetes problems had an increased uptake for cholesterol tests by 9.0% and~~ 11.1% and for cholesterol tests by 8.9% and 13.2%. Individuals with existing eyesight problems and diabetes health problems had an increased uptake for eyesight tests of 11.~~0~~1% and 29.4%. Permanent equivalised household income increased the uptake of dental screening and eyesight tests by 2.~~0% and 1.6%. An increase of one unit in the average self rated health status led to an increase in the uptake of eyesight tests by 2.~~5%.% and 1.8%. Initial conditions show significance for all health-check-ups.

DISCUSSION

~~Our analysis of the BHPS estimated for the first time the uptake of health check ups with a balanced panel over a period for 17 years from 1992 to 2008 in the UK (excluding Northern Ireland). We concentrated on balanced samples for the period from 1992 to 2008 for the different health check ups, because the estimation of balanced panels has advantages over unbalanced panels.[33] Our empirical investigation showed the importance~~

~~of taking the past screening behaviour into account, the relevance of age and visiting a GP. The effects of socioeconomic and health related variables such as education, employment status, living with a partner, health status, and smoking differ for the different health check-ups. Permanent household income decreased the uptake for dental screening and eyesight tests. The advantage of our analysis which used panel data rather than the cross-sectional data as used by most other studies is that individual heterogeneity and state dependence can be considered in a dynamic panel data model which is not possible in a model for cross-sectional data.~~

Our analysis compared the determinants of the uptake of six health check-ups in UK using the BHPS from 1992 to 2008 (excluding Northern Ireland). We investigated which determinants were the same for all health check-ups and which determinants differed for determining uptake with a focus on the importance of past screening behaviour on actual screening behaviour and health related variables.

The strong positive significant effect of past screening behaviour shows that past behaviour influences ~~actual~~current behaviour and this result can be interpreted as persistence in screening behaviour in the sense of state dependence.[~~40~~ ~~41~~49 50] Reasons for the strong positive state dependence are the adherence to the medical screening guidelines in UK~~, i.e. recommendation of checking in certain time intervals, and controlling results from previous~~ such as the NHS Breast and Cervical Screening Programme with explicit recommendations for the time interval between screening examinations ~~with unclear results. Initial conditions show a high~~. The relevance of these screening guidelines on current behaviour can be seen in the high predictive value of

these coefficients for these specific health check-ups 3 years before. Also the coefficient for the same specific health check-up one year before was significantly positive for all the different health check-ups. Persistence in screening behaviour, control follow-ups to check unclear test results from the previous health check-up and shorter recommended time intervals for some of the analysed health check-up (blood pressure check, cholesterol test, dental screening, eyesight test) could explain our results. However, with data from the BHPS it is not possible to differentiate between these different possibilities. Initial conditions show relevance in all analysed screening examinations ~~and so persistence of screening behaviour is caused by unobserved characteristics.~~. If initial conditions for the first three years had not been taken into account, the influence of past screening behaviour on actual behaviour would have been overestimated. For women the uptake of breast and cervical cancer screening is ~~highest~~higher in the age group for which it is recommended~~.~~ than in the reference groups. There is a lower uptake of dental screening for older ages in comparison to persons of middle age ~~group~~, and this result is in accordance with another study.[42~~51~~] The finding of decreasing screening uptake with increasing age is in accordance with the shorter pay-off period for older individuals from the human capital theory approach. For blood pressure ~~check~~checks, cholesterol ~~test~~tests and eyesight ~~test the~~tests uptake increases with age and our results can be explained by the increasing prevalence of hypertension, high cholesterol and eyesight problems with age and the necessity to check these specific health problems.

~~The significance of a GP visit in the year before the actual wave, for all the included health check-ups, can be explained by the fact that the GP plays an important role as~~

gatekeeper in the UK and also an important role in access to prevention by giving advice to accept a health check up or by doing the screening examination.[29] Our results reflect those in an Italian study which analysed the uptake of cervical cancer screening with a recursive probit. The regulations for having a smear test are very similar in Italy and UK with respect to the role of GP in cervical cancer screening. In both countries a visit of the GP is not an essential condition for the provision of a smear test and this test can also be done in specialized institutions.[20] Estimations from the Italian study showed that GP visits led to an increased uptake of cervical screening.

For women, uptakes were higher for blood pressure checks, dental screening and eyesight tests, and these results were in agreement with a recent study from the United States; however there was a negative effect on the uptake of cholesterol tests and the explanation of this result remains unclear.[22] Health status related variables such as a poorer self rated health status had both a significant influence on the uptake of blood pressure checks and cholesterol tests. For both health check-ups the interpretation as health stock proxy is probably most valid and so it is understandable that individuals with a low health stock have a high demand for preventative services. For the other health check-ups there was no such influence. However, health status related variables such as poor self rated health status can be also be interpreted in another way: poor health can influence also perceptions on the preventability of health problems; individuals who were found in a poorer health status also expressed less interest in receiving prevention information in a study[43] and this fact could explain why a poor health status can also be associated with low uptake for prevention services. Smoking had only an influence on the uptake of

~~breast cancer screening, blood pressure screening and dental screening, but not the other health check-ups. Reduced uptake for breast cancer screening has also been found for current smokers in another study.[44]~~

~~Education had only an influence on the uptake of the blood pressure checks and dental screening. Education has often to be found an important predictor in uptake for health check-ups, but not always.[13] Education is correlated with other socioeconomic variables (e.g. employment status, socioeconomic status) and the inclusion of further socioeconomic variables explains why education had an influence in only in one of the health check-ups.~~The significance of a GP visit in the year before the actual wave, for all the included health check-ups with the exception of non-significance for the eyesight test, can be explained by the fact that the GP plays an important role as gatekeeper in the UK and also an important role in access to prevention by giving advice about accepting a health check-up or by doing the screening examination[37] as it the case for cervical cancer screening, blood pressure check or cholesterol test. However, the importance of the GP is also significant for the health check-ups which are done outside of practice: breast cancer and dental screening. Our results reflect those in an Italian study which analysed the uptake of cervical cancer screening with a recursive probit. The regulations for having a smear test are very similar in Italy and UK with respect to the role of the GP in cervical cancer screening. In both countries a visit to the GP is not an essential condition for the provision of a smear test and this test can also be done in specialized services.[29] Estimations from the Italian study showed that GP visits led to an increased uptake of cervical screening. The effect of self-assessed health status is dependent on the specific

health check-up. The uptake of blood pressure checks and cholesterol tests increased with a deteriorating self-assessed health status and was highest for individuals in a very poor health state. Both these health check-ups are often included in a general health check-up for the health status of an individual. The interpretation of health status as a proxy for health stock is most valid for these two health check-ups in comparison to the other health check-ups as individuals in a poor health status have a high demand for these two health check-ups in order to increase their health stock. However, poor self-assessed health status can influence uptake also in other ways such as changed perceptions on the preventability of health problems and diseases. Individuals with poorer health status also expressed less interest in receiving prevention information in another study.[52] Psychological factors such as fear and anxiety about confirmation of a disease can be related to a poor health status and this correlation could be especially relevant for the both analysed female cancer screening examinations. Also individuals with a poor health status could be less able to visit the screening location and these interpretations could explain why such individuals have a lower uptake such as for cervical cancer screening. Individuals with blood pressure or diabetes problems had a higher propensity for the blood pressure checks and cholesterol tests and also individuals with eyesight problems had a higher propensity for the eyesight tests, in accordance with the medical guidelines. This is to our knowledge the first analysis that compares the uptake rates of blood pressure checks and cholesterol tests for individuals who have blood pressure and diabetes problems with individuals without having these diseases in a longitudinal setting for UK. Smoking had an influence on the uptake of breast cancer screening, blood pressure screening, cholesterol tests and dental screening, but not the other 2 health

check-ups. These results are in accordance with the interpretation that smokers have a risk taking behaviour, however the effect of smoking with a reduced uptake on health-check is not found in all studies as a systematic review has shown.[22]

Only the change of medical screening guidelines to extend breast cancer for women of age 65 to 70 screening had the intended effect. For breast cancer screening there was a higher uptake after 2002 in the age group of 65 to 70. Comparing the uptake rates for cervical cancer screening before and after changing the recommended time interval in 2003 from 5 to 3 years for women of age 25 to 49 shows a decrease in uptake rates. This result can be explained by a comparison of our result with official statistics data for the coverage rate of the target age groups for cervical cancer screening, because official statistics data show a declining uptake rate over time and this time trend is especially visible in the age group 25-49.[53] The recommendation of extending the time interval from 6 months to 1 to 2 years for dental screening after 2004 did not have an effect on uptake. The reason why the change in the medical screening guidelines for breast cancer screening had the intended effect could be based on the fact that timed appointments are made and it has a strictly policed screening interval.

The results for the socioeconomic variables are mixed for the different health check-ups. For women, uptakes were higher for blood pressure checks, dental screening and eyesight tests, and lower for of cholesterol tests and these results were in agreement with a recent study from the United States.[31] Education to secondary or tertiary levels had a positive significant influence on the uptake of dental screening. Education has often been found to

be an important predictor of uptake of health check-ups, but not always.[22] The hypothesised influence of higher education is only visible in one health check-up (dental screening). This result is in part explained by education being correlated with other socioeconomic variables and the inclusion of further socioeconomic variables could explain why the effect on education disappears in other regressions. Non-uniform results were also found for other socioeconomic variables for the different analysed health check-ups: employment status as a proxy for opportunity costs of time had ~~only~~ a significant ~~positive~~negative effect on breast cancer screening, blood pressure checks and ~~eyesight test~~cholesterol tests, living with a partner ~~only a significant positive effect for breast, cervical cancer~~as a proxy for social support and network had only a significant positive effect for dental screening and number of children ~~in the household~~as a proxy for a possible time constraint led to a significant negative effect for breast cancer screening and blood pressure ~~check~~checks. In a systematic review which analysed the determinants of screening uptake for different cancer screenings and other different health check-ups, none of the socioeconomic variables were significant in all screening examinations ~~and there were diverging results for a specific socioeconomic variable for a specific health check-up.[13] Our results confirm~~.[22] Our results confirm the result of this systematic review that for different screening examinations different socioeconomic variables are of relevance. Ethnicity had no significant influence on any of the health check-ups, suggesting that ethnicity is not a cultural barrier for access to preventative services. In comparison ~~to~~with our results, another study ~~with~~using the BHPS ~~which~~that analysed an unbalanced panel found for cervical cancer screening a lower uptake for Asian women in comparison to women of other ethnic origin.[16] ~~Women~~[25] Changed residence and address

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with a higher chance for not receiving an invitation letter has influenced the uptake rate of the various health check-ups unequally: women who had changed residence and address within the UK did not have a lower uptake for breast and cervical cancer screening and so the effectiveness of ~~the~~sending invitation letters ~~are~~ for these both female screening examinations is questionable. In ~~contrast~~opposite to these both female cancer screening examinations it was found that for dental screening a changed residence ~~led to an increase~~resulted in ~~the uptake of~~a lower uptake for dental screening. The implementation for the different health check-ups with sending routine periodic invitation letters to individual women for breast and cervical cancer screening, with the decision about invitation left for individual practices for eyesight test and dental screening and as an invitational programme for blood pressure check ~~which~~and cholesterol test could ~~be explained that after moving to a new location and GP registration, the new GP often measured blood pressure if an individual appears for the first time~~have influenced the uptake rates for the different health check-ups in ~~their~~different ways, however there is no information in the BHPS available how the invitational programmes are implemented on an individual practice level. There was no regional effect on uptake of ~~check-ups, so use of prevention services differed not in different parts of UK~~health check-ups.

~~Transitory household income had an effect on the uptake of the cholesterol test and~~ Averaged (permanent) household income had a significant influence only on the uptake for dental screening and eyesight tests~~. This result for the permanent income for these and actual (transitory) household income had no effect on any of the analysed~~ health check-ups. This result is important in comparison ~~to~~with the other analysed free health

check-ups, because income effects exist for ~~the~~ access to preventative health services for which a charge has to be paid in comparison to preventative services for which no charge exist. Permanent income effects could also be caused by unobserved time-invariant factors that have an influence on income and uptake. Another study which estimated the uptake of the health check-ups with unbalanced panels ~~with~~using the BHPS from 1991 until 2003 confirmed our results only in part, because a transitory income effect was found for the blood pressure check and a permanent income effect was found for dental screening.[14] ~~An advantage of our analysis was that we have controlled for attrition bias by estimating a balanced sample. Income effects such as transitory income effects could also be caused by unobserved time varying factors (e.g. motivation) which have an influence on uptake and income and similar permanent income effects could also be caused by unobserved time invariant factors.~~

~~Only the policy change to extend breast cancer screening had the intended effect. For breast cancer screening there was a higher uptake after 2002 in the age group of 65 to 69.[23]~~ The ~~recommendation of shortening the time interval from 5 to 3 years for women of age 25 to 49 after 2003 for cervical cancer screening failed to have the intended effect of increased uptake in the relevant age group and also the recommendation of extending the time interval from 6~~ averaged value of a GP visit during the last 12 months ~~to 1 or 2 years for dental screening after 2004 did not have the intended effect. The reason why only the changed recommendations for breast cancer screening had the intended effect remains unclear and should be the focus of further research. Individuals~~ variable was correlated in five of the six health check-ups with ~~blood pressure or diabetes problems had a higher~~

~~propensity for the blood pressure checks and cholesterol tests and also individuals with eyesight problems had a higher propensity for the eyesight tests, in accordance with the medical guidelines~~the individual specific term for time invariant unobserved heterogeneity.

There are some differences when comparing our results ~~for~~on the uptake of breast and cervical cancer screening with ~~another study~~other studies which had analysed the uptake behaviour for UK and used the BHPS~~.~~ as sample. Analysis of breast cancer screening uptake with the BHPS was done in one analysis with a balanced sample.[26] Identical results were found for the relevance of previous screening history, a GP visit, age and self-assessed health status, however results were different to own results for smoking status, education level, marital status and the averaged income term, because they were significant in this analysis. The different results for the latter mentioned variables are best explained by choosing different specifications in the two empirical analyses. Analysis of cervical cancer screening uptake with the BHPS was done in a further analysis with a balanced sample. In our analysis previous screening history, age and a GP visit were significant for cervical cancer screening in the UK and our results were confirmed by this study which analysed uptake of cervical cancer screening uptake in England with an unbalanced panel for the first 12 waves of the BHPS until 2003.[~~16~~25] The coefficients for education, smoking and changed residence status were not significant in our analysis. The differences in results for the variable education and smoking are remarkable, because in our analysis they had not been significant. However, also some other studies have found no influence of education[~~13~~22] and smoking status[54] on screening behaviour~~.~~[~~45~~]

. Only one analysis compared the sociodemographic determinants for the uptake of breast and cervical cancer screening at the same time for UK with a cross-sectional survey.[2] Results for the effects of determinants on the uptake of both female cancer screening examinations were different, because for mammography level of education, occupational classification and ethnicity were not significant and only indicators for wealth were positively significant. For having a smear test a higher educational level, and white British ethnicity were positively significant, but not indicators for wealth or occupational classification. This is one of the few studies that compared the determinants of the uptake of breast and cervical screening and found different determinants to be responsible for the uptake of both screening examinations. An advantage of this analysis was that is used the same estimation sample for the analysis, however unobserved heterogeneity and state dependency could not be taken into account with cross-sectional data in this analysis and this could explain the different results to the results of our own study. One study with the BHPS found in a descriptive analysis that females reported a higher uptake than males for dental check-ups under NHS provision.[42,51] Individuals between age 46 and 55 years had the highest proportion of dental check-ups with 72% in 2000 and the lowest participation rate was for individuals of age 66 years and older with 43% in 2000. These results are confirmed ~~by~~in our ~~study~~analysis. Another study which ~~analysed with~~used the BHPS to investigate the probability of making a dental check-up visit in 1, 3, 5 and 10 years in comparison to the baseline period of 1991 found that in each of these time periods from 1991 to 2001 females, more educated and non-smokers had a higher uptake which is in accordance with own results. However, in contrast with our own results persons below

age 40 had the highest rate of uptake and this result could be explained by the fact that only a distinction between individuals below age 40 and above age 40 was made.[46~~55~~]

A first limitation of our study is there is no information about results from previous screening examinations available and it is not possible to differentiate between types of health check-ups: preventative health check-ups~~, or taking part after~~ according to screening guidelines, health check-ups following the advice of a GP or consultant ~~and follow up tests~~to do a test, or health check-ups which are in response to previous inconclusive results. A second limitation of our study is that no information was available about level of trust in the NHS or in the GP, because it has been shown that taking part in screening examinations can be dependent on trust.[~~20~~29] A third limitation exists, because there was no information available about the characteristics of the primary care factors that have been shown to be associated with the uptake of screening examinations in England.[47~~56~~] Characteristics of the professional performing of the screening test, structure and organization of medical services can influence the uptake rate. A fourth limitation of our study comes from not using detailed microgeographic information, because uptake rates for a specific health check-up can be higher in affluent and less deprived areas.[48~~57~~]

CONCLUSIONS

~~The~~Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, health status, and existing health problems for these six different health check-ups. A further

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innovative feature of our study is the analysis of the uptake of different health check-ups with a random effects panel probit model with initial conditions (Mundlak-Wooldridge estimator) ~~with a balanced sample.~~and a balanced sample, because some other analyses have used cross-sectional data and unbalanced panels with the possible problem of an attrition bias. Our research shows the high importance of past screening behaviour for each of the analysed health check-ups for recent screening behaviour and it is important, therefore, to maintain a high level of prevention uptake. The GP plays a central role in the uptake of screening examinations and this role in prevention in the UK health care system should not be weakened. Existing diseases are as expected important predictors for the specific health check-up. Income barriers could be removed for health check-ups such as dental screening and eyesight ~~test~~tests to increase the uptake for individuals with ~~lower socioeconomic status~~limited financial possibilities. Future research could use information about results from previous screening examinations and microgeographic information by linking with other data sources ~~and this linking with other datasets would give the possibility to analyse additional determinants of uptake~~.

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Contributions

AL performed statistical analyses. AL, RB and FP discussed the results, and contributed to the text of the manuscript. All three authors reviewed the manuscript.

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Competing financial interests

The authors declare no competing financial interests.

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Utilisation of Preventative Health Check-Ups in UK: Findings from individual-level repeated cross-sectional data from 1992 to 2008

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Utilisation of Preventative Health Check-Ups in the UK: Findings from individual-level repeated cross-sectional data from 1992 to 2008

Alexander Labeit*

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

Frank Peinemann

FOM University of Applied Science for Economics & Management, 45141 Essen, Germany

Richard Baker

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

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ABSTRACT

Objectives: To analyse and compare the determinants of screening uptake for different NHS health check-ups in the UK.

Design: Individual-level analysis of repeated cross-sectional surveys with balanced panel data.

Setting: UK.

Participants: Individuals taking part in the British Household Panel Survey (BHPS), 1992 - 2008.

Outcome measure: Uptake of NHS health check-ups for cervical cancer screening, breast cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.

Methods: Dynamic panel data models (random effects panel probit with initial conditions).

Results: Having had a health check-up one year before, and previously in accordance with the recommended schedule, was associated with higher uptake of health check-ups. Individuals who visited a General Practitioner (GP) had a significantly higher uptake in 5 of the 6 health check-ups. Uptake was highest in the recommended age group for breast and cervical cancer screening. For all health check-ups, age had a nonlinear relationship. Lower self-rated health status was associated with increased uptake of blood pressure checks and cholesterol tests; smoking was associated with decreased uptake of 4 health check-ups. The effects of socioeconomic variables differed for the different health check-ups. Ethnicity did not have a significant influence on any health check-up. Permanent household income had an influence only on eyesight tests and dental screening.

Conclusions: Common determinants for having health check-ups are age, previous screening history and a GP visit. Policy interventions to increase uptake should consider the central role of the GP in promoting screening examinations and in preserving a high level of uptake. Possible economic barriers to access for prevention exist for dental screening and eyesight tests, and could be a target for policy intervention.

Trial registration: This observational study was not registered.

ARTICLE SUMMARY

Article focus

- To identify and compare determinants of the uptake of different preventive health check-ups delivered by the NHS: breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.
- To compare the effect of past screening behaviour, age, GP visits, health status and socioeconomic variables on the uptake of each of these health check-ups.

Key messages

- Past screening behaviour and GP visits explained recent screening behaviour for each of the health check-ups: taking part in past screening examinations and visiting a GP visit increased recent uptake.
- Lower self-rated health status increased the uptake of blood pressure checks and cholesterol tests, but smoking decreased the uptake of 4 health check-ups.
- Permanent household income had a positive significant effect only on eyesight tests and dental screening, but not on the other health check-ups.

Strengths and limitations of this study

- Our study used consistent individual-level repeated cross-sectional data from a panel survey over a period of 17 years for the different health check-ups.

- Our estimation used a balanced panel which considered also attrition effects.
- Medical information about results from previous screening examinations was not available, and linking with other data sources could improve our analysis.

INTRODUCTION

Individuals are offered different health check-ups in the NHS. These include breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental check-ups and eyesight tests. There is no charge for the health check-ups, other than for dental check-ups and eyesight tests. Taking part in health check-ups is important, because screening examinations promote early detection of diseases and are potentially cost saving. There are only few national and international analyses that analyse how different health check-ups are affected by socioeconomic determinants, and typically such studies have been cross-sectional surveys.[1 2] One analysis using UK data has shown that the socioeconomic determinants of breast and cervical cancer screening differ. Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, existing health problems and health status for these six different health check-ups. Can certain determinants explain the uptake of these six health check-ups, and especially what is the influence of health related variables on the uptake? In the next sections the institutional regulations of the six different health check-ups are introduced with a motivation of this analysis, followed by the theoretical framework for our analysis and a discussion of relevant previous empirical prevention research which is related to our own work. The next two sections present own results for the 6 different health check-ups and discuss these results with possible policy implications.

For each health check-up a detailed recommendation exists on how often an individual

should attend a specific health check-up depending on age limits, dependent on risk factors, comorbidities and previous health check-ups. There are differences in invitation policy for different parts of UK for cervical cancer screening and for dental screening and the eyesight test an individual has to pay a charge with certain exemption. Table 1 gives the institutional regulations and recommendations for the different health check-ups in UK.

Table 1: Regulations and recommendations for the different health check-ups in UK

The national NHS Breast Screening Programme (NHSBSP) offers mammography to women at a 3 yearly period.[3] Women between age 50 and 64 are invited, and there has been an extension after 2002 of the age range for these programme and women between age 65 and 70 years are also now invited. The national NHS Cervical Screening Programme (NHSCSP) offers women a smear test at different time intervals depending on age.[4] The age for the first invitation, the age of the last invitation and time periods between invitations for cervical cancer screening are dependent on the country in the UK.[5] The age of first invitation is age 25 in England[6] after 2003 and age 20 in Scotland,[7] Wales[8] and in England until 2003. Between the age of the first invitation and 49 is a 3 yearly recall period in all parts of UK since 2003 and before 2003 there was a 3 to 5 yearly recall period policy in England depending on the Primary Care Trust, with the majority of Primary Care Trusts in England following a 3-year policy.[9] The policy of a uniform 3 yearly recall period for women between age and 25-49 was implemented after a recommendation by Cancer Research UK, because a 3-year recall policy seemed most

effective after analysis of UK data.[10] No information was available for us how quickly each Primary Care Trust in England implemented the changes to the recall policy. Between age 50 and age of the last invitation cervical cancer screening is offered to women every three years until age 60 in Scotland and until age 64 in Wales, and every 5 years in England until age 64 after 2003. Women above the age limits are excluded from the recall system and no longer invited unless they need ongoing surveillance or follow up, for example because of an abnormal result in any of the three most recent tests. For breast and cervical cancer screening examination there are sent out routine periodic invitations to women by their GP. Blood pressure can be checked by a GP or another healthcare professional, and it is recommended that adults aged over 20 are checked at least every 5 years[11] and the recommendations for regular blood pressure are dependent on age, health status and existing diseases, health behaviours and lifestyle. For older individuals and individuals with risk factors such as overweight, obesity, diabetes, family history of high blood pressure, smoking should be checked every year and for individuals with existing hypertension it should be checked several times a year.[12] A cholesterol test is recommended for adults with no symptoms to take place every 5 years starting at age 20.[13 14] For all individuals who are overweight or obese and have high blood pressure or diabetes or who have been diagnosed with coronary heart disease, stroke, peripheral arterial disease or who have a family history of early cardiovascular disease or a close family member with a cholesterol-related condition, such as familial hypercholesterolaemia it is recommended to do it every 1 to 2 years. The cholesterol test is implemented as an invitational programme. For dental screening the national guidelines recommend at least one check-up every two years, unless the dentist

recommends a different interval based on the patient's current dental health.[15] The national guidelines changed in 2004, the previous recommendation being every 6 months. Dental screening incurs a charge to the patient, and is only free for those under the age of 18 or on income support. Dental screening has been free in Scotland since 2006[16] and in Wales it is free for individuals under age 25 and aged 60 or over since 2006.[17] An eyesight test is recommended every two years, or more frequently if necessary.[18] It is especially advised for individuals aged 60 years and older, individuals from certain ethnic groups, for example, Afro-Caribbeans, and for those with selected diseases predisposing to eye disorders, for example diabetes, glaucoma or close relatives with eye disease. There is a charge for the eyesight test, but it is free for individuals aged 60 and older, or who are blind or partially sighted, or who have diabetes or glaucoma. Eyesight tests have been free in Scotland since 2006.[19] For dental screening and eyesight tests the individual dental or optometry practices can decide on sending invitation letters.

THEORETICAL APPROACH

Economic models of the demand of health care in general, and preventative care in particular, are based on human capital models.[20] This framework has also been used for the modelling of demand for primary and secondary prevention.[21] These categories of prevention are self-protection measures that improve early detection and health outcomes.[22] The problem with economic models of prevention is that two important aspects are typically not considered at the same time in detail: the distinction between acute and preventative care, and uncertainty. Some dynamic economic models for the

demand of health care take only uncertainty into consideration, no distinction being made between acute and preventative care.[23] Acute care describes the consumption aspect of health whereas preventative care describes the investment aspect. The (simplified) Grossman model makes the distinction between acute and preventative care, but uncertainty is not considered in this model.[24] Only one economic model explicitly considers both the demand for preventative health care, using a stochastic dynamic framework.[25] However, in this article no non-economic factors were considered. Our conceptual framework is based on a human capital approach and as an extension non-economic factors such as non-monetary barriers are included. Our approach is also supported by previous research which has investigated determinants of different types of screening examinations.[26]

Participation in breast or cervical cancer screening examinations in past periods has predictive value for the uptake in the actual period, i.e. past screening behaviour is correlated with current behaviour.[27 28]Age can have different effects on the demand for prevention.[29 30] For breast and cervical cancer screening examinations, medical guidelines exist with explicit recommendations on how often screening should be done in certain time intervals, and for the recommended age intervals uptake should be higher than for non-recommended age intervals. However, on one hand according to the Grossman model health depreciates at an increasing rate at older ages, and the necessity to maintain health increases and as a consequence the demand for preventive activities increases. On the other hand, older individuals have a shorter life span and pay-off period for their investment in prevention activities. Therefore the effect of increasing age on uptake

cannot be predicted with confidence. Empirical studies often find a negative relationship between age and uptake of health check-ups.[30 31] Studies which analysed possible gender differences in the utilization of health care services found that females have a higher utilization of health care services[32] and also a higher use of preventative services including blood pressure checks, cholesterol tests and dental screening.[33 34] Higher educational level may be expected to lead to an increase in the demand for prevention services, because individuals with a higher education may have higher efficiency in the production of health and also increased self-efficacy, higher confidence and motivation.[21 27 30 31] Individuals who live in a partnership have a higher propensity for screening examinations and living in a partnership may be a proxy for having a more dense social support network that encourages individuals to take part in prevention activities and some empirical studies have confirmed this hypothesis.[35 36 37] A higher number of children in the household can influence screening behaviour through time constraints.[27 38] Household income may be expected to lead to an increase in the demand for prevention services, because higher income leads to an increase in demand for time in perfect health.[20 24] In some studies, increasing household income increased uptake of preventive care,[29 30 39] although the effect may be weaker in the UK compared to other countries, because most preventative services are free in the UK. Employment was added as a further control variable, because individuals who work may have higher opportunity costs in comparison to unemployed and retired individuals. In a systematic review of the influence of different determinants on the uptake of health check-ups, influence of employment for the uptake of different health check-ups was found to be inconsistent.[26 40] The GP plays a role as gatekeeper in the UK health care system and can give advice and information about the

importance of health check-ups for the early detection of diseases, and therefore uptake may be enhanced by previous GP visits.[41 42] Cervical cancer screening, blood pressure checks and cholesterol tests can be done in a GP practice. Poor self-rated health status and existing general health problems could encourage people to think about their health in general and therefore to invest in health and to increase participation in screening examinations, and this seems to be the case for general health check-ups such as blood pressure check and cholesterol test, but not for female specific cancer screenings such as the mammography and the smear test.[29] Psychological factors such as fear and anxiety about receiving a cancer diagnosis may deter some women from attending one of these health check-ups. Furthermore, individuals in a poor health state may not be able to visit the screening location such as the GP, family clinic or mammography unit, the dentist or the optometrist, because of physical limitations. There are contradicting findings on the effect of poor health status on the uptake of health check-ups, with increased uptake of cholesterol checks and a lower uptake of mammograms and pap smears.[43] Smoking can serve as an indicator for the weakened preference of an individual for health in comparison to other goods and smoking individuals show risk taking behaviour.[44] Individuals who smoke have poorer preventative health habits such as a reduced level of physical activity in comparison to non-smoking women.[45] The predicted influence of smoking on uptake was empirically confirmed for breast cancer screening with a lower uptake for smoking women.[30] For individuals with non-white ethnic origin cultural barriers may exist, and this is especially the case for breast and cervical cancer screening. In an empirical investigation ethnicity was the most important predictor for cervical cancer screening, with white British women having a higher uptake than women of other

ethnicity. Registration with a GP is a necessary condition for receiving an invitation letter for breast and cervical cancer screening and routine periodic invitations are sent from the GP according to the recommended interval for breast and cervical cancer screening. A changed residence and address of a woman lowers the chance to receive an invitation letter. A lower uptake of cervical cancer screening was found in one study for women in UK who had changed residence and address,[38] but not in another one.[27]

Information about the uptake of these different health check-ups over a period of nearly 20 years is available in the British Household Panel Survey (BHPS). Only one study has compared these different NHS health check-ups from 1991 to 2003.[46] However, this study didn't analyse the influence of health related and socioeconomic characteristics on the uptake. Random effect panel probit models were only with unbalanced panels, with the potential problem of attrition bias, and as a consequence selection bias in the estimates can occur.[47] Therefore, our analysis compares how past screening behaviour, individual and household characteristics, transitory and permanent household income affect uptake of these different health check-ups.

METHODS

It is sensible for our estimation to consider how screening behaviour was in the past time and the recommended time interval for a screening examination (e.g. for breast and cervical cancer screening examinations the recommended 3 year intervals), because there is an increased likelihood of participating in a screening examination after the

recommended time interval. Additionally, there exists the possibility that screening examinations are recommended in shorter time intervals if an individual belongs to a high risk population such as in the female cancer screening examinations with close relatives have a history of breast or cervical cancer. Also there exists for all the different health check-ups the possibility that an inconclusive check-up in the actual year has a consequence a control follow check-up in the next year. With the BHPS it is not possible to differentiate between routine check-ups according to the screening guidelines or as a response to an inconclusive result from a health check-up in the previous year or as an advice to do a health check-up from a GP. To include these different possibilities for the analysis of uptake behaviour a dynamic specification with lags for the last 3 years was chosen for the different health check-ups. To model the dynamic nature of screening examinations and because uptake is a binary variable, a dynamic random effects (RE) panel probit model was used to estimate the uptake of NHS health check-ups over the panel period from 1992 to 2008. The advantage of such a specification is that the uptake of health check-ups is not only explained by individual and household characteristics, but also at the same time by past screening behaviour and therefore persistence in screening behaviour (state dependence). A further advantage of this econometric specification which uses panel data and not cross-sectional data is that both individual heterogeneity and state dependence can be considered in a dynamic panel data model, which is not possible in a model for cross-sectional data. One possibility for estimating a dynamic random effects (RE) panel probit is the Mundlak-Wooldridge estimator that specifies a relationship between the unobserved time-invariant individual effect and the observed

characteristics and initial conditions,[48] and the econometric model is given by the following 3 equations (1), (2), (3).

$$y_{it}^{*} = \gamma_1 y_{it-1} + \gamma_2 y_{it-2} + \gamma_3 y_{it-3} + x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (1)$$

In the first equation y_{it}^{*} indicates the unobserved latent variable of an individual i at a given time t for taking part in a specific screening exam, $y_{it-1}, y_{it-2}, y_{it-3}$ are the screening examination decisions of the individual i 1, 2 and 3 periods before t and γ_1, γ_2, γ_3 are the related coefficients for these variables, x is a vector of time variant and time invariant covariates, β is the vector of coefficients associated with these covariates, ε_{it} is the random error term and α_i indicates the individual specific term for time invariant unobserved variables which is modelled according to equation (2) as individual specific random effect:

$$\alpha_i = \delta_1 S_{i1} + \delta_2 S_{i2} + \delta_3 S_{i3} + +\delta_4 \overline{X}'_i + \upsilon_i \quad (2)$$

A normal density for the individual specific random effect is assumed and the first three terms are the initial conditions with the uptake of the specific health check-up for an individual i in the first three periods of the panel: S_{i1}, S_{i2} , S_{i3}.The fourth term allows correlation between the time-varying variables of an individual by including the average $\overline{X}'_i$ over the whole panel observation period and the individual specific random effect,[49] which divides the time-varying variables into a transitory and permanent component for

the estimation. ν_i is the error term assumed normally distributed with zero mean and standard deviation σ_α. This specification has the advantage that time-invariant unobserved variables which are correlated to time-varying variables are captured by the mean of these variables and give a less biased estimate of the transitory component of these variables. The third equation gives the observed binary outcome y_{it} of taking part in a specific health check-up for individual i in period t.

$$y_{it} = \begin{cases} 1, if \;\; y_{it}^{*} > 0 \\ 0, otherwise \end{cases} \qquad (3)$$

The chosen Mundlak-Wooldridge specification has the advantage that under certain assumptions the bias which is caused by the persistence of screening behaviour is removed. Crucial assumptions for the estimation of the dynamic random effect model are that the relationship between the unobserved time-invariant individual effect and the mean of the observed characteristics is correctly specified and also the distributional assumptions on the initial conditions are correct. The breast cancer screening programme (NHSBSP) and cervical cancer screening programme (NHSCSP) were introduced in 1988 before the beginning of the BHPS and also the four other health check-ups had been available to individuals before the BHPS had started. For our estimation technique it is assumed that the health check-ups that had been undertaken before the first wave of the BHPS are uncorrelated with the health check-ups recorded in the BHPS. If this assumption is violated, the inclusion of initial conditions of health check-ups for the years 1992 to 1994 could result in biased estimates for our regressions. An advantage of our

statistical approach is that some previous analyses have investigated the uptake of health check-ups with cross-sectional data and therefore could not control for unobserved heterogeneity, and other analyses used unbalanced panel data sets for their estimation.[27 46] Estimation of unbalanced panels with ad hoc treatments of initial problems has unfavourable estimation properties and could result in biased estimation as has been shown by simulation studies.[47] The estimation results of balanced panels are more reliable, because balanced panels satisfy the assumptions of the Mundlak-Wooldridge estimator.[50 51] Therefore, estimation of balanced panels for the different health check-ups was preferred over unbalanced panels. An alternative to the Mundlak-Wooldridge estimator would be the maximum likelihood estimator proposed by Heckman,[52] however for balanced panels with more than 5 to 8 periods the finite sample properties of the Mundlak-Wooldridge estimator are better.[47]

We used the BHPS, which is an annual survey of households in UK. It is a nationally representative sample of more than 5,000 households and individuals aged 16 and over.[53] The first wave of the data collection for this survey started in 1991 and all the original individuals were interviewed in each succeeding year unless they dropped out. Questions about taking part in NHS health checks-up have been in every wave from the start of the panel survey in 1991 until 2008. For the analysis of breast and cervical cancer screening, only females were included, for all other types of health check-ups both males and females were included. In our analysis and construction of the balanced sample only individuals from England, Wales and Scotland were selected, because data collection started in Northern Ireland from wave 11 and not from the first wave. For the

construction of the balanced panel 17 years of information were used: from 1992 to 2008, because in the first wave only a small number of individuals were interviewed in 1991. For an individual to be included in our analysis, provision of the specific health check-up had to be from the NHS; individuals with private provision or with NHS and private provision for a specific health check-up have been excluded from the analysis. The dependent variable takes the value of 1 in a specific year if the specific health check-up (breast cancer screening, cervical cancer screening, blood pressure check, cholesterol test, dental test, eyesight test) was done and 0 if not. For analysing the changes in the medical screening guidelines for 3 different health check-ups (breast cancer screening, cervical cancer screening, dental screening) a dummy coding was chosen: for breast cancer screening and age group 65-70, all years before and including 2002 were coded with 0 and all the following years with 1; for cervical cancer screening and age group 25-49 all years before and including 2003 were coded with 0 and all the following years with 1; for dental screening all years before and including 2004 were coded with 0 and all the following years with 1.

The balanced panel included for breast cancer screening 861 women with 12,054 observations, for cervical cancer screening 867 women with 12,138 observations, for blood pressure checks 1,405 individuals with 19,670 observations, for cholesterol tests 1,568 individuals with 21,952 observations, for dental screening 706 individuals with 9,884 observations and for eyesight tests 613 individuals with 8,582 observations. In our analysis, for breast cancer screening, we followed the age groups of the screening guidelines: 16 to 49 (reference group), 50 to 64, 65 to 70, and age 71 and older. For

cervical cancer screening we used the age groups of the screening guidelines: 16 to 19 (reference group), 20 to 24, 25 to 49, 50 to 64, and age 65 and older. For all other screening checks, the following groups were used: 16 to 39 (reference group), 40 to 49, 50 to 59, 60 to 69, 70 to 79 and 80 and older. For blood pressure checks and cholesterol tests, we included information on whether the person had diabetes or also heart/blood pressure/blood circulation problems, and for eyesight tests, information on eyesight problems and diabetes was used. Actual (transitory) income was defined as the total equivalised and deflated household annual income divided by 100 and permanent household income was defined as annual household income over the 17 years between 1992 and 2008. Household income was deflated and transformed in per capita income using the modified OECD scale to allow for household size and needs.[54] The International Standard Classification of Education (ISCED) was used for the categorisation of educational levels with tertiary, secondary and primary education (reference category). Health status was self-rated and included in our analysis with categories from excellent (1) as reference category in regressions, good (2) fair (3), poor (4) to very poor (5).[55]

RESULTS

Table 2 presents descriptive statistics for the variables used in our estimation for the balanced panels for the different health check-ups.

Table 2: Sample characteristics for the balanced panels of different health check-ups in

UK

For the period 1992 to 2008 there were the following uptake rates within one year for individuals for the balanced panel: 13.9% for breast cancer screening, 20.4% for cervical cancer screening, 51.2% for the blood pressure check, 19.5% for the cholesterol test, 57.6% for dental screening and 34.4% for the eyesight test.

Table 3 provides the estimated coefficients for the dynamic random effects (RE) probit model with initial conditions for the balanced panel (BP) for the different health check-ups. For a robustness check of the age categorisation for cervical cancer screening 2 different possibilities of age categorisation have been selected. Age categorisation is in specification 1: age 16-19 (ref.), 20-24, 25-49, 50-64, 65+ (sample age≥16). Age categorisation is in specification 2: age 20-24 (ref.), 25-49, 50-64, 65+ (sample age≥20). The estimation results for specifications 1 and 2 with the different age categorisations are very similar for all other variables (technical appendix table 1). We have selected to choose age categorisation as in the specification 1 in the comparison table 3 for the different health check-ups.

Table 3: Parameter estimates and standard errors for the uptake of health check-ups in UK

For all health check-ups, taking part in past screening examinations showed a strong

influence on the current screening examination. The effect of having the same screening examination one year ago was strongest for dental screening. The magnitude of the effects, the marginal effects, are shown in table 4 and for dental screening examinations there was an increase of 18.2% if there has been a visit one year before.

Table 4: Marginal effects and standard errors for main predictors of uptake for health check-ups in UK

The effect of having the same screening examination three years ago was similar for breast and cervical cancer screening and the marginal effects resulted in an increase in uptake of 12.3% and 12.6%. For individuals who visited their GP in the last year, there was an increase for 5 of the 6 analysed health check-ups with only the eyesight test not significant, the increase being highest for blood pressure with a 25.9% increase and lowest for dental screening with a 1.7% increase. Poor self-rated health status increased the uptake of blood pressure checks by about 12.6% and cholesterol tests about 4.5% and for the eyesight test poor health status increased the uptake by 5.4%. For breast and cervical cancer screening there was no significant influence of poor health status on uptake. Women aged between 50 and 64 had an increased uptake of 9.9% for breast cancer screening and women aged between 25 and 49 had an increased uptake of 7.3% for cervical cancer screening in comparison to the reference categories. Also for the other four health check-ups there was a nonlinear relationship between age and uptake. For blood pressure check, cholesterol test and eyesight test uptake increased nonlinearly for the different age categories. Women aged between 65 and 70 had a higher uptake of

breast cancer screening after 2002; an increase of 7.9% for this age group in comparison to the years before. Women aged between 25 and 49 had a 2.5% lower uptake of cervical cancer screening after 2003 in comparison to women of this age group before 2003. Individuals who had a dental screening after 2004 did not have a significant changed uptake in comparison to the years before.

Females had a higher uptake in three of the four analysed health check-ups that are not sex-specific (blood pressure check, dental screening, eyesight tests), but the influence on the uptake of the cholesterol tests was non-significant. The increase in uptake for females was highest for eyesight tests with an increase of 4.4%. The marginal effects for education, employment status, household income, living with a partner, smoking, changed residence status were non-uniform for the different health check-ups. The effect of secondary and tertiary education was strongest for the uptake of dental screening (30.5% and 28.3% increase). Being employed decreased the uptake for breast cancer screening by 3.1%, for blood pressure checks by 2.5% and cholesterol test by 2.2%. Increasing actual household income had no significant effect on any of the uptakes. Living with a partner increased the uptake of dental screening by 3.8%. Smoking decreased the uptake of breast cancer screening by 3.3%, blood pressure checks by 6.3%, cholesterol tests by 2.9% and dental screening by 3.2%. An additional child in the household decreased the uptake of breast cancer screening examinations and blood pressure checks by 2.1% and 2.4%. Change of residence decreased the uptake of dental screening by 3.5%; however, it increased the uptake of blood pressure checks by 3.6%. Individuals with existing blood pressure problems or diabetes had increased uptake of

blood pressure checks by 22.5% and 11.1% and for cholesterol tests by 8.9% and 13.2%. Individuals with existing eyesight problems and diabetes health problems had an increased uptake for eyesight tests of 11.1% and 29.4%. Permanent equivalised household income increased the uptake of dental screening and eyesight tests by 2.5% and 1.8%. Initial conditions show significance for all health-check-ups.

DISCUSSION

Our analysis compared the determinants of the uptake of six health check-ups in UK using the BHPS from 1992 to 2008 (excluding Northern Ireland). We investigated which determinants were the same for all health check-ups and which determinants differed for determining uptake with a focus on the importance of past screening behaviour on actual screening behaviour and health related variables.

The strong positive significant effect of past screening behaviour shows that past behaviour influences current behaviour and this result can be interpreted as persistence in screening behaviour in the sense of state dependence.[56 57] Reasons for the strong positive state dependence are the adherence to the medical screening guidelines in UK such as the NHS Breast and Cervical Screening Programme with explicit recommendations for the time interval between screening examinations. The relevance of these both screening guidelines on current behaviour can be seen in the high predictive value of the coefficients for the same specific screening examination 3 years before. Our results for the high predictive value of a breast or cervical cancer screening examination which had

been done three years ago for the uptake in the current year are in accordance with other results which analysed the uptake for these both screening examinations.[27 58] Also the coefficient for the same specific health check-up one year before was significantly positive for all the different health check-ups. These results are in agreement with a further analysis which used a lagged dependent variable of uptake one period before as predictor variable and analysed these six different health check-ups.[46] Different other studies have confirmed the importance of past screening behaviour for recent uptake of screening examinations such as for mammographies,[59] smear tests[60] and faecal occult blood test[61] and also a systematic review confirmed that past screening examinations had a positive influence on a recent screening examination.[26] Persistence in screening behaviour, control follow-ups to check unclear test results from the previous health check-up and shorter recommended time intervals for some of the analysed health check-up (blood pressure check, cholesterol test, dental screening, eyesight test) are of importance to explain the significance of the one year lagged dependent variable as predictor variable. However, with data from the BHPS it is not possible to differentiate between these different possibilities. Initial conditions show relevance in all analysed screening examinations. If initial conditions for the first three years would not been taken into account, the influence of past screening behaviour on actual behaviour would have been overestimated, because some of the persistence in screening examinations uptake has been to be attributed to unobserved characteristics. Initial conditions have also to be found significant in other analyses which have used the Mundlak-Wooldridge estimator for the analysis of dynamic panel data models.[28]

For women the uptake of breast and cervical cancer screening is higher in the age group for which it is recommended than in the reference groups and this result has also found for other empirical studies which has analysed the uptake of screening examinations for UK[27 28] and our results are similar to an Australian study which confirmed that the uptake of the pap smear test in the recommended age group was also higher than in the non-recommended age group.[62] There is a lower uptake of dental screening for older ages in comparison to persons of middle age, and our result is in accordance with another study which has analysed the dental screening uptake with the BHPS in UK.[63] The finding of decreasing screening uptake with increasing age can be explained with the shorter pay-off period for older individuals from the human capital theory approach and are in agreement with a study in the Netherlands for which participation in a health examination increased until age 60 and then decreased.[64] For blood pressure checks, cholesterol tests and eyesight tests uptake increases with age and our results can be explained by the increasing prevalence of hypertension, high cholesterol and eyesight problems at older ages and the necessity to check these specific health problems and are confirmed for these specific health check-ups also by other studies.[65]

The significance of a GP visit in the year before the actual wave, for all the included health check-ups with the exception of non-significance for the eyesight test, can be explained by the fact that the GP plays an important role as gatekeeper in the UK and also an important role in access to prevention by giving advice about accepting a health check-up or by doing the screening examination[42] as it is the case for cervical cancer screening, blood pressure check or cholesterol test. Our results reflect those in an Italian

study which analysed the uptake of cervical cancer screening with a recursive probit.[31] The regulations for having a smear test are very similar in Italy and UK with respect to the role of the GP in cervical cancer screening. In both countries a visit to the GP is not an essential condition for the provision of a smear test and this test can also be done in specialized services. Estimations from the Italian study showed that GP visits led to an increased uptake of cervical screening. However, the importance of the GP is also significant in our analysis for the health check-ups which are done outside of practice: breast cancer screening and dental screening. Two further analyses reinforce the interpretation of the importance of a GP visit as a healthcare provider contact for prevention, because a higher number of healthcare provider contacts increases the uptake rate for breast cancer screening examinations[66] and cholesterol tests.[65] Furthermore, individuals who visit their GP more often have a higher uptake of general cardiovascular checks in UK.[67] [68] The importance of the GP for prevention in UK is also further strengthened by the fact that individuals who have visited a GP in the previous year have a higher propensity to make an appointment for a health check-up in the recent year.[69] In the auxiliary regressions the averaged value of a GP visit during the last 12 months variable was correlated in five of the six health check-ups with the individual specific term for time invariant unobserved heterogeneity and could also be caused by unobserved time-invariant factors that have an influence on probability of a GP visit and uptake of the different health check-ups. The effect of self-assessed health status is dependent on the specific health check-up. The uptake of blood pressure checks and cholesterol tests increased with a deteriorating self-assessed health status and was highest for individuals in a very poor health state. Both these health check-ups are often included in a general

health check-up for the health status of an individual. The interpretation of health status as a proxy for health stock is most valid for these two health check-ups in comparison to the other health check-ups as individuals in a poor health status have a high demand for these two health check-ups in order to increase their health stock.[70] However, poor self-assessed health status can influence uptake also in other ways such as changed perceptions on the preventability of health problems and diseases. Individuals with poorer health status also expressed less interest in receiving prevention information in another study.[71] Psychological factors such as fear and anxiety about confirmation of a disease can be related to a poor health status and this correlation could be especially relevant for the both analysed female cancer screening examinations. Also individuals with a poor health status could be less able to visit the screening location and these interpretations could explain why such individuals have a lower uptake such as for cervical cancer screening. The effect of self-perceived health status on breast cancer screening was non-uniform in other studies: Women with poor or fair self-perceived health status attended mammograms less often than in good self-perceived health status,[72] however another study have found no influence for breast and cervical cancer screening.[73]

Individuals with blood pressure or diabetes problems had a higher propensity for the blood pressure checks and cholesterol tests and also individuals with eyesight problems had a higher propensity for the eyesight tests, in accordance with the medical guidelines. This is to our knowledge the first analysis that compares the uptake rates of blood pressure checks and cholesterol tests for individuals who have blood pressure and diabetes problems with individuals without having these diseases in a longitudinal setting

for UK. Individuals with chronic medical conditions such as diabetes, hypertension and cardiovascular diseases have a higher uptake for a routine check-up by physicians in the USA.[70] Smoking had an influence on the uptake of breast cancer screening, blood pressure screening, cholesterol tests and dental screening, but not the other 2 health check-ups. These results are in accordance with the interpretation that smokers have a risk taking behaviour and non-smoking women have been found a higher uptake for breast and cervical cancer screening,[72 74] Also smoking individuals who registered as patients in a GP practice for the first time have had a lower probability to do a general health check-up.[75] However the effect of smoking with a reduced uptake on health check-ups has not been found in all studies as two systematic reviews have shown.[26 40] The change of the medical screening guideline to extend breast cancer screening for women of age 65 to 70 had the effect of an increased uptake. The reason why the change in the medical screening guidelines for breast cancer screening had the intended effect could be based on the fact that timed appointments are made and there is a strictly policed screening interval. However, the result could be influenced by varying unobservable variables (e.g. changing macroeconomic conditions) which are correlated with the policy change dummy variable.

The results for the socioeconomic variables are mixed for the different health check-ups. For women, uptakes in non-specific screening examinations were higher for blood pressure checks, dental screening and eyesight tests, and lower for of cholesterol tests and these results were in agreement with three recent studies from the United States.[33 70 76] Two systematic reviews find that the uptake of health check-ups is typically higher for

women and not for men with the exception of cholesterol tests.[26 40] Individuals with a higher education level are more aware of the benefits of preventative care and also early detection of diseases and this explains the higher uptake of preventative activities. Therefore, education has sometimes been found to be an important predictor of uptake of health check-ups,[77 78] but a systematic review has found more often not a significant influence on the uptake rates of different health check-ups.[26] The hypothesised influence of higher education was in our analysis only visible in dental screening and a secondary or tertiary education level had a positive significant influence on the uptake of dental screening. This result is in part explained that education is being correlated with other socioeconomic variables and the inclusion of further socioeconomic variables could explain why the effect on education disappears in the other health check-up regressions. Non-uniform results were also found for other socioeconomic variables for the different analysed health check-ups: employment status as a proxy for opportunity costs of time had a significant negative effect on breast cancer screening, blood pressure checks and cholesterol tests. However, in other studies the effect of employment status has to be found insignificant on the uptake of breast cancer screening,[79] cervical cancer screening[62] and general health check-ups for new GP registered patients.[75] Living with a partner as a proxy for social support and network had only a significant positive effect for dental screening. Most analyses have found no effect of living in a partnerships on the uptake for specific health check-ups, e.g. breast cancer screening examinations[80] and cervical cancer screening examinations.[26] Number of children as a proxy for a possible time constraint led to a significant negative effect for breast cancer screening and blood pressure checks. A UK based study which has analysed the attendance rate for health

check-ups in a general practice setting has found that a predictor for attendance was not to have children under 5 and other dependants,[68] however the effect of the number of children has not been confirmed in another study for the uptake of breast cancer screening.[81] In two systematic reviews which analysed the determinants of screening uptake for a variety of health check-ups none of the socioeconomic variables have been significant in all screening examinations.[26 40] Actual (transitory) household income had no effect on any of the analysed health check-ups and averaged (permanent) household income had a significant influence only on the uptake for dental screening and eyesight tests. No effect of actual household income on attendance rates has also been found for other screening examinations such as breast cancer screening,[82] cervical cancer screening[73] and colorectal cancer screening.[61] This result is important in comparison with the other analysed free health check-ups, because income effects exist for access to preventative health services for which a charge has to be paid in comparison to preventative services for which no charge exist. Permanent income effects could also be caused by unobserved time-invariant factors that have an influence on income and uptake. Another study which estimated the uptake of the health check-ups with unbalanced panels using the BHPS from 1991 until 2003 confirmed our results only in part, because a transitory income effect was found for the blood pressure check and a permanent income effect was found for dental screening.[46]

Ethnicity had no significant influence on any of the health check-ups, suggesting that ethnicity is not a cultural barrier for access to preventative services. In comparison with our results, another study using the BHPS that has analysed an unbalanced panel has

found for cervical cancer screening a lower uptake for Asian women in comparison to women of other ethnic origin.[27] For two studies on the uptake rates of cervical cancer screening in the USA there has not been found such an influence of ethnicity.[83 84] Changed residence and address with a higher chance for not receiving an invitation letter influenced the uptake rate of the various health check-ups unequally: women who had changed residence and address within the UK did not have a lower uptake for breast and cervical cancer screening and so the effectiveness of sending invitation letters for these both female screening examinations is questionable. In agreement with our results for changed residence and address the length of time an individual woman has lived in her own country and women's postcode of residence have not been a significant predictor of attendance for cervical cancer screening uptake.[60] In contrast to these both female cancer screening examinations it was found that for dental screening a changed residence with a lower chance of receiving an invitation resulted in a lower uptake for dental screening. Sending invitation letters have also been reported to be successful in increasing for the participation rates of dental screening.[85] The implementation for the different health check-ups with sending routine periodic invitation letters to individual women for breast and cervical cancer screening, with the decision about invitation left for individual practices for eyesight test and dental screening and as an invitational programme for blood pressure check and cholesterol test could have influenced the uptake rates for the different health check-ups in different ways, however there is no information in the BHPS available how the invitational programmes are implemented on an individual practice level. The effectiveness of sending invitation letters for increasing participation rates for blood pressure checks has been shown,[86] however invitational follow-up letters

have not contributed to increase participation in comparison to a control group for the cholesterol test.[87]

There are some differences when comparing our results on the uptake of breast and cervical cancer screening with other studies which had analysed the uptake behaviour for UK and used the BHPS as sample. Analysis of breast cancer screening uptake with the BHPS was done in one analysis with a balanced sample.[28] Identical results were found for the relevance of previous screening history, a GP visit, age and self-assessed health status, however results were different to own results for smoking status, education level, marital status and the average household income, because they were significant in this analysis. The different results for the later mentioned variables are best explained by choosing different specifications in the two empirical analyses. Analysis of cervical cancer screening uptake with the BHPS was done in a further analysis with a balanced sample. In our analysis previous screening history, age and a GP visit were significant for cervical cancer screening in the UK and our results were confirmed by this study which analysed uptake of cervical cancer screening uptake in England with an unbalanced panel for the first 12 waves of the BHPS until 2003.[27] The coefficients for education, smoking and changed residence status were not significant in our analysis. The differences in results for the variable education and smoking are remarkable, because in our analysis they had not been significant. However, also some other studies have found no influence of education[60] and smoking status[88] on cervical cancer screening uptake. Only one analysis has compared the sociodemographic determinants for the uptake of breast and cervical cancer screening at the same time for UK with a cross-sectional survey.[2] Results

for the effects of determinants on the uptake of both female cancer screening examinations were different, because for mammography level of education, occupational classification and ethnicity were not significant and only indicators for wealth were positively significant. For having a smear test a higher educational level, and white British ethnicity were positively significant, but not indicators for wealth or occupational classification. This is one of the few studies which has compared the determinants of the uptake of breast and cervical screening and has found different determinants to be responsible for the uptake of both screening examinations. An advantage of this analysis was that is used the same estimation sample for the analysis, however unobserved heterogeneity and state dependency could not be taken into account with cross-sectional data in this analysis and this could explain the different results to the results of our own study. One study with the BHPS found in a descriptive analysis that females reported a higher uptake than males for dental check-ups under NHS provision.[63] Individuals between age 46 and 55 years had the highest proportion of dental check-ups with 72% in 2000 and the lowest participation rate was for individuals of age 66 years and older with 43% in 2000. These results are confirmed in our analysis. Another study which used the BHPS to investigate the probability of making a dental check-up visit in 1, 3, 5 and 10 years in comparison to the baseline period of 1991 found that in each of these time periods from 1991 to 2001 females, more educated and non-smokers had a higher uptake which is in accordance with own results. However, in contrast with our own results persons below age 40 had the highest rate of uptake and this result could be explained by the fact that only a distinction between individuals below age 40 and above age 40 was made.

A first limitation of our study is there is no information about results from previous screening examinations available and it is not possible to differentiate between types of health check-ups: preventative health check-ups according to screening guidelines, health check-ups following the advice of a GP or consultant to do a test, or health check-ups which are in response to previous inconclusive results. There is also no information available about close female relatives with a history of breast or cervical cancer. A second limitation of our study is that no information was available about level of trust in the NHS or in the GP, because it has been shown that taking part in screening examinations can be dependent on trust.[31] A third limitation exists, because there was no information available about the characteristics of the primary care factors that have been shown to be associated with the uptake of screening examinations in England.[89] Characteristics of the professional performing of the screening test, structure and organization of medical services can influence the uptake rate. A fourth limitation of our study comes from not using detailed microgeographic information, because uptake rates for a specific health check-up can be higher in affluent and less deprived areas.[90]

CONCLUSIONS

Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, health status, and existing health problems for these six different health check-ups. A further innovative feature of our study is the analysis of the uptake of different health check-ups

with a random effects panel probit model with initial conditions (Mundlak-Wooldridge estimator) and a balanced sample, because some other analyses have used cross-sectional data and unbalanced panels with the possible problem of an attrition bias. Our research shows the high importance of past screening behaviour for each of the analysed health check-ups for recent screening behaviour and it is important, therefore, to maintain a high level of prevention uptake. The GP plays a central role in the uptake of screening examinations and this role in prevention in the UK health care system should not be weakened. Existing diseases are as expected important predictors for the specific health check-up. Income barriers could be removed for health check-ups such as dental screening and eyesight tests to increase the uptake for individuals with limited financial possibilities. Future research could use information about results from previous screening examinations and microgeographic information by linking with other data sources.

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Contributions

AL performed statistical analyses. AL, RB and FP discussed the results, and contributed to the text of the manuscript. All three authors reviewed the manuscript.

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Competing financial interests

The authors declare no competing financial interests.

Data sharing

There are no additional data available.

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Technical appendix table: Parameter estimates and standard errors for the uptake of two different specifications for cervical cancer screening in UK

Variable	Cervical cancer screening Specification 1	Cervical cancer screening Specification 2
Health check-up in 1992	0.229***(0.044)	0.222***(0.044)
Health check-up in 1993	0.195***(0.045)	0.191***(0.044)
Health check-up in 1994	0.142***(0.047)	0.142***(0.046)
Averaged HH income	0.008(0.022)	0.012(0.022)
Averaged living with partner	0.017(0.107)	0.037(0.107)
Averaged number of children in HH	0.022(0.046)	0.029(0.046)
Averaged secondary education (ISCED)	-0.169(0.383)	-0.169(0.382)
Averaged tertiary education (ISCED)	-0.245(0.427)	-0.179(0.423)
Average status employed	-0.041(0.093)	-0.055(0.092)
Averaged GP visit during last 12 months	-0.037(0.120)	-0.044(0.120)
Averaged health status self rated good	-0.029(0.107)	-0.023(0.106)
Averaged health status self rated fair	-0.131(0.136)	-0.132(0.135)
Averaged health status self rated poor	0.189(0.235)	0.210(0.232)
Averaged health status self rated very poor	0.129(0.378)	0.122(0.376)
Averaged status smoking	-0.154(0.118)	-0.174(0.117)
Averaged status moved residence	0.121(0.293)	0.119(0.287)
Averaged age	-0.006(0.004)	-0.010***(0.003)
Health check-up one year before (t-1)	0.233***(0.039)	0.236***(0.038)
Health check-up two years before (t-2)	-0.286***(0.039)	-0.285***(0.039)
Health check-up three years before (t-3)	0.570***(0.036)	0.568***(0.036)
HH income	0.005(0.013)	0.004(0.012)
Living with partner	0.136(0.086)	0.108(0.085)
Number of children in HH	-0.001(0.031)	-0.005(0.031)
Secondary education (ISCED)	0.180(0.377)	0.170(0.377)
Tertiary education (ISCED)	0.278(0.419)	0.202(0.416)
Employed	0.055(0.056)	0.073(0.055)
GP visit during last 12 months	0.419***(0.048)	0.426***(0.047)
Health status self rated good	-0.039(0.050)	-0.040(0.050)
Health status self rated fair	-0.031(0.062)	-0.030(0.062)
Health status self rated poor	-0.048(0.089)	-0.050(0.088)
Health status self rated very poor	-0.253*(0.144)	-0.248*(0.143)
Smoking	0.131(0.100)	0.146(0.099)
Moved residence	-0.063(0.070)	-0.047(0.069)
Scotland	0.028(0.075)	0.030(0.074)
Wales	-0.129(0.093)	-0.135(0.093)
Ethnic origin non-white	-0.242(0.188)	-0.239(0.187)
Age 50-64	0.189***(0.066)	0.118*(0.060)
Age 20-24	0.472***(0.173)	
Age 25-49	0.327***(0.087)	0.203***(0.073)
Age 65 and older	-0.803***(0.083)	-0.810***(0.082)
Cervical cancer screening policy change	-0.113**(0.045)	-0.121***(0.044)

Source: BHPS. (*),(**),(***): significance at 10%, 5%, 1% level. Estimation sample consisted for cervical cancer screening of 867 women of age 16 and older from 12,138 observations for the first specification. Estimation sample consisted for cervical cancer screening of 867 women of age 20 and older from 12,135 observations for the second specification. Cervical cancer screening policy change: for cervical cancer screening and age group 25-49 all years before and inclusive 2003 were coded with 0 and all the following years with 1.

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Utilisation of Preventative Health Check-Ups in the UK: Findings from individual-level repeated cross-sectional data from 1992 to 2008

Alexander Labeit*

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

Frank Peinemann

FOM University of Applied Science for Economics & Management, 45141 Essen, Germany

Richard Baker

Department of Health Sciences, University of Leicester, Leicester, LE1 6TP, UK

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ABSTRACT

Objectives: To analyse and compare the determinants of screening uptake for different NHS health check-ups in the UK.

Design: Individual-level analysis of repeated cross-sectional surveys with balanced panel data.

Setting: UK.

Participants: Individuals taking part in the British Household Panel Survey (BHPS), 1992 - 2008.

Outcome measure: Uptake of NHS health check-ups for cervical cancer screening, breast cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.

Methods: Dynamic panel data models (random effects panel probit with initial conditions).

Results: Having had a health check-up one year before, and previously in accordance with the recommended schedule, was associated with higher uptake of health check-ups. Individuals who visited a General Practitioner (GP) had a significantly higher uptake in 5 of the 6 health check-ups. Uptake was highest in the recommended age group for breast and cervical cancer screening. For all health check-ups, age had a nonlinear relationship. Lower self-rated health status was associated with increased uptake of blood pressure checks and cholesterol tests; smoking was associated with decreased uptake of 4 health check-ups. The effects of socioeconomic variables differed for the different health check-ups. Ethnicity did not have a significant influence on any health check-up. Permanent household income had an influence only on eyesight tests and dental screening.

Conclusions: Common determinants for having health check-ups are age, previous screening history and a GP visit. Policy interventions to increase uptake should consider the central role of the GP in promoting screening examinations and in preserving a high level of uptake. Possible economic barriers to access for prevention exist for dental screening and eyesight tests, and could be a target for policy intervention.

Trial registration: This observational study was not registered.

ARTICLE SUMMARY

Article focus

- To identify and compare determinants of the uptake of different preventive health check-ups delivered by the NHS: breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental screening and eyesight tests.
- To compare the effect of past screening behaviour, age, GP visits, health status and socioeconomic variables on the uptake of each of these health check-ups.

Key messages

- Past screening behaviour and GP visits explained recent screening behaviour for each of the health check-ups: taking part in past screening examinations and visiting a GP visit increased recent uptake.
- Lower self-rated health status increased the uptake of blood pressure checks and cholesterol tests, but smoking decreased the uptake of 4 health check-ups.
- Permanent household income had a positive significant effect only on eyesight tests and dental screening, but not on the other health check-ups.

Strengths and limitations of this study

- Our study used consistent individual-level repeated cross-sectional data from a panel survey over a period of 17 years for the different health check-ups.

- Our estimation used a balanced panel which considered also attrition effects.
- Medical information about results from previous screening examinations was not available, and linking with other data sources could improve our analysis.

INTRODUCTION

Individuals are offered different health check-ups in the NHS. These include breast cancer screening, cervical cancer screening, blood pressure checks, cholesterol tests, dental check-ups and eyesight tests. There is no charge for the health check-ups, other than for dental check-ups and eyesight tests. Taking part in health check-ups is important, because screening examinations promote early detection of diseases and are potentially cost saving. There are only few national and international analyses that analyse how different health check-ups are affected by socioeconomic determinants, and typically such studies have been cross-sectional surveys.[1 2] One analysis using UK data has shown that the socioeconomic determinants of breast and cervical cancer screening differ. Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, existing health problems and health status for these six different health check-ups. Can certain determinants explain the uptake of these six health check-ups, and especially what is the influence of health related variables on the uptake? In the next sections the institutional regulations of the six different health check-ups are introduced with a motivation of this analysis, followed by the theoretical framework for our analysis and a discussion of relevant previous empirical prevention research which is related to our own work. The next two sections present own results for the 6 different health check-ups and discuss these results with possible policy implications.

For each health check-up a detailed recommendation exists on how often an individual

should attend a specific health check-up depending on age limits, ~~comorbidities and previous health check-ups. The national NHS Breast Screening Programme (NHSBSP) offers mammography to women at different time intervals depending on age.[3]~~dependent on risk factors, comorbidities and previous health check-ups. There are differences in invitation policy for different parts of UK for cervical cancer screening and for dental screening and the eyesight test an individual has to pay a charge with certain exemption. Table 1 gives the institutional regulations and recommendations for the different health check-ups in UK.

Table 1: Regulations and recommendations for the different health check-ups in UK

The national NHS Breast Screening Programme (NHSBSP) offers mammography to women at a 3 yearly period.[3] Women between age 50 and 64 are invited, and ~~from 2003~~ there has been an extension after 2002 of the age range for these programme and women between age 65 and 70 years are also now invited. The national NHS Cervical Screening Programme (NHSCSP) offers women a smear test at different time intervals depending on age.[4~~4~~] The age for the first invitation ~~and the age of the last invitation to cervical cancer screening is dependent on country in the UK: age 25 in England since 2003, or 20 in Scotland, Wales and in England before 2003.[5]~~, the age of the last invitation and time periods between invitations for cervical cancer screening are dependent on the country in the UK.[5] ~~[6]~~The age of first invitation is age 25 in England[6] after 2003 and age 20 in Scotland,[7] Wales[7] [8] and in England until 2003. Between the age of the first invitation and 49 is a 3 yearly recall period in all parts of UK since 2003 and before 2003 there was a 3

to 5 yearly recall period policy ~~depending on the Primary Care Trust, with the majority of Primary Care Trusts following a 3 year policy.[7]~~in England depending on the Primary Care Trust, with the majority of Primary Care Trusts in England following a 3-year policy.[9] The policy of a uniform 3 yearly recall period for women between age and 25-49 was implemented after a recommendation by Cancer Research UK, because a 3-year recall policy seemed most effective after analysis of UK data.[8]10 No information was available for us how quickly each Primary Care Trust in England implemented the changes to the recall policy. ~~Cervical~~Between age 50 and age of the last invitation cervical cancer screening is offered to women ~~aged 50 and over~~ every three years until age 60 in Scotland and until age 64 in Wales, and every 5 years in England until age 64 ~~from 2003.[5] Before 2003 a majority of women were screened every 3 years.[7]~~after 2003. Women above the age limits are excluded from the recall system and no longer invited unless they need ongoing surveillance or follow up, for example because of an abnormal result in any of the three most recent tests. For breast and cervical cancer screening examination there are sent out routine periodic invitations to women by their GP. Blood pressure can be checked by a GP or another healthcare professional, and it is recommended that adults aged over ~~40 are checked at least every 5 years.[9] For individuals with increased risk of hypertension or with comorbidities (e.g. diabetes), blood pressure should be checked every year. A cholesterol test is recommended for individuals aged over 40 and especially for individuals who have a family history of early cardiovascular disease or who have high blood pressure or diabetes.[10]~~20 are checked at least every 5 years[11] and the recommendations for regular blood pressure are dependent on age, health status and existing diseases, health behaviours and lifestyle. For older

individuals and individuals with risk factors such as overweight, obesity, diabetes, family history of high blood pressure, smoking should be checked every year and for individuals with existing hypertension it should be checked several times a year.[12] A cholesterol test is recommended for adults with no symptoms to take place every 5 years starting at age 20.[13 14] For all individuals who are overweight or obese and have high blood pressure or diabetes or who have been diagnosed with coronary heart disease, stroke, peripheral arterial disease or who have a family history of early cardiovascular disease or a close family member with a cholesterol-related condition, such as familial hypercholesterolaemia it is recommended to do it every 1 to 2 years. The cholesterol test is implemented as an invitational programme. For dental screening the national guidelines recommend at least one check-up every two years, unless the dentist recommends a different interval based on the patient's current dental health.[11 15] The national guidelines changed in 2004, the previous recommendation being every 6 months. Dental screening incurs a charge to the patient, and is only free for those under the age of 18 or on income support. Dental screening has been free in Scotland since 2006[12 16] and in Wales it is free for individuals under age 25 and aged 60 or over since 2006.[13 17] An eyesight test is recommended every two years, or more frequently if necessary.[14 18] It is especially advised for individuals aged 60 years and older, individuals from certain ethnic groups, for example, Afro-Caribbeans, and for those with selected diseases predisposing to eye disorders, for example diabetes, glaucoma or close relatives with eye disease. There is a charge for the eyesight test, but it is free for individuals aged 60 and older, or who are registered blind or partially sighted, or who have diabetes or glaucoma. Eyesight tests have been free in Scotland since 2006.[15 19] For dental screening and eyesight tests the

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individual dental or optometry practices can decide on sending invitation letters.

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THEORETICAL APPROACH

Economic models of the demand of health care in general, and preventative care in particular, are based on human capital models.[~~16~~20] This framework has also been used for the modelling of demand for primary and secondary prevention.[~~17~~21] These categories of prevention are self-protection measures that improve early detection and health outcomes.[~~18~~22] The problem with economic models of prevention is that two important aspects are typically not considered at the same time in detail: the distinction between acute and preventative care, and uncertainty. Some dynamic economic models for the demand of health care take only uncertainty into consideration, no distinction being made between acute and preventative care.[~~19~~23] Acute care describes the consumption aspect of health whereas preventative care describes the investment aspect. The (simplified) Grossman model makes the distinction between acute and preventative care, but uncertainty is not considered in this model.[~~20~~24] Only one economic model explicitly considers both the demand for preventative health care, using a stochastic dynamic framework.[~~21~~25] However, in this article no non-economic factors were considered. Our conceptual framework is based on a human capital approach[21] ~~and as an extension,~~ and as an extension non-economic factors such as non-monetary barriers are included. Our approach is also supported by previous research which has investigated determinants of different types of screening examinations.[~~22~~26]

Information about the uptake of these different health check-ups over a period of nearly 20 years is available in the British Household Panel Survey (BHPS). Only one study has compared these different NHS health check-ups from 1991 to 2003.[23] However, this study analysed not the influence of health related and socioeconomic characteristics on the uptake and estimated random effects panel probit models only with unbalanced panels, with the potential problem of attrition bias, and as a consequence selection bias in the estimates can occur.[24] The influence of household and individual characteristics on uptake is analysed in our study and also the effects of transitory and permanent household income on uptake. Also in our analysis the effect of changes in the medical screening guidelines on the uptake for three health check-ups (cervical cancer screening, breast cancer screening and dental screening) are additionally considered. Therefore, our analysis compares how past screening behaviour, individual and household characteristics and changes of medical screening guidelines affect uptake of these different health check-ups.

Participation in breast or cervical cancer screening examinations in past periods has predictive value for the uptake in the actual period, i.e. past screening behaviour is correlated with current behaviour.[22 25 26] Age can have different effects on the demand for prevention.[27 28] For breast and cervical cancer screening examinations, medical guidelines exist with explicit recommendations on how often screening should be done in certain time intervals, and for the recommended age intervals uptake should be higher than for non-recommended age intervals. However, on one hand according to the Grossman

model health depreciates at an increasing rate at older ages, and the necessity to maintain health increases and as a consequence the demand for preventive activities increases. On the other hand, older individuals have a shorter life span and pay-off period for their investment in prevention activities. Therefore the effect of increasing age on uptake cannot be predicted with confidence. Empirical studies often find a negative relationship between age and uptake of health check-ups.[28 29] Studies which analysed possible gender differences in the utilization of health care services found that females have a higher utilization of health care services[30] and also a higher use of preventative services including blood pressure checks, cholesterol tests and dental screening.[31] Higher educational level may be expected to lead to an increase in the demand for prevention services, because individuals with a higher education may have higher efficiency in the production of health and also increased self-efficacy, higher confidence and motivation.[17 25 28 29] Individuals who live in a partnership have a higher propensity for screening examinations and living in a partnership may be a proxy for having a more dense social support network that encourages individuals to take part in prevention activities and some empirical studies have confirmed this hypothesis.[32 33] A higher number of children in the household can influence screening behaviour through time constraints.[25 34] Household income may be expected to lead to an increase in the demand for prevention services, because higher income leads to an increase in demand for time in perfect health.[16 20] In some studies, increasing household income increased uptake of preventive care,[27 28 35] although the effect may be weaker in the UK compared to other countries, because most preventative services are free in the UK. Employment was added as a further control variable, because individuals who work may have higher opportunity costs in comparison

to unemployed and retired individuals. In a systematic review of the influence of different determinants on the uptake of health check-ups, influence of employment for the uptake of different health check-ups was found to be inconsistent. The GP plays a role as gatekeeper in the UK health care system and can give advice and information about the importance of health check-ups for the early detection of diseases, and therefore uptake may be enhanced by previous GP visits.[36 37] Cervical cancer screening, blood pressure checks and cholesterol tests can be done in a GP practice. Poor self rated health status and existing general health problems could encourage people to think about their health in general and therefore to invest in health and to increase participation in screening examinations, and this seems to be the case for general health check-ups such as blood pressure check and cholesterol test, but not for female specific cancer screenings such as the mammography and the smear test.[27] Psychological factors such as fear and anxiety about receiving a cancer diagnosis may deter some women from attending one of these health check-ups. Furthermore, individuals in a poor health state may not be able to visit the screening location such as the GP, family clinic or mammography unit, the dentist or the optometrist, because of physical limitations. There are contradicting findings on the effect of poor health status on the uptake of health check-ups, with increased uptake of cholesterol checks and a lower uptake of mammograms and pap smears.[38] Smoking can serve as an indicator for the weakened preference of an individual for health in comparison to other goods and smoking individuals show risk taking behaviour.[39] Individuals who smoke have poorer preventative health habits such as a reduced level of physical activity in comparison to non smoking women.[40] The predicted influence of smoking on uptake was empirically confirmed for breast cancer screening with a lower

~~uptake for smoking women.[28] For individuals with non white ethnic origin cultural barriers may exist, and this is especially the case for breast and cervical cancer screening. In an empirical investigation ethnicity was the most important predictor for cervical cancer screening, with white British women having a higher uptake than women of other ethnicity. Registration with a GP is a necessary condition for receiving an invitation letter for breast and cervical cancer screening and routine periodic invitations are sent from the GP according to the recommended interval for breast and cervical cancer screening. A changed residence and address of a woman lowers the chance to receive an invitation letter. A lower uptake of cervical cancer screening was found in one study for women in UK who had changed residence and address,[34] but not in another one.[25]~~

~~**METHODS**~~

~~It is sensible for our estimation to consider how screening behaviour was in the past time and the recommended time interval for a screening examination (e.g. for breast and cervical cancer screening examinations the recommended 3 year intervals), because there is an increased likelihood of participating in a screening examination after the recommended time interval. Additionally, there exists also~~

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Information about the uptake of these different health check-ups over a period of nearly 20 years is available in the British Household Panel Survey (BHPS). Only one study has compared these different NHS health check-ups from 1991 to 2003.[46] However, this study didn't analyse the influence of health related and socioeconomic characteristics on the uptake. Random effect panel probit models were only with unbalanced panels, with the potential problem of attrition bias, and as a consequence selection bias in the estimates can occur.[47] Therefore, our analysis compares how past screening behaviour, individual and household characteristics, transitory and permanent household income affect uptake of these different health check-ups.

METHODS

It is sensible for our estimation to consider how screening behaviour was in the past time and the recommended time interval for a screening examination (e.g. for breast and cervical cancer screening examinations the recommended 3 year intervals), because there is an increased likelihood of participating in a screening examination after the recommended time interval. Additionally, there exists the possibility that screening examinations are recommended in shorter time intervals if an individual belongs to a high risk population such as in the female cancer screening examinations with close relatives ~~with~~have a history of breast or cervical cancer. Also there exists for all the different health check-ups the possibility that an inconclusive check-up in the actual year has a consequence a control follow check-up in the next year. With the BHPS it is not possible to differentiate between routine check-ups according to the screening guidelines or as a response to an inconclusive result from a health check-up in the previous year or as an advice to do a health check-up from a GP. To include these different possibilities for the analysis of uptake behaviour a dynamic specification with lags for the last 3 years was chosen for the different health check-ups. To model the dynamic nature of screening examinations and because uptake is a binary variable, a dynamic random effects (RE) panel probit model was used to estimate the uptake of NHS health check-ups over the panel period from 1992 to 2008. The advantage of such a specification is that the uptake of health check-ups is not only explained by individual and household characteristics, but also at the same time by past screening behaviour and therefore persistence in screening behaviour (state dependence). A further advantage of this econometric specification which uses panel data and not cross-sectional data is that both individual heterogeneity

and state dependence can be considered in a dynamic panel data model, which is not possible in a model for cross-sectional data. One possibility for estimating a dynamic random effects (RE) panel probit is the Mundlak-Wooldridge estimator that specifies a relationship between the unobserved time-invariant individual effect and the observed characteristics and initial conditions,[4148] and the econometric model is given by the following 3 equations (1), (2), (3).

$$y_{it}^{*} = \gamma_1 y_{it-1} + \gamma_2 y_{it-2} + \gamma_3 y_{it-3} + x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (1)$$

In the first equation y_{it}^{*} indicates the unobserved latent variable of an individual i at a given time t for taking part in a specific screening exam, y_{it-1}, y_{it-2}, y_{it-3} are the screening examination decisions of the individual i 1, 2 and 3 periods before t and γ_1, γ_2, γ_3 are the related coefficients for these variables, x is a vector of time variant and time invariant covariates, β is the vector of coefficients associated with these covariates, ε_{it} is the random error term and α_i indicates the individual specific term for time invariant unobserved variables which is modelled according to equation (2) as individual specific random effect:

$$\alpha_i = \delta_1 S_{i1} + \delta_2 S_{i2} + \delta_3 S_{i3} + +\delta_4 \overline{X}'_i + \upsilon_i \quad (2)$$

A normal density for the individual specific random effect is assumed and the first three

terms are the initial conditions with the uptake of the specific health check-up for an individual *i* in the first three periods of the panel: S_{i1}, S_{i2} , S_{i3}.The fourth term allows correlation between the time-varying variables of an individual by including the average $\overline{X}_i'$ over the whole panel observation period and the individual specific random effect,[42] ~~which divides the time-varying variables into a transitory and permanent component for the estimation.~~[49] which divides the time-varying variables into a transitory and permanent component for the estimation. ν_i is the error term assumed normally distributed with zero mean and standard deviation σ_α. This specification has the advantage that time-invariant unobserved variables which are correlated to time-varying variables are captured by the mean of these variables and give a less biased estimate of the transitory component of these variables. The third equation gives the observed binary outcome y_{it} of taking part in a specific health check-up for individual *i* in period *t*.

$$y_{it} = \begin{cases} 1, if \ \ y_{it}^* > 0 \\ 0, otherwise \end{cases} \qquad (3)$$

The chosen Mundlak-Wooldridge specification has the advantage that under certain assumptions the bias which is caused by the persistence of screening behaviour is removed. Crucial assumptions for the estimation of the dynamic random effect model are that the relationship between the unobserved time-invariant individual effect and the mean of the observed characteristics is correctly specified and also the distributional assumptions on the initial conditions are correct. The breast cancer screening programme (NHSBSP) and cervical cancer screening programme (NHSCSP) were introduced in

1988 before the beginning of the BHPS and also the four other health check-ups had been available to individuals before the BHPS had started. For our estimation technique it is assumed that the health check-ups that had been undertaken before the first wave of the BHPS are uncorrelated with the health check-ups recorded in the BHPS. If this assumption is violated, the inclusion of initial conditions of health check-ups for the years 1992 to 1994 could result in biased estimates for our regressions. An advantage of our statistical approach is that some previous analyses have investigated the uptake of health check-ups with cross-sectional data and therefore could not control for unobserved heterogeneity, and other analyses used unbalanced panel data sets for their estimation.[23 25 27 46] Estimation of unbalanced panels with ad hoc treatments of initial problems has unfavourable estimation properties and could result in biased estimation as has been shown by simulation studies.[24 47] The estimation results of balanced panels are more reliable, because balanced panels satisfy the assumptions of the Mundlak-Wooldridge estimator.[43 44 50 51] Therefore, estimation of balanced panels for the different health check-ups was preferred over unbalanced panels. An alternative to the Mundlak-Wooldridge estimator would be the maximum likelihood estimator proposed by Heckman,[45 52] however for balanced panels with more than 5 to 8 periods the finite sample properties of the Mundlak-Wooldridge estimator are better.[24 47]

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We used the BHPS, which is an annual survey of households in UK. It is a nationally representative sample of more than 5,000 households and individuals aged 16 and over.[46 53] The first wave of the data collection for this survey started in 1991 and all the original individuals were interviewed in each succeeding year unless they dropped out.

Questions about taking part in NHS health checks-up have been in every wave from the start of the panel survey in 1991 until 2008. For the analysis of breast and cervical cancer screening, only females were included, for all other types of health check-ups both males and females were included. In our analysis and construction of the balanced sample only individuals from England, Wales and Scotland were selected, because data collection started in Northern Ireland from wave 11 and not from the first wave. For the construction of the balanced panel 17 years of information were used: from 1992 to 2008, because in the first wave only a small number of individuals were interviewed in 1991. For an individual to be included in our analysis, provision of the specific health check-up had to be from the NHS; individuals with private provision or with NHS and private provision for a specific health check-up have been excluded from the analysis. The dependent variable takes the value of 1 in a specific year if the specific health check-up (breast cancer screening, cervical cancer screening, blood pressure check, cholesterol test, dental test, eyesight test) was done and 0 if not. For analysing the changes in the medical screening guidelines for 3 different health check-ups (breast cancer screening, cervical cancer screening, dental screening) a dummy coding was chosen: for breast cancer screening and age group 65-70, all years before and including 2002 were coded with 0 and all the following years with 1; for cervical cancer screening and age group 25-49 all years before and including 2003 were coded with 0 and all the following years with 1; for dental screening all years before and including 2004 were coded with 0 and all the following years with 1.

The balanced panel included for breast cancer screening 861 women with 12,054

observations, for cervical cancer screening 867 women with 12,138 observations, for blood pressure checks 1,405 individuals with 19,670 observations, for cholesterol tests 1,568 individuals with 21,952 observations, for dental screening 706 individuals with 9,884 observations and for eyesight tests 613 individuals with 8,582 observations.

~~In our analysis, for~~ In our analysis, for breast cancer screening, we followed the age groups of the screening guidelines: 16 to 49 (reference group), 50 to 64, 65 to 70, and age 71 and older. For cervical cancer screening we used the age groups of the screening guidelines: 16 to 19 (reference group), 20 to 24, 25 to 49, 50 to 64, and ~~aged 65 and older. For breast cancer screening, we followed also the age groups of the screening guidelines: 16 to 49 (reference group), 50 to 64, 65 to 69, and aged 70 and older.~~age 65 and older. For all other screening checks, the following groups were used: 16 to 39 (reference group), 40 to 49, 50 to 59, 60 to 69, 70 to 79 and 80 and older. For blood pressure checks and cholesterol tests, we included information on whether the person had diabetes or also heart/blood pressure/blood circulation problems, and for eyesight tests, information on eyesight problems and diabetes was used. Actual (transitory) income was defined as the total equivalised and deflated household annual income divided by 100 and permanent household income was defined as annual household income over the 17 years between 1992 and 2008. Household income was deflated and transformed in per capita income using the modified OECD scale to allow for household size and needs.[~~47~~54] The International Standard Classification of Education (ISCED) was used for the categorisation of educational levels with tertiary, secondary and primary education (reference category). ~~Household income was deflated and transformed into per capita~~

~~income using the modified OECD scale to allow for household size and needs.~~[47] Health status was self-rated and included in our analysis with categories from excellent (1) as reference category in regressions, good (2) fair (3), poor (4) to very poor (5).[48,55]

RESULTS

Table ~~1~~2 presents descriptive statistics for the variables used in our estimation for the balanced panels for the different health check-ups.

Table ~~1~~2: Sample characteristics for the balanced panels of different health check-ups in UK

For the period 1992 to 2008 there were the following uptake rates within one year for individuals for the balanced panel: 13.9% for breast cancer screening, 20.4% for cervical cancer screening, 51.2% for the blood pressure check, 19.5% for the cholesterol test, 57.6% for dental screening and 34.4% for the eyesight test.

Table ~~2~~3 provides the estimated coefficients for the dynamic random effects (RE) probit model with initial conditions for the balanced panel (BP) for the different health check-ups.

Table ~~2~~3: Parameter estimates and standard errors for the uptake of health check-ups in

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UK

For all health check-ups, taking part in past screening examinations showed a strong influence on the current screening examination. The effect of having the same screening examination one year ago was strongest for dental screening. The magnitude of the effects, the marginal effects, are shown in table ~~3~~4 and for dental screening examinations there was an increase of 18.2% if there has been a visit one year before.

Table ~~3~~4: Marginal effects and standard errors for main predictors of uptake for health check-ups in UK

The effect of having the same screening examination three years ago was similar for breast and cervical cancer screening and the marginal effects resulted in an increase in uptake of 12.3% and 12.6~~% ~~%. For individuals who visited their GP in the last year, there was an increase for 5 of the 6 analysed health check-ups with only the eyesight test not significant, the increase being highest for blood pressure with a 25.9% increase and lowest for dental screening with a 1.7% increase. Poor self-rated health status increased the uptake of blood pressure checks by about 12.6% and cholesterol tests about 4.5% and for the eyesight test poor health status increased the uptake by 5.4%. For breast and cervical cancer screening there was no significant influence of poor health status on uptake. Women aged between 50 and 64 had an increased uptake of 9.9% for breast cancer screening and women aged between 25 and 49 had an increased uptake of 7.3% for cervical cancer screening in comparison to the reference categories. Also for the other

four health check-ups there was a nonlinear relationship between age and uptake. For blood pressure check, cholesterol test and eyesight test uptake increased nonlinearly for the different age categories. Women aged between 65 and 70 had a higher uptake of breast cancer screening after 2002; an increase of 7.9% for this age group in comparison to the years before. Women aged between 25 and 49 had a 2.5% lower uptake of cervical cancer screening after 2003 in comparison to women of this age group before 2003. Individuals who had a dental screening after 2004 did not have a significant changed uptake in comparison to the years before.

Females had a higher uptake in three of the four analysed health check-ups that are not sex-specific (blood pressure check, dental screening, eyesight tests), but the influence on the uptake of the cholesterol tests was non-significant. The increase in uptake for females was highest for eyesight tests with an increase of 4.4%. The marginal effects for education, employment status, household income, living with a partner, smoking, changed residence status were non-uniform for the different health check-ups. The effect of secondary and tertiary education was strongest for the uptake of dental screening (30.5% and 28.3% increase). Being employed decreased the uptake for breast cancer screening by 3.1%, for blood pressure checks by 2.5% and cholesterol test by 2.2%. Increasing actual household income had no significant effect on any of the uptakes. Living with a partner increased the uptake of dental screening by 3.8%. Smoking decreased the uptake of breast cancer screening by 3.3%, blood pressure checks by 6.3%, cholesterol tests by 2.9% and dental screening by 3.2%. An additional child in the household decreased the uptake of breast cancer screening examinations and blood

pressure checks by 2.1% and 2.4%. Change of residence decreased the uptake of dental screening by 3.5%; however, it increased the uptake of blood pressure checks by 3.6%. Individuals with existing blood pressure problems or diabetes had increased uptake of blood pressure checks by 22.5% and 11.1% and for cholesterol tests by 8.9% and 13.2%. Individuals with existing eyesight problems and diabetes health problems had an increased uptake for eyesight tests of 11.1% and 29.4%. Permanent equivalised household income increased the uptake of dental screening and eyesight tests by 2.5% and 1.8%. Initial conditions show significance for all health-check-ups.

DISCUSSION

Our analysis compared the determinants of the uptake of six health check-ups in UK using the BHPS from 1992 to 2008 (excluding Northern Ireland). We investigated which determinants were the same for all health check-ups and which determinants differed for determining uptake with a focus on the importance of past screening behaviour on actual screening behaviour and health related variables.

The strong positive significant effect of past screening behaviour shows that past behaviour influences current behaviour and this result can be interpreted as persistence in screening behaviour in the sense of state dependence.[49 56 50 57] Reasons for the strong positive state dependence are the adherence to the medical screening guidelines in UK such as the NHS Breast and Cervical Screening Programme with explicit recommendations for the time interval between screening examinations. The relevance of

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these both screening guidelines on current behaviour can be seen in the high predictive value of ~~these~~the coefficients for ~~these~~the same specific ~~health check ups~~screening examination 3 years before. Our results for the high predictive value of a breast or cervical cancer screening examination which had been done three years ago for the uptake in the current year are in accordance with other results which analysed the uptake for these both screening examinations.[27 58] Also the coefficient for the same specific health check-up one year before was significantly positive for all the different health check-ups. These results are in agreement with a further analysis which used a lagged dependent variable of uptake one period before as predictor variable and analysed these six different health check-ups.[46] Different other studies have confirmed the importance of past screening behaviour for recent uptake of screening examinations such as for mammographies,[59] smear tests[60] and faecal occult blood test[61] and also a systematic review confirmed that past screening examinations had a positive influence on a recent screening examination. Persistence in screening behaviour, control follow-ups to check unclear test results from the previous health check-up and shorter recommended time intervals for some of the analysed health check-up (blood pressure check, cholesterol test, dental screening, eyesight test) ~~could explain our results.~~are of importance to explain the significance of the one year lagged dependent variable as predictor variable. However, with data from the BHPS it is not possible to differentiate between these different possibilities. Initial conditions show relevance in all analysed screening examinations. If initial conditions for the first three years ~~had~~would not been taken into account, the influence of past screening behaviour on actual behaviour would have been overestimated~~.~~, because some of the persistence in screening examinations uptake has

been to be attributed to unobserved characteristics. Initial conditions have also to be found significant in other analyses which have used the Mundlak-Wooldridge estimator for the analysis of dynamic panel data models.[28]

For women the uptake of breast and cervical cancer screening is higher in the age group for which it is recommended than in the reference groups. and this result has also found for other empirical studies which has analysed the uptake of screening examinations for UK[27 28] and our results are similar to an Australian study which confirmed that the uptake of the pap smear test in the recommended age group was also higher than in the non-recommended age group.[62] There is a lower uptake of dental screening for older ages in comparison to persons of middle age, and this result is in accordance with another study.[51] The finding of decreasing screening uptake with increasing age is in accordance with the shorter pay-off period for older individuals from the human capital theory approach.our result is in accordance with another study which has analysed the dental screening uptake with the BHPS in UK.[63] The finding of decreasing screening uptake with increasing age can be explained with the shorter pay-off period for older individuals from the human capital theory approach and are in agreement with a study in the Netherlands for which participation in a health examination increased until age 60 and then decreased.[64] For blood pressure checks, cholesterol tests and eyesight tests uptake increases with age and our results can be explained by the increasing prevalence of hypertension, high cholesterol and eyesight problems with age and the necessity to check these specific health problems.at older ages and the necessity to check these specific health problems and are confirmed for these specific health check-ups also by other

studies.[65]

The significance of a GP visit in the year before the actual wave, for all the included health check-ups with the exception of non-significance for the eyesight test, can be explained by the fact that the GP plays an important role as gatekeeper in the UK and also an important role in access to prevention by giving advice about accepting a health check-up or by doing the screening examination[37] ~~as it the case for cervical cancer screening, blood pressure check or cholesterol test. However, the importance of the GP is also significant for the health check-ups which are done outside of practice: breast cancer and dental screening.~~[42] as it is the case for cervical cancer screening, blood pressure check or cholesterol test. Our results reflect those in an Italian study which analysed the uptake of cervical cancer screening with a recursive probit. The regulations for having a smear test are very similar in Italy and UK with respect to the role of the GP in cervical cancer screening. In both countries a visit to the GP is not an essential condition for the provision of a smear test and this test can also be done in specialized services.[29,31] Estimations from the Italian study showed that GP visits led to an increased uptake of cervical screening. However, the importance of the GP is also significant in our analysis for the health check-ups which are done outside of practice: breast cancer screening and dental screening. Two further analyses reinforce the interpretation of the importance of a GP visit as a healthcare provider contact for prevention, because a higher number of healthcare provider contacts increases the uptake rate for breast cancer screening examinations[66] and cholesterol tests.[65] Furthermore, individuals who visit their GP more often have a higher uptake of general cardiovascular checks in UK.[67,68] The importance

of the GP for prevention in UK is also further strengthened by the fact that individuals who have visited a GP in the previous year have a higher propensity to make an appointment for a health check-up in the recent year.[69] In the auxiliary regressions the averaged value of a GP visit during the last 12 months variable was correlated in five of the six health check-ups with the individual specific term for time invariant unobserved heterogeneity and could also be caused by unobserved time-invariant factors that have an influence on probability of a GP visit and uptake of the different health check-ups. The effect of self-assessed health status is dependent on the specific health check-up. The uptake of blood pressure checks and cholesterol tests increased with a deteriorating self-assessed health status and was highest for individuals in a very poor health state. Both these health check-ups are often included in a general health check-up for the health status of an individual. The interpretation of health status as a proxy for health stock is most valid for these two health check-ups in comparison to the other health check-ups as individuals in a poor health status have a high demand for these two health check-ups in order to increase their health stock.[70] However, poor self-assessed health status can influence uptake also in other ways such as changed perceptions on the preventability of health problems and diseases. Individuals with poorer health status also expressed less interest in receiving prevention information in another study.[52,71] Psychological factors such as fear and anxiety about confirmation of a disease can be related to a poor health status and this correlation could be especially relevant for the both analysed female cancer screening examinations. Also individuals with a poor health status could be less able to visit the screening location and these interpretations could explain why such individuals have a lower uptake such as for cervical cancer screening. The effect of self-

perceived health status on breast cancer screening was non-uniform in other studies: Women with poor or fair self-perceived health status attended mammograms less often than in good self-perceived health status,[72] however another study have found no influence for breast and cervical cancer screening.[73]

Individuals with blood pressure or diabetes problems had a higher propensity for the blood pressure checks and cholesterol tests and also individuals with eyesight problems had a higher propensity for the eyesight tests, in accordance with the medical guidelines. This is to our knowledge the first analysis that compares the uptake rates of blood pressure checks and cholesterol tests for individuals who have blood pressure and diabetes problems with individuals without having these diseases in a longitudinal setting for UK. Individuals with chronic medical conditions such as diabetes, hypertension and cardiovascular diseases have a higher uptake for a routine check-up by physicians in the USA.[70] Smoking had an influence on the uptake of breast cancer screening, blood pressure screening, cholesterol tests and dental screening, but not the other 2 health check-ups. These results are in accordance with the interpretation that smokers have a risk taking behaviour~~, however the effect of smoking with a reduced uptake on health-check is not found in all studies as a systematic review has shown.[22]~~ and non-smoking women have been found a higher uptake for breast and cervical cancer screening.[72 74] Also smoking individuals who registered as patients in a GP practice for the first time have had a lower probability to do a general health check-up.[75] However the effect of smoking with a reduced uptake on health check-ups has not been found in all studies as two systematic reviews have shown.[26 40] The change of the medical screening guideline

to extend breast cancer screening for women of age 65 to 70 had the effect of an increased uptake. The reason why the change in the medical screening guidelines for breast cancer screening had the intended effect could be based on the fact that timed appointments are made and there is a strictly policed screening interval. However, the result could be influenced by varying unobservable variables (e.g. changing macroeconomic conditions) which are correlated with the policy change dummy variable.

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~~Only the change of medical screening guidelines to extend breast cancer for women of age 65 to 70 screening had the intended effect. For breast cancer screening there was a higher uptake after 2002 in the age group of 65 to 70. Comparing the uptake rates for cervical cancer screening before and after changing the recommended time interval in 2003 from 5 to 3 years for women of age 25 to 49 shows a decrease in uptake rates. This result can be explained by a comparison of our result with official statistics data for the coverage rate of the target age groups for cervical cancer screening, because official statistics data show a declining uptake rate over time and this time trend is especially visible in the age group 25-49.[53] The recommendation of extending the time interval from 6 months to 1 to 2 years for dental screening after 2004 did not have an effect on uptake. The reason why the change in the medical screening guidelines for breast cancer screening had the intended effect could be based on the fact that timed appointments are made and it has a strictly policed screening interval.~~

~~The results for the socioeconomic variables are mixed for the different health check ups. For women, uptakes were higher for blood pressure checks, dental screening and eyesight~~

tests, and lower for of cholesterol tests and these results were in agreement with a recent study from the United States.[31] Education to secondary or tertiary levels had a positive significant influence on the uptake of dental screening. Education has often been found to be an important predictor of uptake of health check ups, but not always.[22] The hypothesised influence of higher education is only visible in one health check-up (dental screening). This result is in part explained by education being correlated with other socioeconomic variables and the inclusion of further socioeconomic variables could explain why the effect on education disappears in other regressions. Non uniform results were also found for other socioeconomic variables for the different analysed health check ups: employment status as a proxy for opportunity costs of time had a significant negative effect on breast cancer screening, blood pressure checks and cholesterol tests, living with a partner as a proxy for social support and network had only a significant positive effect for dental screening and number of children as a proxy for a possible time constraint led to a significant negative effect for breast cancer screening and blood pressure checks. In a systematic review which analysed the determinants of screening uptake for different cancer screenings and other different health check ups, none of the socioeconomic variables were significant in all screening examinations.[22] Our results confirm the result of this systematic review that for different screening examinations different socioeconomic variables are of relevance. Ethnicity had no significant influence on any of the health check ups, suggesting that ethnicity is not a cultural barrier for access to preventative services. In comparison with our results, another study using the BHPS that analysed an unbalanced panel found for cervical cancer screening a lower uptake for Asian women in comparison to women of other ethnic origin.[25] Changed

~~residence and address with a higher chance for not receiving an invitation letter has influenced the uptake rate of the various health check-ups unequally: women who had changed residence and address within the UK did not have a lower uptake for breast and cervical cancer screening and so the effectiveness of sending invitation letters for these both female screening examinations is questionable. In opposite to these both female cancer screening examinations it was found that for dental screening a changed residence resulted in a lower uptake for dental screening. The implementation for the different health check-ups with sending routine periodic invitation letters to individual women for breast and cervical cancer screening, with the decision about invitation left for individual practices for eyesight test and dental screening and as an invitational programme for blood pressure check and cholesterol test could have influenced the uptake rates for the different health check-ups in different ways, however there is no information in the BHPS available how the invitational programmes are implemented on an individual practice level. There was no regional effect on uptake of health check-ups.~~

~~Averaged (permanent) household income had a significant influence only on the uptake for dental screening and eyesight tests and actual (transitory) household income had no effect on any of the analysed health check-ups. This result is important in comparison with the other analysed free health check-ups, because income effects exist for access to preventative health services for which a charge has to be paid in comparison to preventative services for which no charge exist. Permanent income effects could also be caused by unobserved time invariant factors that have an influence on income and uptake. Another study which estimated the uptake of the health check-ups with~~

~~unbalanced panels using the BHPS from 1991 until 2003 confirmed our results only in part, because a transitory income effect was found for the blood pressure check and a permanent income effect was found for dental screening.[23] The averaged value of a GP visit during the last 12 months variable was correlated in five of the six health check-ups with the individual specific term for time invariant unobserved heterogeneity.~~

The results for the socioeconomic variables are mixed for the different health check-ups. For women, uptakes in non-specific screening examinations were higher for blood pressure checks, dental screening and eyesight tests, and lower for of cholesterol tests and these results were in agreement with three recent studies from the United States.[33 70 76] Two systematic reviews find that the uptake of health check-ups is typically higher for women and not for men with the exception of cholesterol tests.[26 40] Individuals with a higher education level are more aware of the benefits of preventative care and also early detection of diseases and this explains the higher uptake of preventative activities. Therefore, education has sometimes been found to be an important predictor of uptake of health check-ups,[77 78] but a systematic review has found more often not a significant influence on the uptake rates of different health check-ups.[26] The hypothesised influence of higher education was in our analysis only visible in dental screening and a secondary or tertiary education level had a positive significant influence on the uptake of dental screening. This result is in part explained that education is being correlated with other socioeconomic variables and the inclusion of further socioeconomic variables could explain why the effect on education disappears in the other health check-up regressions. Non-uniform results were also found for other socioeconomic variables for the different

analysed health check-ups: employment status as a proxy for opportunity costs of time had a significant negative effect on breast cancer screening, blood pressure checks and cholesterol tests. However, in other studies the effect of employment status has to be found insignificant on the uptake of breast cancer screening,[79] cervical cancer screening[62] and general health check-ups for new GP registered patients.[75] Living with a partner as a proxy for social support and network had only a significant positive effect for dental screening. Most analyses have found no effect of living in a partnerships on the uptake for specific health check-ups, e.g. breast cancer screening examinations[80] and cervical cancer screening examinations.[26] Number of children as a proxy for a possible time constraint led to a significant negative effect for breast cancer screening and blood pressure checks. A UK based study which has analysed the attendance rate for health check-ups in a general practice setting has found that a predictor for attendance was not to have children under 5 and other dependants,[61] however the effect of the number of children has not been confirmed in another study for the uptake of breast cancer screening.[81] In two systematic reviews which analysed the determinants of screening uptake for a variety of health check-ups none of the socioeconomic variables have been significant in all screening examinations.[26 40] Actual (transitory) household income had no effect on any of the analysed health check-ups and averaged (permanent) household income had a significant influence only on the uptake for dental screening and eyesight tests. No effect of actual household income on attendance rates has also been found for other screening examinations such as breast cancer screening,[82] cervical cancer screening[73] and colorectal cancer screening.[61] This result is important in comparison with the other analysed free health check-ups, because income effects exist for access to

preventative health services for which a charge has to be paid in comparison to preventative services for which no charge exist. Permanent income effects could also be caused by unobserved time-invariant factors that have an influence on income and uptake. Another study which estimated the uptake of the health check-ups with unbalanced panels using the BHPS from 1991 until 2003 confirmed our results only in part, because a transitory income effect was found for the blood pressure check and a permanent income effect was found for dental screening.[46]

Ethnicity had no significant influence on any of the health check-ups, suggesting that ethnicity is not a cultural barrier for access to preventative services. In comparison with our results, another study using the BHPS that has analysed an unbalanced panel has found for cervical cancer screening a lower uptake for Asian women in comparison to women of other ethnic origin.[27] For two studies on the uptake rates of cervical cancer screening in the USA there has not been found such an influence of ethnicity.[83 84] Changed residence and address with a higher chance for not receiving an invitation letter influenced the uptake rate of the various health check-ups unequally: women who had changed residence and address within the UK did not have a lower uptake for breast and cervical cancer screening and so the effectiveness of sending invitation letters for these both female screening examinations is questionable. In agreement with our results for changed residence and address the length of time an individual woman has lived in her own country and women's postcode of residence have not been a significant predictor of attendance for cervical cancer screening uptake.[60] In contrast to these both female cancer screening examinations it was found that for dental screening a changed residence with a

lower chance of receiving an invitation resulted in a lower uptake for dental screening. Sending invitation letters have also been reported to be successful in increasing for the participation rates of dental screening.[85] The implementation for the different health check-ups with sending routine periodic invitation letters to individual women for breast and cervical cancer screening, with the decision about invitation left for individual practices for eyesight test and dental screening and as an invitational programme for blood pressure check and cholesterol test could have influenced the uptake rates for the different health check-ups in different ways, however there is no information in the BHPS available how the invitational programmes are implemented on an individual practice level. The effectiveness of sending invitation letters for increasing participation rates for blood pressure checks has been shown,[86] however invitational follow-up letters have not contributed to increase participation in comparison to a control group for the cholesterol test.[87]

There are some differences when comparing our results on the uptake of breast and cervical cancer screening with other studies which had analysed the uptake behaviour for UK and used the BHPS as sample. Analysis of breast cancer screening uptake with the BHPS was done in one analysis with a balanced sample.[26~~28~~] Identical results were found for the relevance of previous screening history, a GP visit, age and self-assessed health status, however results were different to own results for smoking status, education level, marital status and the ~~averaged~~average household income~~ term~~, because they were significant in this analysis. The different results for the latter mentioned variables are best explained by choosing different specifications in the two empirical analyses. Analysis of

cervical cancer screening uptake with the BHPS was done in a further analysis with a balanced sample. In our analysis previous screening history, age and a GP visit were significant for cervical cancer screening in the UK and our results were confirmed by this study which analysed uptake of cervical cancer screening uptake in England with an unbalanced panel for the first 12 waves of the BHPS until 2003.[~~25~~27] The coefficients for education, smoking and changed residence status were not significant in our analysis. The differences in results for the variable education and smoking are remarkable, because in our analysis they had not been significant. ~~However, also some other studies have found no influence of education[22] and smoking status[54] on screening behaviour. Only one analysis~~However, also some other studies have found no influence of education[60] and smoking status[88] on cervical cancer screening uptake. Only one analysis has compared the sociodemographic determinants for the uptake of breast and cervical cancer screening at the same time for UK with a cross-sectional survey.[2] Results for the effects of determinants on the uptake of both female cancer screening examinations were different, because for mammography level of education, occupational classification and ethnicity were not significant and only indicators for wealth were positively significant. For having a smear test a higher educational level, and white British ethnicity were positively significant, but not indicators for wealth or occupational classification. This is one of the few studies ~~that~~which has compared the determinants of the uptake of breast and cervical screening and has found different determinants to be responsible for the uptake of both screening examinations. An advantage of this analysis was that is used the same estimation sample for the analysis, however unobserved heterogeneity and state dependency could not be taken into account with cross-sectional data in this analysis and

this could explain the different results to the results of our own study. One study with the BHPS found in a descriptive analysis that females reported a higher uptake than males for dental check-ups under NHS provision.[51~~63~~] Individuals between age 46 and 55 years had the highest proportion of dental check-ups with 72% in 2000 and the lowest participation rate was for individuals of age 66 years and older with 43% in 2000. These results are confirmed in our analysis. Another study which used the BHPS to investigate the probability of making a dental check-up visit in 1, 3, 5 and 10 years in comparison to the baseline period of 1991 found that in each of these time periods from 1991 to 2001 females, more educated and non-smokers had a higher uptake which is in accordance with own results. However, in contrast with our own results persons below age 40 had the highest rate of uptake and this result could be explained by the fact that only a distinction between individuals below age 40 and above age 40 was made[~~55~~].

A first limitation of our study is there is no information about results from previous screening examinations available and it is not possible to differentiate between types of health check-ups: preventative health check-ups according to screening guidelines, health check-ups following the advice of a GP or consultant to do a test, or health check-ups which are in response to previous inconclusive results. There is also no information available about close female relatives with a history of breast or cervical cancer. A second limitation of our study is that no information was available about level of trust in the NHS or in the GP, because it has been shown that taking part in screening examinations can be dependent on trust.[29~~31~~] A third limitation exists, because there was no information available about the characteristics of the primary care factors that have been shown to be

associated with the uptake of screening examinations in England.[56][89] Characteristics of the professional performing of the screening test, structure and organization of medical services can influence the uptake rate. A fourth limitation of our study comes from not using detailed microgeographic information, because uptake rates for a specific health check-up can be higher in affluent and less deprived areas.[57][90]

CONCLUSIONS

Our analysis compares for the first time the determinants of six different NHS health check-ups and has a focus on health related variables such as the role of the GP, health status, and existing health problems for these six different health check-ups. A further innovative feature of our study is the analysis of the uptake of different health check-ups with a random effects panel probit model with initial conditions (Mundlak-Wooldridge estimator) and a balanced sample, because some other analyses have used cross-sectional data and unbalanced panels with the possible problem of an attrition bias. Our research shows the high importance of past screening behaviour for each of the analysed health check-ups for recent screening behaviour and it is important, therefore, to maintain a high level of prevention uptake. The GP plays a central role in the uptake of screening examinations and this role in prevention in the UK health care system should not be weakened. Existing diseases are as expected important predictors for the specific health check-up. Income barriers could be removed for health check-ups such as dental screening and eyesight tests to increase the uptake for individuals with limited financial possibilities. Future research could use information about results from previous screening

examinations and microgeographic information by linking with other data sources.

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Contributions

AL performed statistical analyses. AL, RB and FP discussed the results, and contributed to the text of the manuscript. All three authors reviewed the manuscript.

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The authors declare no competing financial interests.

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