

## Evaluation and Equity Audit of the Domestic Radon Programme in England

Y Chow, J Meara, B M R Green and W Zhang

### ABSTRACT

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The UK has a radon programme to limit the radon risk to health. This involves advice on protective measures in new buildings, technical guidance on their installation, encouragement of radon measurements and remediation in existing dwellings in high radon areas. This audit evaluates the radon programme at the individual homes and geographical level to identify factors that influence the likelihood of remediation. The results show that 49% of the householders responded to our survey and 30% of the respondents stated that they had done some remediation to reduce the indoor radon levels. We found that householders with higher incomes and higher socio-economic status are more likely than others to remediate. Householders are less likely to remediate if they have one of the following: living in a property with higher radon concentration, current smokers in the dwelling, being unemployed or an unskilled worker, long length of time living in that property or elderly (65+ years) living by themselves. Householders appeared to be more likely to remediate if they considered the information on radon and its risk to be very clear and useful. This emphasises the importance of communication with householders, as well as with local stakeholders (mainly local authority staff in housing and environmental health departments) who can engage the general public, disseminate information and raise awareness of health risks from radon.



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# 1 INTRODUCTION

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## 1.1 Health risks of radon

Natural sources are responsible for the majority of the exposure to ionising radiation of the UK population and the largest contribution comes from radon (Watson 2005). Radon is a radioactive gas and isotopes occur in the three naturally-occurring decay chains headed by uranium-238, uranium-235 and thorium-232. These primordial radionuclides are found as trace elements in most rocks and soils; the more abundant uranium isotope (over 99%) is uranium-238 which includes radon-222 in its decay chain. The greater abundance of radon-222, coupled with a relatively long half-life of 3.8 days, means it is the most important radon isotope as far as health risks are concerned and is referred to as radon hereafter. Radon undergoes radioactive decay by alpha-particle emission to form a short-lived isotope of polonium. Several further short-lived decay products are formed in a series of decays by alpha and beta-particle emission before a long-lived isotope, lead-210 with half-life of 22 years, is reached. The damage to human lung from alpha-particle and beta particle emissions when the short-lived decay products of radon are inhaled result in increased risk of serious adverse health effects.

The detrimental effects of exposure to high radon levels were first observed in sixteenth century silver miners in central Europe as high levels of fatal lung disease, identified as lung cancer in 20th century. Many epidemiological studies of miners in different parts of the world demonstrated that an increased level of radon gas resulted in a statistically significant increase in the risk of lung cancer (BEIR VI). Domestic case-control studies have linked radon and lung cancer in Sweden and England (Pershagen et al. 1994; Darby et al. 1998). These studies showed that the risks from exposure to elevated levels of radon in the home were consistent with the outcomes of previous studies on miners, who were occupationally exposed to radon. Studies have consistently shown an increased risk of lung cancer with radon exposure for both smokers and non-smokers; in particular, international pooling studies in Europe, North America and a further study in China, have now demonstrated and quantified more precisely than before, the risks from exposure to radon in the domestic situation (Darby et al. 2005, Krewski et al. 2006, Lubin et al. 2004). An in-depth review of the health effects of radon exposure by the independent Advisory Group on Ionising Radiation to the Health Protection Agency was published recently (AGIR 2009).

## 1.2 UK control strategy and radon programmes

This strategy involves protective measures in new buildings and radon measurements and encouragement of remediation in existing dwellings in high radon areas. In January 1990, the National Radiological Protection Board (NRPB, now part of the Centre for Radiation, Chemical and Environmental Hazards of the Health Protection Agency, HPA) published the principles underpinning the advice to Government on the limitation of human exposure to radon in homes (NRPB 1990a). A supporting document explored the practical implications and provided numerical limits (NRPB 1990b). It included a recommended Action Level for radon in existing homes in the UK of 200 Bq m<sup>-3</sup>

averaged over a year. It also proposed that parts of the country with 1% probability or more of present or future homes being above the Action Level, (identified from radiological evidence and periodically reviewed), should be regarded as Radon Affected Areas and that appropriate authorities should delimit localities where precautions against radon should be installed in future homes.

Approved Document part C, issued in support of the Building Regulations, refers to guidance on these localities (CLG 2004). This guidance, which includes the technical details of the radon protective measures for new buildings, extensions, conversions and refurbishments, is published by the building Research Establishment (BRE 2007). More recently, HPA has recommended to Government that basic protection measures should be installed in all new buildings (HPA 2008) and, earlier this year, published updated advice on the limitation of human exposure to radon which took account of the new epidemiological data and more recent international advice (HPA 2010). The Action Level remains unchanged, the recommendation that basic protection measures should be installed in all new buildings is re-iterated and a Target Level of 100 Bq m<sup>-3</sup> introduced for protective measures in new build and remedial measures in existing buildings.

The highest risks are in homes with highest radon levels, although it should be noted that most cases of radon induced lung cancer will occur in residents of homes with low or average level due to the much larger number of such dwellings. It is not possible to predict the radon level in an individual dwelling and radon levels vary significantly between neighbouring and even adjoining properties. A key element to identifying which homes pose the greatest risk to the occupants is the development of radon maps showing the probability that an individual dwelling will exceed the Action Level. These maps are used to guide radon measurement programmes.

The first radon map for part of the United Kingdom (UK) was published in 1990. The current UK radon maps consist of a joint map for England and Wales, and separate maps for Scotland and Northern Ireland. The latest map for England and Wales was published in 2007 (Miles 2007) and those for Scotland and Northern Ireland in 2009 (Green 2009). The radon programme, with the overall objective of reducing the radiation doses from radon by identifying homes at or above the Action Level and encouraging the householder or landlord to take the appropriate remedial action, was rolled out by Government Departments with responsibility for radon policy throughout the UK to reduce the risk to health (Kendall 2005). The programme was successful in identifying the homes with high radon levels but the remediation rates were disappointingly low around 10-20%. A new programme model was rolled out in 2001 (POST 2001) which was locally tailored with the local authority acting as the public face, supported by central Government/Devolved Administrations and NRPB. Some 30 local authorities across England took part in this programme which ended in March 2005. Each programme is run in the higher radon-risk areas of a local authority or a group of neighbouring authorities, for a defined period, normally a year. The local authority is the main point of contact for householders with HPA providing expert support and resources such as access to technical building support from the Building Research Establishment, mailing of invitations and radon detectors to participants, contact with commercial remediators, disseminate literature and hold publicity events for public and local professionals.

There have been previous audits and evaluations of the radon programmes in the UK, both nationwide and in defined areas. Lee and MacDonald (1994) used a nationwide sample of over 7,000 households and found that cost was a clear deterrent to remediation, the elderly and retired paid more attention to the radon issue but remediated less than others and making radon an issue at house sales promotes testing and remediation. Bradley and Thomas (1996) also found that cost was a deterrent and reported 27% of the 5,153 responders, out of a sample of 10,174 householders in southwest England, had taken some remedial work and that homes with higher levels of radon were more likely to be remediated. Denman et al. (1998, 2004, 2005) obtained a 60% response from a sample of 122 homes in Northamptonshire and reported that householders with radon levels just above the Action Level were less likely to carry out remediation work and those who remediated are not representative of the general population: householders who were older, smoked less and had fewer children were more likely to take action. An analysis of the radon programme (DETR 2000) found that it had resulted in increased awareness amongst both the public and professionals (councillors, council officers, solicitors, estate agents, surveyors, health professionals, builders). Whilst rates of testing homes and identifying those with high radon levels were good, the remediation rate was still too low. Since 2005, the HPA has taken over the management of the English radon programme and has evolved the model to take account of many of the findings of these audits. The format of the programmes initiated in 2001 has evolved to include not only the local authority but also locally based colleagues within HPA (Local and Regional Services, LaRS), the local Primary Care Trust (PCT) and community organisations. This has delivered a significant increase in the initial response from householders and modest increase in remediation rates.

### **1.3 Objectives of this audit**

This audit evaluated the radon programme at the individual household level and geographical level to identify the factors associated with householder's willingness to participate in the programme and carry out remediation. The audit also focused on the health equity of the radon programme. Health equity means:

- Equal needs are treated equally
- People in more need get more help in proportion to their need
- Outcomes of help are equal across ethnic, gender, socio-economic and other population groups

The relevant equity question for the radon programme is whether it meets the needs of those most at risk from adverse health effects of radon (e.g. high levels of radon, long exposure, and exposure to cigarette smoke). It is also important to assess inequality in the programme to identify factors that may hinder access to testing and remediation. These factors may be financial, organisational, due to lack of knowledge or the personal behaviour and beliefs of the homeowner. The information from this report will help to improve the effectiveness and cost-effectiveness of the radon programme and recommend ways of reducing any inequities or inequalities found.

Figure 1 shows the cycle of a typical Health Equity Audit, which is a tool to enable study of how fairly the programme and resources are distributed across different populations, identifying priorities and designing and targeting services that will reduce barriers to remediation and increase fairness. The information from this report will allow consideration of stages 1-3 of a Health equity audit cycle, and the conclusions from this study will help to complete the latter stages of the cycle.



**Figure 1 The cycle of a typical Health Equity Audit**

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## **2 MATERIAL AND METHODS**

### **2.1 Householder questionnaire**

Questionnaires were sent to all householders (88% were owner occupiers, remainder were private tenants) in the national radon database that have a record of a test finding a high radon level ( $>195 \text{ Bqm}^{-3}$ ) since 01/01/2000. We excluded tenants in social housing as the responsibility for remediation was not theirs. The householder questionnaire contains 4 main sections (Appendix A):

1. Measuring radon levels in your home
2. Your views on the radon programme, information, advice and support
3. Actions taken to reduce radon levels in your home
4. Some general questions about you, your home and household

The HPA's radon team collated the information gathered from the householders with data held on radon levels in the dwellings. All individual identifiers were removed before the data were passed to the public health practitioner and statistician for analysis.



## 2.2 Statistical analysis

Responders were divided into those who had done some remedial work and those who had not. The objective of the analysis is to evaluate and identify the factors that were associated with the remediation. An unconditional logistic regression model was applied to estimate the odds ratio for the remediators compared to non-remediators. This identified factors with a significant association to the householder's willingness to remediate. All the analyses were done with STATA software (STATA Corp LP, College Station, Texas). Statistical tests were two sided, with the type I error of 5%. The 95% confidence intervals for the odds ratio were also calculated.

## 3 RESULTS

### 3.1 Descriptive results of the survey

#### 3.1.1 Response rates

8,834 questionnaires were sent to householders between July and September 2006. Of these, 8,424 surveys were assumed delivered and 329 were returned because the addressee had either moved or died. A reminder letter was sent to non-responders three weeks after the first mailing. 4,326 surveys were returned, which gives a response rate of 49% of delivered surveys. This is a good response especially in view of the large number of questions in the questionnaire.

The data were examined to see whether there were any difference between responders and non-responders depending on the radon concentration. This found no systematic differences as shown in Table 1.

**Table 1 Radon levels in responders versus non-responders**

	All radon levels		195 to 500 Bq m <sup>-3</sup>		501 to 1000 Bq m <sup>-3</sup>		>1000 Bq m <sup>-3</sup>	
	Number	Average radon level (Bq m <sup>-3</sup> )	Number	Average radon level (Bq m <sup>-3</sup> )	Number	Average radon level (Bq m <sup>-3</sup> )	Number	Average radon level (Bq m <sup>-3</sup> )
All invitees	8,834	542	6096 (69%)	306	1924 (22%)	700	814 (9%)	1935
Responded to first mailing	2,340	533	1597 (68%)	303	537 (23%)	692	206 (9%)	1904
All responders	4,326	533	2996 (69%)	304	937 (22%)	696	393 (9%)	1888
Non-responders	4,508	549	3100 (69%)	307	988 (22%)	703	420 (9%)	1982

#### 3.1.2 Remediation rate

Of the 4,326 households that responded, 1,317 (30%) stated that they have done some remediation work to reduce the indoor radon levels. The majority (88%) of households that had carried out remediation work did so soon, within 18 months, of receiving a high radon test result.

### 3.1.3 Remediation methods

A range of remediation methods have been employed by the householders. Early studies of the effectiveness of remedial measures to reduce radon concentrations in UK homes indicated that fan-assisted radon sumps under solid floors are the most effective measures (Naismith et al., 1998). Further work (Dixon and Scivyer 1999) provided a quantitative method, based on floor type and radon concentration, of determining the most appropriate remedy for an individual dwelling. A recent work has simplified this advice to a menu of three remedial measures: active sumps for solid floors; increased under-floor ventilation for suspended floors; positive-pressure units for moderately-high radon levels in well-sealed modern homes (Hodgson 2008). Table 2 shows the method used by the 1,317 remediating households. Some households had used several methods and the table reflects this. 65% of the remediators have used a method considered to be effective. This is a vast improvement from the 1996 audit where only 22% used an effective method (Bradley et al., 1996).

**Table 2 Remediation methods undertaken (most effective in bold)**

Remediation methods	Median cost, £ (number analysed)	Frequency (n)	Percentage
<b>A sump fitted with a fan</b>	800 (418)	285	20.82
A sump without a fan	450 (61)	127	9.28
<b>Fan assisted under-floor ventilation</b>	800 (50)	66	4.82
<b>Natural under-floor ventilation with air bricks</b>	150 (147)	373	27.24
<b>Indoor ventilation with a positive pressure unit or a small fan</b>	515 (291)	160	11.69
Permanent room ventilation e.g. trickle vents	80 (39)	219	16.00
Sealing	75 (29)	99	7.23
Don't know	-	15	1.1
Other	-	25	1.82
Total	-	1369	100.00

### 3.1.4 Remediation cost

The survey indicated that cost of remediation varied from few hundred pounds to over £3000. There were 767 responses to the question about cost of remediation. Of these over 79% had spend less than £1000 on remediation. An investigation of the households who had spent more than £3000 showed that these household often had exceptional circumstances. For example, the house was built into a hill or other building projects had been included in the cost, such as installing trickle vents by placing new double glazed windows. The cost data given in table 2 are the median values taken from a forthcoming publication reporting the analysis of 3,100 radon remediation projects in 2,700 dwellings (Hodgson 2010).

Householders are encouraged to retest radon levels after remediation. Retesting is free of charge after remediation if it is requested through the local authority. However, only 53% of the households who remediated had undergone a retest of the radon levels.

Eighty three percent of responders who have done the remediation work thought that the work was worthwhile. The main reason being the perception that it would benefit their health and that of their family. Over 40% stated that the benefit were for both health reasons and their property value.

### 3.1.5 Building contractors

Only 10% of the 821 householders who responded to a question about how easy it was to find building contractors for radon remediation work, said they had difficulties. This is a great improvement from the audit carried out in 1996 where householders experienced some difficulties with obtaining advice on remedial measures and were often worried about obtaining quotations from building companies.

Over 50 % reported that they did the work themselves; this is likely to be simple remediation like sealing. A further 20% found a contractor via a local list provided by their council and another 20% used a builder that they had employed previously. The remainder were split between personal recommendation, a national list and yellow pages. This reflects the view of the HPA's radon team that any good builder is capable of doing radon work and that local information is the most useful.

### 3.1.6 Non-remediators

Although all households included in the survey had radon levels above the action level, 70% (n=3,009) of responders said that they had not carried out remediation work. As shown in Table 3, 2,503 householders also gave reasons of why remediation work has not been conducted: many quoting more than one reason. Over 61% were worried about the cost of the work and 24% felt that the work would be ineffective. While a further 27% did not believe it was a health risk. This is reflected in some of the free text comments which reported neighbours living to an old age and their own experience of long years of good health while living in the property. These results are similar to the 1996 audit, where 50% cited cost as the reason for not taking remedial action and 25% of householders were sceptical about the health risks.

**Table 3 Reasons for not carrying out work in houses with high radon levels**

Reasons for non-remediating	Frequency	Percentage
Feel that the work will be ineffective	598	23.9
Worried about the cost of the work	1540	61.5
Difficulty in finding someone to do the work	315	12.60
The landlord has refused to pay	39	1.5
I do not believe it's a health risk	676	27
Inconvenience/disruption of having work done	608	24.3
The work is planned within the next 6 months	109	4.4
Other	215	8.6
Total	2503 (not the sum of above due to multiple reasons)	

## **3.2 Factors associated with increased likelihood of remediation**

An unconditional logistic regression model was used to estimate the odds ratio for remediation, comparing the 1,317 homes where remediation work had been done with the 3,009 non-remediating homes. Table 4 shows the association of anxiety about property value and health, smoking status, medical condition and disability, radon concentration, length of time living in the property, employment status, job type and age composition in relation to a homeowner's willingness to remediate. The odds ratios are calculated for each factor mentioned above. However, there are possible interrelationships and confounders between variables in the study. Therefore the variables were adjusted against each other in the analysis to allow investigation of each independent factor in whether people remediate their homes. The results are described in the following sub-sections.

### **3.2.1 Property value and health concerns**

When householders were asked if they were worried about the radon levels affecting the value of their home, only 25.8% of the responders had high anxiety levels. However, anxiety appears to be a significant factor in driving people to carry out remediation. Householders who rate property value as a more worrying factor are 43%-73% more likely to remediate than those who rate this factor as 'not worrying' (Table 4). These results are statistically significant ( $p=0.001$ ). Adjustment against other variables still show a raised odds ratio with borderline statistical significance ( $p=0.06$ ).

The questionnaire asked householders how worried (range 1-4) they were that the radon level in their home affected the health of their family. Householders are 31% to 36% more likely to remediate if they have higher anxiety about their health and the results are statistically significant ( $p<0.01$ ). After adjustment for other factors, the likelihood of remediation increased to 47% for those very worried for their health compared to those not worried ( $p=0.06$ ).

### **3.2.2 Smoking**

The survey asked about current smokers and recent ex-smokers (given up in the last 6 months before completing the questionnaire) in the house to gauge the exposure to cigarette smoke of the people living there. 3,937 households (91% of the returned questionnaires) answered this question and 18% reported smokers or recent ex-smokers in the dwelling. This is lower than the national figure of 24% of adult population over 16 year old smoking in the UK (ONS, 2007). Further analysis shows that there is 21% of current and recent ex-smokers among non-remediators, but only 14% of current and recent ex-smokers among the remediators that is substantially lower than the national rate ( $p<0.0001$ ).

There is a significant negative association between smoking status in the household and remediation. Non-smokers are 68% more likely to remediate their home than households with smokers ( $p<0.001$ ). Ex-smokers may be open to modifying their behaviour and are 51% more likely to remediate than the smokers (although number of ex-smokers is rather small in this survey and result is not statistically significant ( $p=0.16$ )). The results are similar after adjusting for other possible confounding variables.

**Table 4 Association between various factors and remediation**

	Number of action versus no-action*	Odds ratio (95%CI)*	p-value*	Adjusted Odds ratio (95%CI)**	p-value**
<b>Anxiety about property value:</b>					
Not worried = 1	344/774	1.00		1.00	
2	358/792	1.02 (0.85, 1.22)	0.85	0.98 (0.78, 1.23)	0.84
3	231/364	1.43 (1.16, 1.76)	0.001	1.29 (0.98, 1.70)	0.06
Very worried=4	84/109	1.73 (1.27, 2.37)	0.001	1.47 (0.96, 2.26)	0.07
<b>Anxiety about health:</b>					
Not worried = 1	399/969	1.00		1.00	
2	404/989	0.99 (0.84, 1.17)	0.92	1.00 (0.79, 1.28)	0.98
3	335/622	1.31 (1.10, 1.56)	0.003	1.27 (0.96, 1.68)	0.09
Very worried=4	139/248	1.36 (1.07, 1.73)	0.011	1.47 (0.98, 2.21)	0.06
<b>Smoking status:</b>					
Current smoker	153/510	1.00		1.00	
Ex-smoker	19/42	1.51 (0.85, 2.67)	0.16	1.87(0.92, 3.65)	0.08
Non-smoker	1075/2138	1.68 (1.38, 2.04)	0.00	1.78 (1.38, 2.31)	0.00
<b>Medical condition &amp; disability:</b>					
With	263/642	0.87 (0.74, 1.03)	0.10	0.82 (0.66, 1.03)	0.08
without	1012/2158	1.00		1.00	
<b>Radon Concentration (Bqm-3):</b>					
Less than 250	376/707	1.00		1.00	
251-400	444/1014	0.82 (0.70, 0.97)	0.023	0.80 (0.65, 0.99)	0.045
401-800	337/816	0.78 (0.65, 0.93)	0.005	0.72 (0.57, 0.91)	0.006
Greater than 800	160/472	0.64 (0.51, 0.79)	0.000	0.55 (0.42, 0.73)	0.000
<b>Length of time living in the property (years):</b>					
Less than 5	323/607	1.00		1.00	
5-15	550/1181	0.88 (0.74, 1.03)	0.12	0.81 (0.66, 1.00)	0.05
16-30	289/677	0.80 (0.66, 0.97)	0.03	0.91 (0.71, 1.16)	0.46
Greater than 30	121/369	0.62 (0.48, 0.79)	0.00	0.73 (0.52, 1.02)	0.07
<b>Employment status:</b>					
Employed	561/1307	1.00		1.00	
Retired	685/1388	1.15 (1.00, 1.32)	0.04	1.61 (1.25, 2.07)	0.00
Unemployed	14/74	0.44 (0.25, 0.79)	0.006	0.70 (0.31, 1.58)	0.39
Disability or ill health	31/87	0.83 (0.54, 1.27)	0.387	1.63 (0.89, 2.98)	0.11
<b>Job type:</b>					
Professional	518/837	2.36 (1.68, 3.34)	0.00	2.03 (1.26, 3.28)	0.00
Managerial & technical	290/562	1.97 (1.39, 2.81)	0.00	1.68 (1.03, 2.73)	0.04
Skilled (non-manual)	194/493	1.51 (1.05, 2.17)	0.03	1.48 (0.90, 2.44)	0.12
Skilled (manual)	44/147	1.15 (0.72, 1.83)	0.57	0.90 (0.48, 1.68)	0.75
Partly skilled	83/279	1.14 (0.76, 1.71)	0.62	0.95 (0.54, 1.68)	0.87
Unskilled	46/176	1.00		1.00	
other	46/143	1.23 (0.77, 1.96)	0.38	1.33(0.69, 2.55)	0.40
<b>Age composition:</b>					
65+ with 18-64	150/276	1.25 (0.99, 1.57)	0.06	1.27 (0.94, 1.72)	0.12
18-64 with children	215/525	0.94 (0.77, 1.15)	0.55	1.18 (0.83, 1.68)	0.36
18-64 only	482/1016	1.09 (0.93, 1.28)	0.29	1.35 (1.02, 1.77)	0.03
65+ only	405/931	1.00		1.00	

\* no adjustment

\*\* Adjusted for other variables in the table.

### **3.2.3 Chronic medical condition and disability**

22% of responders reported at least one member of the household with a disability. There appears to be no statistically significant association between disability in the household and remediation rates. After adjustment against other factors in Table 4, the households are 18% less likely to remediate if there is someone in the household with medical condition compared to those household without medical condition. However, the difference is not statistically significant ( $p=0.08$ ).

### **3.2.4 Radon concentration and remediation.**

We categorised radon level into 4 groups: up to 250 Bqm<sup>-3</sup>, 251-400 Bqm<sup>-3</sup>, 401-800 Bqm<sup>-3</sup> and greater than 800 Bqm<sup>-3</sup>. As show in Table 4, the likelihood of remediation decreases as the radon concentration increases and the results are highly statistically significant with p-values less than 0.02 for all the estimates. This trend persists even after adjusting for other possible confounding variables.

### **3.2.5 Length of residence in the property**

The average time length of living in the same property was 16 years for the non-remediators and 14 years for the remediators, which is close to the mean of 13.9 years for all tenures in England (CLG 2009 ) and similar to the 16.1 years reported from the study of 72 Northamptonshire households by Denman et al. (2005). No meaningful conclusions can be drawn without a knowledge of tenure, in particular for the type of owner-occupier: the average length of stay for householders in England varies from 23.4 years for owned outright; 9.8 years for buying with a mortgage; 12.1 years for renters of social housing to 4.5 years for private renters(CLG 2009).

The longer someone lives in a home with high radon levels, the greater their exposure. The length of time that householders had been living in their properties ranged from 1 year to over 40 years (Table 4). We categorised this variable into 4 groups: less than 5 years, 5-15 years, 16-30 years and greater than 30 years. The likelihood of remediation decreases as the length of residence in that property increases. People who had lived in the property for 30 or more years were only about half as likely to have remediated as those who had lived in their house for less than 5 years ( $p<0.001$ ). After adjustment for other variables, the likelihood of remediation is still 30% lower ( $p=0.07$ ).

### **3.2.6 Socio-economic status (employment and job type)**

The effect of socio-economic status on remediation rate was explored using the self-reported classification of employment status and job types (Table 4). Retired householders are 15% more likely for remediation ( $p=0.04$ ) and unemployed householders are 56% less likely to remediate ( $p=0.006$ ) in comparison with employed group. This pattern remains after adjustment for other variables although the odds ratio for unemployed group loses statistical insignificance due to small number of householders in the analysis.

Job type influences the likelihood of remediation (Table 4). Households that described themselves as professionals are more than twice as likely to remediate than households

that consider themselves unskilled manual workers ( $p < 0.001$ ) within an overall trend ranging from a low for unskilled workers to a high for professionals.

### **3.2.7 Household composition**

The questionnaire asked about the age composition of households. Based on the information obtained, we categorised the responding households into 4 groups: Elderly (65+ years) living with people aged between 18-64 years, people aged between 18-64 years with children, 18-64 year old living alone, 65+ year old living alone (Table 4). This is not an ideal categorisation since each category contains some retired people. Our analysis shows that the 65+ year old living alone and 18-64 years with children are less likely to do remediation compared to other age groups. The adjusted odds ratio calculation shows that the elderly (65+ years) living alone is the group less likely to do the remediation after adjustment for other variables, particularly comparing to the 18-64 years group ( $p = 0.03$ ).

### **3.2.8 Ethnicity**

In our survey, 93% of responders define themselves as white and this reflects the ethnic mix of the areas with high radon levels. After adjustment for job types, the odds ratio equals 1.008 (0.648, 1.569) with a p-value of 0.96. This clearly indicates that there is no association between ethnicity and remediation rates.

### **3.2.9 Programme factors**

In this survey, the vast majority of respondents rated the information on radon and its risks provided in the Radon Programme to be very clear and this influenced their willingness to carry out remediation. Table 5 show the clarity of information and usefulness of information in relation to the likelihood of remediation. The information, practical advice and support for reducing radon appears to be crucial and people who rate it as very useful are 9 times more likely to remediate than those that felt it was not.

Our analysis shows that householders receiving a grant are significantly more likely to remediate than people not receiving a grant (Table 5). Householders are 16 times more likely to remediate if they received a grant. Of the 80 households reported that they had received a grant from their local council, only one has not carried out remediation work.

**Table 5 Association between programme factors, district deprivation and remediation**

	Odds ratio (95%CI)	P-value	Number of action versus no-action	Deprivation score (higher numbers are more deprived)
<b>Clarity of information:</b>				
Not clear = 1	1.00		36/128	
2	0.88 (0.57, 1.36)	0.58	94/378	
3	1.47 (0.99, 2.17)	0.05	399/965	
Very clear=4	2.08 (1.43, 3.05)	0.00	767/1308	
<b>Usefulness of information:</b>				
Not useful = 1	1.00		44/389	
2	2.12 (1.49, 3.02)	0.00	176/734	
3	4.82 (3.46, 6.72)	0.00	459/842	
Very useful=4	9.96 (7.15, 13.89)	0.00	611/542	
<b>Receipt of grant:</b>				
Grant	15.96 (2.21, 115.25)	0.01	79/1	
No-grant	1.00		1178/238	
<b>Deprivation at district level:</b>				
Cornwall and isles of Scilly, Kerrier	1.00		582/1756	25.30
Torbay	1.69 (1.27, 2.27)	0.00	80/142	23.52
Devon South Hams	1.33 (1.10, 1.63)	0.00	188/423	14.20
Someset(HA) Bath and NorthEast Someset	1.16 (0.79, 1.72)	0.42	38/98	12.45
Cumbria Lakeland	2.39 (1.70, 3.40)	0.00	62/78	11.89
Lincolnshire North Kesteven	1.70 (1.21, 2.43)	0.00	54/95	11.52
Rutland	1.46 (1.04, 2.06)	0.02	53/109	6.91

### 3.2.10 District-level deprivation

Table 5 also shows the association between districts, their deprivation scores and remediation rates for districts with more than 100 respondents in the survey. Most of the data come from Kerrier District, which is also the most deprived district in the survey. Residents in most other districts are more likely to remediate than Kerrier residents. However there may be confounding factors that influence remediation rate in different districts. For example Torbay is the only district that is mainly urban while others are rural areas where the average deprivation score may hide a wide range of deprivation and affluence. In addition the programmes do vary slightly according to the set up by the local authority.

## 4 DISCUSSION

Motivating householders to remediate against radon has always been a challenging task in UK (Kennedy 1999, Lee and McDonald 1994, Bradley and Thomas 1996) and the USA (Smith et al., 1995; Rimer 1997, Wang et al., 1999, Larsson et al., 2009). In the



USA, Larsson et al (2009) have shown that a significant level of unawareness of radon. The most frequently cited reason for not remediating was that the level was too low or that they did not perceive a significant risk (Smith et al, 1988, 1990, 1995). Wang et al (1999) showed that the cost of radon remediation was a major barrier in decision making for performing radon remediation, and they emphasised the necessity the development of less expensive radon remediation methods. In the UK (Lee and McDonald 1994, Bradley and Thomas 1996), the variables most commonly associated with not remediating were reduced concern over property value, low income, disbelief of risk, highly perceived uncertainty about risk and worry about the costs.

The response rate to the householder postal questionnaire was 49% with two reminders which is comparable to other studies of this type (Iglesias and Torgerson 2000). Socioeconomic status is likely to be related both to remediation rate and likelihood of responding. Therefore the remediation rate in study respondents may be inflated. At worst, none of the non-responders remediated. If this were the case it would halve the observed remediation rate of 30%. The radon levels in responders did not differ from those in non-responders which suggests no bias related to radon level.

Exposure to cigarette smoke increases the risk of lung cancer from radon and the relationship between radon and smoking is thought to be sub-multiplicative (i.e., less than the anticipated effect if the joint effect were the product of the risks from the two agents individually, but more than if the joint effect were the sum of the individual risks) (Darby et al., 2005, BEIR VI, 1998). The majority of deaths attributable to radon are estimated to be caused in conjunction with cigarette smoke: however it is noteworthy that already over half the total deaths occur in ex-smokers and never-smokers and this percentage is likely to increase as smoking rates continue to fall (AGIR 2009). Therefore, to reduce their radon exposure is a good way for ex-smokers to reduce their risk.

Unfortunately, the current smokers in our survey appeared to be the group least likely to remediate. The odds ratio of remediation in our survey for current smokers was nearly half of that for non-smokers. It could be that the current smokers are generally less concerned about the consequence of smoking and radon exposure on their health, or they might not be fully aware the synergistic effect of radon and smoke on lung cancer risk. Therefore it is important to disseminate information of synergistic effect of tobacco smoke and radon on lung cancer, in particular to current smokers, to try to improve the remediation rate and reduce the health risks from radon. The synergistic risk of radon and smoking could be a motivating opportunity to encourage smoking reduction and remediation against radon.

Our analysis shows that the remediation rate decreases as the radon concentration increases. This is not in agreement with some previous reports. Bradley and Thomas (1996) showed that radon concentration was a significant positive factor for undertaking remediation, though the probability of remediating only rose significantly at radon levels over 1700 Bqm<sup>-3</sup>. International studies did not show a consistent picture of the likelihood of remediation against radon concentration (Sandman et al.1987, Baechler and Englin 1991). The results of Sandman et al showed almost no correlation with the radon concentration and householders perception of the severity of the radon risk.

Baechler and Englin reported that radon concentrations are an important positive determinant of remediation rate in the non-low income householders.

To explore this result, the reasons for non-remediation at different radon levels were examined (Table 6). It appears that several factors might contribute to the reduced likelihood of remediation as radon levels increase. These factors include “feel the work will be ineffective” and “worried about the cost of the work”. The proportion of households with these factors appear to be higher in the higher radon houses than those with lower radon levels. In particular, the increased trend of percentage of subjects worried about the cost of the work as radon concentration increases was statistically significant ( $p=0.001$ ). The reasons could be related to fear of very high remediation costs for houses with higher radon levels. This suggests that anxieties about the cost of remediation need to be addressed by the radon programme to improve the remediation rate among those households with very high radon levels.

**Table 6 Association between reasons for non-remediation and radon level (non-remediation only)**

Radon concentration	Less than 250 Bqm <sup>-3</sup>	251-400 Bqm <sup>-3</sup>	401-800 Bqm <sup>-3</sup>	Greater than 800 Bqm <sup>-3</sup>	P value for trend test
Feel the work will be ineffective	22.87%	23.01%	24.68%	25.98%	0.19
Worried about the cost of the work	54.67%	57.66%	64.91%	71.08%	0.00
Difficulty in finding someone to do the work	9.8%	14.6%	13.11%	11.29%	0.61
The landlord has refused to pay	1.63%	1.55%	0.99%	2.47%	0.63
Not believe it's a health risk	30.84%	30.38%	24.26%	19.66%	0.00
Inconvenience /disruption	22.11%	25.65%	22.98%	26.79%	0.29
<b>Total Number</b>	<b>551 (100%)*</b>	<b>843 (100%)*</b>	<b>701 (100%)*</b>	<b>408 (100%)*</b>	

The likelihood of remediation decreases as the length of time living in the property increases. The initially significant ( $p<0.001$ ) negative trend remains even after adjustments were made for possible confounding variables but the level of significance decreases ( $p=0.07$ ). Probable explanation is that people would be more likely to be complacent about health risks from radon and less likely to initiate building works or alterations the longer they lived in their home: it becomes a familiar, comfortable, secure and safe-feeling environment which they do not wish to change. This is reflected in some of the free text comments which reported neighbours living to an old age and their own experience of long years of good health while living in the property. There is also a cohort effect as long term residents are, on average likely to be older.

Employment status is also an important factor in deciding remediation. It is clear that unemployed households are less likely to remediate than employed households although there were few unemployed householders in the survey (2% of respondents). To improve the remediation rate among the unemployed could be a challenge task and grants may be needed to make remediation affordable.

The job type reflects the socioeconomic status and education level of people in the households. Households who have jobs in categories of professional, managerial & technical and skilled (non-manual) are more likely to remediate than unskilled or partly skilled workers. This could be a result of different levels of income or simply due to better understanding and awareness of health risk from radon exposure in the higher socioeconomic groups. Public information about radon risk, measurements and remediation needs to be clear and understandable by the target population.

Regarding the age composition of the households, 65+ years old living alone were less likely to remediate than other age composition groups after adjustment for other variables. Although we found that overall retired people are more likely to do remediation compared with employed and unemployed households, 65+ years old living alone could be an exceptional case as this analysis suggests. The lower remediation rate for this particular age group could be related to disposal income or simply due to old age. This result is in line with Bradley and Thomas (1996) that showed a large proportion of the non-remediating householders did not perceive themselves to be at increased risk because they were too old. Lee and MacDonald (1994) also reported that elderly pay more attention to the radon issue but remediate less than others, partly because they have less disposable income, or because they think that their own health is unlikely to be affected. Nevertheless, the data on age categorisation in this survey does not enable us to separate the retired households from others. Therefore, we can only compare 65+ years old living alone with 18-64 years old who may or may not have children. This finding need to be explored further by future surveys in which a finer age categorisation is used.

As indicated in a previous article (Dixon 2001), an obstacle to greater remediation is the effectiveness of the information about radon for the householders. In our survey, householders appeared to be more likely to remediate if they considered the information on radon and its risk to be very clear and useful. This result is consistent with Dixon's view. This emphasises the importance of communication with householders, as well as with local stakeholders (mainly local Authority staff in housing and environmental health departments) who can engage the general public, disseminate information and raise awareness of health risks from radon.

The bulk of the data comes from one district in Cornwall (Kerrier) which is particularly deprived. The likelihood of remediation in this area was less than other areas in the survey. Apart from Cornwall (Kerrier), the study found no clear relationship between district level deprivation index and remediation rate. This may be due to individual and other geopolitical characteristic, for example level of urbanity, which was not taken into account in the analysis. However, defining different levels of need between different districts may be important to improve the equity of the programme as a whole.

The lack of access to grants from the council or other organisations has been raised before as an inhibiting factor to radon remediation, especially in more deprived areas where there are very high radon levels with many households above the action level, e.g., parts of Cornwall. The 1996 audit (Bradley 1996) showed that some householders took the lack of grant to indicate that the radon risk need not be taken seriously. In this survey, qualitative data were gathered from telephone semi-structured interviews with local key stakeholders. Their opinions were sought on what were the main drivers of the

programme. In stakeholder interviews with council officers, the availability of grants were seen as a definite factor in increasing remediation rates and some have taken very active steps to secure more grants for their residents.

## **5 CONCLUSION**

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This audit has examined what factors influence a householder's decision to remediate against radon gas. The factors stand out that, though interrelated, are predictors of low remediation rates even when all other relevant factors have been controlled for. These are high radon level, long length of time living in the same property, smoking, household-level measures of deprivation and possibly elderly (65+ years) living by themselves. The householders with higher radon levels are more likely to worry about the cost of the work and smokers and householders living in the same property for many years are less likely to believe that radon poses a real health risk. This gives a clear steer to recommendations to improve equity in the radon programme which may need to be supported by grants to people with higher radon levels or significant deprivation. For smokers it is important to consider the possible role of radon programmes as part of smoking cessation programmes to decrease lung cancer risks as a whole. This survey also found that householders were more likely to remediate if they considered the information on radon and its risk to be very clear and useful. This re-emphasises the importance of effective communication with householders, as well as with local stakeholders (mainly local Authority staff in housing and environmental health departments) who can engage the general public, disseminate information and raise awareness of health risks from radon.

The data from this study suggest that the four factors that are most likely to improve the remediation rate in houses that are above the action level for radon are:

- Decreasing the cost of remediation for the householder and ensuring householders know the actual cost.
- Increasing public understanding of the health risks of radon
- Increasing the understanding by high testers, especially those whose houses greatly exceed the action level, that fairly modest costing remedial measures can be effective in decreasing radon levels and that remediation costs do not necessarily increase with increasing radon concentrations
- Increasing the understanding by high testers that remedial measures can be straightforward and entail little disruption

Practical measures to support these conclusions and increase the equity of the programme could include:

- Targeting households who have the highest radon levels and thus potentially the highest exposures. Methods could include bespoke explanation of the how easy and effective radon remediation can be and/or grants for remediation in lower income households.
- Targeting the groups who may be most vulnerable to the effects of radon, notably smokers, ex-smokers and possibly young children who have many more years of potential exposure
- Engaging with local health professionals to combine radon remediation programmes with other health promotion programmes, particularly stop smoking clinics.
- Targeting recent ex-smokers who are already predisposed to improve their health, may have some spare money and are one of the groups more likely to remediate.
- Targeting all high testers soon after their test, ideally starting at the same time as their result, with a follow up within the first six months.
- Reviewing information, advice and support given by HPA to ensure the ease and effectiveness of remediation measures is highlighted with realistic costs and information about any grants available. The information should be also reviewed to ensure clarity for people with a range of reading ages.
- Clear up-to-date regional/ local lists of building contractors should be available to high testing householders.
- There should be more training on radon remediation for local builders in areas where radon programmes are underway.
- Change the website and use other methods to encourage householders who have remediated to take up the offer of a free post-remediation radon test.
- The audit should be repeated after the next round of radon programmes to evaluate these measures and complete the audit cycle.

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## 6 REFERENCES

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- AGIR (2009) : Radon and Public Health. Report of the Independent Advisory Group on Ionising Radiation. Doc HPA, RCE-11. Available as a pdf at:  
[http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb\\_C/1243838496225?p=1199451989432](http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1243838496225?p=1199451989432).
- Baechler MC and Englin JE (1991). Public response to radon information in the pacific northwest. Intern. *J Environ Studies*, **38** 189-198.
- BEIR VI (1998). Effects of exposure to radon. Washington DC, National Academy Press.
- Bradley EJ and Thomas JM (1996). An analysis of response to radon remediation advice, NRPB-M707, Chilton.
- BRE (2007). Radon: Guidance on protective measures for new buildings. BRE Report BR211, 2007 Edition. ISBN 978-0-84806-013-5.

- CLG (2004). Communities and Local Government. The Building Regulations 2000, Approved Document C. Site preparation and resistance to contaminants and moisture. London, The Stationery Office (2004 edition, as amended)
- CLG (2009) Communities and Local Government. Housing in England 2007-2008. ISBN 978-1-40981-825-0 (available at <http://www.communities.gov.uk/publications/corporate/statistics/housingengland200708>)
- Darby S, Whitley E, Silcocks P, Thakrar B, Green M, Lomas P, Miles J, Reeves G, Fearn T, Doll R (1998). Risk of lung cancer associated with residential radon exposure in South-West England: a case-control study. *Br J Cancer* **78**(3), 394-408.
- Darby S, Hill H, Auvinen A, Barros-Dios JM, Baysson H, Bochicchio F, Deo H, Falk R, Forastiere F, Hakama M, Heid I, Kreienbrock L, Kreuzer M, Lagarde F, Mäkeläinen I, Muirhead C, Oberaigner W, Pershagen G, Ruano-Ravina A, Ruosteenoja E, Schaffrath Rosario A, Tirmarche M, Tomásek L, Whitley E, Wichmann H-E, and Doll R (2005). Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case-control studies. *BMJ*, Jan 29;330(7485):223.
- Denman AR and Phillips PS (1998). A Review of the Cost Effectiveness of Radon Mitigation in Domestic Properties in Northamptonshire. *J Radiol Prot* **18**(2), 119-124.
- Denman AR, Groves-Kirkby CJ, Phillips PS and Tornberg R (2004). Using the European Community Radon Software to Estimate the Individual Health Benefits of a Domestic Radon Remediation Programme. *J Radiol Prot* **24**(1), 83-89.
- Denman AR, Phillips PS, Tornberg R, and Groves-Kirkby CJ (2005). Analysis of the Individual Health Benefits Accruing from a Domestic Radon Remediation Programme. *J Environ Radioact* **79**(1), 7-23.
- DETR (2000). Department of the Environment, Transport and the Regions. Review and evaluation of the radon remediation pilot programme. DETR/RAS/00.004, London.
- Dixon DW (2001). An overview of issues in the reduction of UK radon exposure. *Environ Management & Health* **12**(5), 516-524.
- Green BMR, Miles JCH and Rees DM (2009). Radon in dwellings in Scotland: 2008 review and atlas. Chilton, HPA-RPD-051.
- Green BMR, Larmour R, Miles JCH, Rees DM and Ledgerwood FK (2009). Radon in dwellings in Northern Ireland: 2009 review and atlas. HPA-RPD-061.
- Hodgson SA, Bradley EJ and Green BMR (2008). Efficacy of radon remediation methods. HPA conference.
- HPA (2008). Health Protection Agency Board gives advice on radon measures for new homes. See press release on 21<sup>st</sup> May 2008, available at [www.hpa.org.uk](http://www.hpa.org.uk).
- HPA (2010): Limitation of Human Exposure to Radon. Advice from the Health Protection Agency. Doc HPA. RCE-15. Available as a pdf at: <http://www.hpa.org.uk/Publications/Radiation/DocumentsOfTheHPA/RCE15LimitationofHumanExposuretoRadon/>
- Iglesias C and Torgerson D (2000). Does length of questionnaire matter? A randomised trial of response rates to a mailed questionnaire. *J Health Service & Res Policy*. **5**, 219-21.
- Kendall G M, Green B M R, Miles J C H and Dixon D W (2005). The development of the UK radon programme. *J Radiol Prot* **25**, 475-492.
- Kennedy CA, Gray AM, Denman AR and Phillips PS (1999). A cost effectiveness analysis of a residential radon remediation programme in the United Kingdom. *Br J Cancer* **81**(7), 1243-7.
- Krewski, D, Lubin JH, Zielinski JM, Alavanja M, Catalan VS, Field RW, Klotz JB, Letourneau EG, Lynch CF, Lyon JI, Sandler DP, Schoenberg JB, Steck DJ, Stolwijk JA, Weinberg C, Wilcox HB (2006). A combined analysis of 7 North American case-control studies of residential radon and lung cancer. *J Toxicol Environ Health A* **69**(7), 533-597.

- Larsson LS, Hill WG, Odom-Maryon T and Yu P (2009). Householder Status and Residence Type as Correlates of Radon Awareness and Testing Behaviors. *Pub Health Nursing* **26**(5), 387-395. doi: 10.1111/j.1525-1446.2009.00796.x
- Lee TR and MacDonald S (1994). Public responses to indoor pollution from radon, *Radiat Prot Dosimetry*, Vol 56 No. 1-4, pp.331-7.
- Lubin JH, Wang ZY, Boice Jr., JD, Xu ZY, Blot WJ, Wang LD and Kleinerman RA (2004). Risk of lung cancer and residential radon in China: pooled results of two studies. *Int J Cancer* **109**, 132-137.
- Miles JCH, Appleton JD, Rees DM, Green BMR, Adlam KAM, Myers AH (2007). Indicative atlas of radon in England and Wales. Chilton, HPA-RPD-033.
- NRPB (1990a). Statement by the National Radiological Protection Board. Limitation of human exposure to radon in homes. *Doc NRPB* **1**(1), 15–16.
- NRPB (1990b). Human exposure to radon in homes. Recommendations for the practical application of the Board's Statement. *Doc NRPB*, **1**(1), 17–32.
- ONS (2007). Smoking prevalence data from: <http://www.statistics.gov.uk/cci/nugget.asp?id=866> (accessed on 03/12/2007)
- Pershagen G, Akerblom G, Axelson O, Clavensjo B, Damber L, Desai G, Enflo A, Lagarde F, Mellander H, Svartengren M et al. (1994) Residential radon exposure and lung cancer in Sweden. *N Engl J Med* **330**(3), 159-64
- POST (2001). Postnote no. 158. Reducing radon risks in the home. Parliamentary Office of Science and Technology, June 2001.
- Rimer LB (1997). Risk perception and risk communication : decision making related to environmental radon exposures. Ph.D dissertation, University of Illinois at Chicago, Chicago, IL.
- Sandman PM, Weinstein ND and Klotz ML (1987). Public response to the risk of geological radon. *J Communication* **37**(3), 93-108.
- Smith VK, Desvougues WH, Fisher A and Reed Johnson F (1988). Learning about radon's risk. *J Risk & Uncert* **1**, 233-58.
- Smith VK, Desvougues WH, Reed Johnson F and Fisher A (1990). Can public information programs affect risk perceptions? *J Policy Analysis & Management* **9**(1),41-59.
- Smith VK, Desvougues WH and Payne JW (1995). Do risk information programs promote mitigating behaviour? *J Risk & Uncert* **10**, 203-21.
- Wang, Y., Ju, C., Stark, A. D., & Teresi, N. (1999). Radon mitigation survey among New York state residents living in high radon homes. *Health Phys* **77**(4), 403-409.
- Watson SL, Jones AL, Oatway WB and Hughes JS (2005). Ionising Radiation Exposure of the UK Population: 2005 Review. Chilton, HPA-RPD-001

## **APPENDIX A**

### **Householder questionnaire**

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Tear off the letter if you wish

Radon Studies Group  
Radiation Protection Division  
Health Protection Agency  
Chilton, Didcot, Oxfordshire  
OX11 0RQ

01235 822622  
Radon@hpa-rp.org.uk  
www.hpa.org.uk/radiation

«Name»  
«A1»  
«A2»  
«A3»  
«Postcode»

4<sup>th</sup> September, 2006

Our Ref: Audit2006/a/«Letter\_batch»

«Meas\_id»

Dear «Sal»

### **Radon in homes**

I am sorry to trouble you again, but we have not received back your completed questionnaire. It maybe that you have already responded and it is in the post – if so please accept my apologies for this letter. You may also have decided not to respond to this voluntary survey. If this is the case, I ask you to reconsider your decision as your views are important to us and will influence how the programme, which is funded from taxpayers' money, will be run in the future.

Please see overleaf for the original letter and attached questionnaire. I look forward to your reply.

Yours sincerely

Dr Jill Meara BM. BCh. FFPH  
Deputy Director  
Radiation Protection Division

Copy of original letter sent August 2006

**Radon in homes**

You may recall that you had a radon test in your home as part of the national radon programme within the last few years. Radon testing is an on-going programme, funded by the Government, to reduce the health risks from exposure to radon in homes. The Radiation Protection Division of the Health Protection Agency (formerly the National Radiological Protection Board) is responsible for the programme.

We have asked an independent public health doctor to help us improve the programme. As part of this review, we are asking everyone who has had a high radon test result and/or carried out remedial work in the last few years to complete the enclosed survey.

Participation in this survey is completely voluntary and will not affect future communications with us. However you would be helping us to improve our service to householders throughout the country and to obtain better value for the taxpayers' money we spend. I can assure you that the survey is completely confidential; no information that allows individual homes to be identified will be passed to the researcher. No published data will identify individuals or their houses.

Please complete the attached survey by following the instructions at the start. Please try to return it to us by the 1<sup>st</sup> September using the pre-paid envelope provided – there is no need for a postage stamp.

I do hope that you are able to help us and thanking you in anticipation for your cooperation.

Yours sincerely

Dr Jill Meara BM. BCh. FFPH  
Deputy Director  
Radiation Protection Division

P S Your answers will help us get better value for the taxpayers' money we spend.

**National Radon Programme - Householder's Remedial Measures Survey 2006**

**Instructions**

- The survey should be answered by the homeowner/tenant/lessee.
- Most questions are answered by ticking one or more boxes.
- In some, you can also write your answer if none of the tick boxes applies
- Please answer each question in turn unless the instructions tell you otherwise.
- Please try to give the most accurate answer you can to each question.
- This survey should take less than 10 minutes to complete.
- Please fill in both sides of the page.

Your answers will be treated in the strictest confidence.

The information gathered will help us improve the radon programme in the future.

Note. The National Radiological Protection Board (NRPB) became the Radiation Protection Division of the Health Protection Agency (HPA) in April 2005

**Measuring radon levels in your home**

1. Why did you test the radon level in your home? *Please tick all boxes that apply.*

- |   |                          |   |
|---|--------------------------|---|
| a. Selling or buying this property  | <input type="checkbox"/> | a |
| b. Health concerns  | <input type="checkbox"/> | b |
| c. Received literature and the test was free                              | <input type="checkbox"/> | c |
| d. Saw newspaper article/ advertisements                                  | <input type="checkbox"/> | d |
| e. Heard a radio or saw a TV report                                       | <input type="checkbox"/> | e |
| f. Picked up a leaflet in the GP's surgery/the library/the Council office | <input type="checkbox"/> | f |
| g. Other, please specify:   | <input type="checkbox"/> | g |
- .....

2. About the radon measurement programme:

- |   |                          |     |                          |    |
|---|--------------------------|-----|--------------------------|----|
| a. Did you find carrying out the radon test easy?               | <input type="checkbox"/> | Yes | <input type="checkbox"/> | No |
| b. Were the instructions clear and simple?                      | <input type="checkbox"/> | a   | <input type="checkbox"/> | a  |
| c. Did you receive the results?                                 | <input type="checkbox"/> | b   | <input type="checkbox"/> | b  |
| d. Did the letter and the enclosed leaflets explain the result? | <input type="checkbox"/> | c   | <input type="checkbox"/> | c  |
|   | <input type="checkbox"/> | d   | <input type="checkbox"/> | d  |

3. Are you worried about the radon levels in your home and how it might affect:

	Not	←————→		Very
	worried			worried
	1	2	3	4
Your health and the health of your family	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The value of your property	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other concerns, please specify:				

.....

**Your views on the radon programme, information, advice and support**

4. How did you learn about radon and its risks? *Please tick all boxes that apply.*

1

- a. The HPA or NRPB
- b. The Building Research Establishment (BRE)
- c. Your local Council
- d. GP surgery
- e. On the Internet
- f. Newspaper story or radio/TV programme
- g. Discussions with neighbours, friends or family
- h. Other, please specify:

a
b
c
d
e
f
g
h

.....

5. How clear was the information sent with the result of your radon test?  
*Please tick one box only*

Not clear	←—————→	Very clear
1		4
<input type="checkbox"/>	2      3	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>

6. How did you get advice to reduce the radon in your home? *Please tick all boxes that apply.*

- a. Home visit by the local Council
- b. Attended a local radon roadshow/seminar/advice session
- c. Telephone advice from the local Council/HPA/BRE
- d. Posted literature from the local Council/HPA/BRE
- e. Internet
- f. Did not get advice
- g. Other, please specify:

a
b
c
d
e
f
g

.....

7. How useful was the information, advice and support you received on reducing radon levels in your home? *Please tick one box only.*

Not useful	←—————→	Very useful
1		4
<input type="checkbox"/>	2      3	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/>

**Actions taken to reduce radon levels in your home**

8. Have you (or your landlord) taken action to reduce the radon level?

Yes                       No

**If YES, please go to question 10.**

**If NO, please go to question 9.**

9. If **NO** what are the reasons? *Please tick all boxes that apply.*

- a. Feel that the work will be ineffective
- b. Worried about the cost of the work
- c. Difficulty in finding someone to do the work
- d. The landlord has refused to pay
- e. I do not believe it's a health risk
- f. Inconvenience/disruption of having work done
- g. The work is planned within the next 6 months  
*(in this case please complete questions 10-15 as far as you are able)*
- h. Other, please specify:  
h

a
b
c
d
e
f
g

2

**Now please go to question 19**

10. If **YES**, to question 8, what remediation work have you had done? *Please tick all boxes that apply.*

- a. A sump fitted with a fan
- b. A sump without a fan
- c. Fan assisted underfloor ventilation
- d. Natural underfloor ventilation with air bricks
- e. Indoor ventilation with a positive pressure unit or a small fan
- f. Permanent room ventilation e.g. trickle vents
- g. Sealing
- h. Don't know
- i. Other, please specify:

a
b
c
d
e
f
g
h
i

11. Did you receive a grant to help with the remediation work?

Yes  No

12. When was remediation work carried out? *Please tick one box only.*

- a. Less than 6 months after getting the result of the radon test
- b. 6-18 months after getting the result of the radon test
- c. More than 18 months after getting the result of the radon test

a
b
c

13. How/where did you find a contractor to do the remediation work? *Please tick all boxes that apply.*

- a. We did it ourselves (DIY)
- b. Local list from the Council/Radon roadshow
- c. Personal recommendation
- d. Builder I have used before
- e. Yellow pages or Internet search

a
b
c
d
e

f. National list from the BRE/Radon Council

f
g

g. Other, please specify:

.....

14. Did you have any difficulty finding a building contractor to do the work?

Yes  No

3

15. Can you estimate how much **in total** the remediation work/s has cost?

£.....

16. Have you had a **retest** of the radon levels in your property after remediation work has been carried out?

Yes  No

17. Do you feel that the actions taken to reduce the radon level were worthwhile?

Yes  No

If **Yes**, Why?

a. It has reduced the risk to my (and my family's) health

b. It will protect the value of my home

c. Other, please specify:

.....

a
b
c

18. If the radon level is still above the Action Level are you going to try to remedy further?

Yes  No

**Some general questions about you, your home and household**

*The following questions will help us to ensure we obtain the views of all sections of the community, but leave them blank if you wish.*

19. How long have you lived in this property? .....years

20. Are there any persons with a chronic long term medical condition or disability living in your home?

Yes  No

21. Of the people living in your home (including yourself):

Is anyone a current smoker? Yes  No

Is anyone a recent ex-smoker (given up in the last 6 months)? Yes  No

22. How many people of each age group live in your home? *(Please write the numbers in each box)*

- a. Under 5
- b. 5-17
- c. 18-64
- d. 65 or over

a
b
c
d

23. Which is the best description of the main homeowner, tenant or lessee? *Please tick one box only*

4

- a. Employed or self employed
- b. Retired
- c. Unemployed
- d. Unable to work due to disability or ill health
- e. Caring for my home and family/ dependents
- f. A full-time student

a
b
c
d
e
f

g. Other, please specify:  
g

.....

24. Which of the following best describes the sort of work the main homeowner, tenant or lessee does (or did in the last job if they are not working now)? *Please tick one box only*

- a. Professional
- b. Managerial and technical
- c. Skilled occupations
- d. Non-manual
- e. Manual
- f. Partly skilled
- g. Unskilled
- h. Other, please specify:

a
b
c
d
e
f
g

h

.....

25. I would describe my ethnic group as: *(please tick as appropriate)*

**White**

- British
- Irish
- Other White


**Asian or Asian British**

- Indian
- Pakistani
- Bangladeshi
- Other Asian


**Black or Black British**

Caribbean	<input type="checkbox"/>
African	<input type="checkbox"/>
Other Black	<input type="checkbox"/>

**Other Ethnic Groups**

Chinese	<input type="checkbox"/>
Other ethnic groups	<input type="checkbox"/>

**Mixed**

White and Black Caribbean	<input type="checkbox"/>
White and Black African	<input type="checkbox"/>
White and Asian	<input type="checkbox"/>
Other mixed	<input type="checkbox"/>

Decline to specify	<input type="checkbox"/>
Please specify if you wish:	

.....

«Meas\_id»  
«Meas\_id»

5

26. Anything else that you would like to say about the radon programme?

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**Finally**

- **Please check that you have answered all the questions that apply to you.**
- **Please return the completed survey in the supplied pre-paid addressed envelope to:**

Radon Studies Group  
Health Protection Agency  
Radiation Protection Division  
Chilton  
Didcot  
OX11 0RQ

- **To arrive by the 25<sup>th</sup> of August if possible**

**Thank you very much for your help; we are extremely grateful for the time and trouble you have taken to fill out this survey.**