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Local health campaigns to reduce lung cancers induced by radon and smoking—Who responds?

Antony Roger Denman^{a,*}, Karen Timson^b, George Shield^b,
Christopher John Groves-Kirkby^a, Stephen Rogers^b, Jackie Ann Campbell^c,
Paul Scott Phillips^a

^a School of Applied Sciences, The University of Northampton, Boughton Green Road, Northampton, NN2 7AL, UK

^b Public Health Department, Northamptonshire Teaching Primary Care Trust, Bevan House, Kettering Parkway South, Venture Park, Kettering, NN15 6XR, UK

^c School of Health, The University of Northampton, Boughton Green Road, Northampton, NN2 7AL, UK

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ABSTRACT

The greatest risk factor for lung cancer is smoking, the second largest factor being raised radon levels at home. Initiatives to stop smoking and reduce domestic radon levels have met with some success, but in both cases a significant proportion of those affected have not taken action.

The two risk factors combine, so that those who smoke and live in a house with high radon levels are at higher risk than if exposed to only one of the two threats. There is the potential for combined public health campaigns to better target those affected.

Using postal questionnaires, we collected demographic information of those in Northamptonshire, UK, a radon Affected Area, who participated in Smoking Cessation Programmes, and compared these to a recent study by our group of those who had taken action to reduce radon. The comparison suggests that these two groups are significantly different, and in some cases differ from the general population. In addition, those who continue to quit smoking at 1 year were more likely to have children under 18 at home, and live with a parent or partner compared to those who had relapsed after the previous assessment at 4 weeks.

There is merit in extending Smoking Cessation Programmes to include advice on reducing the risks from radon.

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1. Introduction

Smoking is the most significant risk factor for lung cancer, and since this became known, education and health campaigns have been conducted to reduce smoking prevalence [1]. In the UK, smoking prevalence has dropped from 45% in 1974 to 28% in the late 1990s, and since then has declined to 22% in 2006 [1].

The naturally-occurring radioactive gas, radon, is the second most significant risk for lung cancer after tobacco

smoking. High levels of radon were first identified in uranium mines, but more recently, it has been established that significant levels are found in the built environment, and case control studies have shown an associated increase in lung cancer [2,3].

The UK has a number of geographical areas affected by radon, of which Northamptonshire is one, with 6.3% of existing homes having radon levels over the UK domestic Action Level of 200 Bq m^{-3} [4]. A programme to reduce radon risk comprises tests in occupied houses in an area to measure radon levels, identifying those with raised levels, and then taking remedial action. Radon levels can be tested simply and at low cost, and, if raised radon levels are found, remediation work, usually involving the

* Corresponding author. Tel.: +44 0752 700 8781.
E-mail address: tony.denman@northampton.ac.uk (A.R. Denman).

introduction of a sump and attached pump to extract radon to outside and costing around £750, will reduce radon levels nearly always well below the Action Level. Over the last 15 years, campaigns in UK radon Affected Areas to measure and reduce radon in the home have been implemented through the local councils' environmental health departments. Despite quite extensive publicity, only around 40% of householders have tested radon levels in their home, and of those who discover raised levels, only 15% remediate their homes [5]. Our group has studied the characteristics of those who remediate their homes, and has shown that they are older, have fewer children, and include fewer smokers than the general population [6].

From studies of radon-exposed miners, the combination of risks from radon and smoking suggests a sub-multiplicative interaction [2], while recent studies in homes [3] suggest a multiplicative interaction. In view of this, those most at risk from radon are not being targeted by current radon remediation campaigns. This led our group to consider the local smoking cessation initiatives, and whether these might be valuable in reducing radon-induced lung cancers by reaching new at-risk sub-groups of the population, which radon remediation programmes had not reached to date. Our initial work showed that the Smoking Cessation Programme in Northamptonshire has greater health benefit compared to an identical cessation programme in an area with lower radon levels. In addition, there is greater health benefit for a smoker living in a high radon house from quitting smoking than from remediating the house and continuing smoking [7].

In England, Smoking Cessation Programmes are conducted by the local Primary Care Trust (PCT), part of the National Health Service (NHS), with the assistance of General Practitioners (GPs). Our group has studied the characteristics of those who join and participate in Smoking Cessation Programmes.

This paper compares those who remediate and those who quit smoking, and considers the characteristics of each group, and their similarities and differences, and also compares both groups to the local population. These results can inform future public health initiatives to improve the response to both risks.

2. Methods

All participants who joined the Northamptonshire PCT Smoking Cessation Programme during the period 1st July 2006 to 30th September 2006, and who had successfully quit at 4 weeks, as assessed by the Department of Health criteria, were included in this study. This group had previously consented to be followed up at 1 year, as part of routine data collection to ascertain their current quit status, and were asked, during this telephone contact, if they would provide some further information in a written questionnaire for research. They were contacted by telephone for this purpose in late 2007. During the call, participants were invited to complete a written questionnaire, and if they agreed, this was posted to them with a stamped addressed envelope for return. The data on smoking cessation was collected as part of a study on factors affecting the decision to stop smoking given ethical approval by

NHS Nottingham Research Ethics Committee on 6th August 2007. The answers were entered into a bespoke Access database, using double entry and record comparison to ensure data accuracy.

Our study on those who had found raised radon levels in their Northamptonshire homes, and had taken remedial action has been reported previously [6], when individual risk assessments were reported. All these houses were remediated by a single company following UK Radon Council good practice [8]. In early 2002, additional personal information was obtained by postal questionnaires sent to all the houses in the study population. The questionnaire included questions about all the individuals in the house, including age, occupation, smoking habits and the time each spent inside the house on a recent day, and detailed results from this study have been reported previously. Both studies covered the same geographic area—the county of Northamptonshire, UK.

The results from the Smoking Cessation Programme were assessed by examining the relationships between the main outcome measure (whether the respondent indicated that they continued to have quit smoking), and the socio-demographic factor under consideration, using Chi-squared tests. The results from the remediators were compared to the smoking cessation scheme participants. Where appropriate both groups were compared to statistics for the general population of Northamptonshire, obtained from the National Statistics Office, in similar analyses. In all cases, statistical significance was taken to be at the 5% level ($p \leq 0.05$).

3. Results

Four hundred and eighty-two 4-week quitters in the Smoking Cessation Programme were identified. Three hundred and seventeen agreed to participate and were sent questionnaires. Completed questionnaires were received from 103 quitters (32%), 68 of whom confirmed that they had not smoked since, while 35 had relapsed. Seventy-seven lived with a partner, or parent, 63 had children under 18 living at home, while a further 17 had children over 18 at home. Participants in the Smoking Cessation Programme had provided details of their age and sex when joining the programme, and there was no statistically significant difference between the age distribution and sex ratio of the initial sample of 482 and the 103 who returned questionnaires.

As previously reported, 122 questionnaires were sent to people who had remediated their homes in Northamptonshire, and 73 householders replied (59.8%). The houses contained 162 occupants, an average of 2.22 per house (range: 1–5). These comprised 138 adults and 24 children. One household did not give personal data on the occupants, leaving 72 houses with 160 occupants suitable for further analysis, although two further respondents omitted to indicate how long they had lived in their current house. Householders had been living in the house for an average of 16.2 years (range: 0.8–45.9 years). Three households (six occupants) had moved in since remediation. Six households smoked; three indicated that around 100 cigarettes a week were smoked in the house, two reported 30 cigarettes

Table 1
Length of time in current home.

Time in current house	National population	Radon	Quitters
$t < 3$ years	2755000 (19.3%)	5 (7.1%)	18 (17.5%)
$3 < t < 5$	1424000 (10%)	6 (8.6%)	15 (14.6%)
$5 < t < 10$	2416000 (16.9%)	13 (18.6%)	27 (26.2%)
$10 < t < 20$	3525000 (24.7%)	20 (28.6%)	19 (18.4%)
$t > 20$ years	4174000 (29.2%)	26 (37.1%)	24 (23.3%)
Total	14294000 (100%)	70 (100%)	103 (100%)

Table 2
Association between quit status and demographic factors.

	Children under 18 at home		Children over 18 at home		Partners or parents at home	
	Yes	No	Yes	No	Yes	No
Relapsed	14 (22.2%)	21 (52.5%)	11 (64.7%)	24 (27.9%)	22 (28.6%)	13 (50%)
Still not Smoking	49 (77.8%)	19 (47.5%)	6 (35.3%)	62 (72.1%)	55 (71.4%)	13 (50%)
Total	63 (100%)	40 (100%)	17 (100%)	86 (100%)	77 (100%)	26 (100%)

per week, and one household smoked four cigars a week. In addition, one respondent indicated that only a young adult in their household smoked, but did so only outside the house. Ten of the 160 occupants (6.25%) indicated that they were current smokers. In two households, both adults smoked. The remaining four households who smoked contained five non-smokers who would be subject to passive smoking risk in addition to the radon risk.

In this study, statistically significant differences in family size were found between remediators, quitters, and the national population. Remediators' family size is smaller, and more likely to be 2, less than that of the national population ($p < 0.001$), while the distribution of family sizes for quitters differs to that of both remediators ($p = 0.006$) and the national population ($p = 0.011$), with the quitters generally having larger family sizes.

From the questionnaires, analysis of the ages of responders indicates that the remediators tend to be older than quitters, and for the radon remediators there is a clear peak in the age range of 60–80 years, which can be seen in Fig. 1. However, the difference between remediators and quitters

is not statistically significant at the 5% level ($p = 0.185$). The age distribution of all occupants of remediated houses and of houses with quitters is shown in Fig. 1, together with a comparison with the age distribution of the Northamptonshire population. The differences in this case are highly statistically significant (all have $p < 0.001$). This is presumably related to the statistically different family sizes in each group, as noted above.

The length of time that people had spent in their current house was also studied, and compared to National Statistics. The results are shown in Table 1. Separate data was obtained for < 1 year and > 40 years but the frequencies were too low for valid statistical analysis and they were therefore combined to form those shown in the table. Although it appears that remediators have been in their current home longer than the national average, this is not statistically significant ($p = 0.110$). However, it is statistically significant that quitters are more likely to have been in their current house for a shorter time than both remediators and the national population ($p = 0.036$, and $p = 0.033$, respectively). Theoretically, this finding could be related to the respondent's age differences, but, as noted above, the difference between the ages of remediators and quitters is not statistically significant at the 5% level ($p = 0.185$).

The questionnaire sent to those on the Smoking Cessation Programme also permitted comparisons between those who had remained quitters for a full year, and those who had relapsed since the previous assessment at 4 weeks. Table 2 shows that the continuing quitters were more likely to have children under 18 at home. This is statistically significant, with $p = 0.002$. Those who relapsed were more likely to have children over 18 at home, as shown in Table 2. This is also statistically significant ($p = 0.003$). Continuing quitters are also more likely to be living with a partner or parent, see Table 2, with this finding being significant at the 5% level ($p = 0.046$).

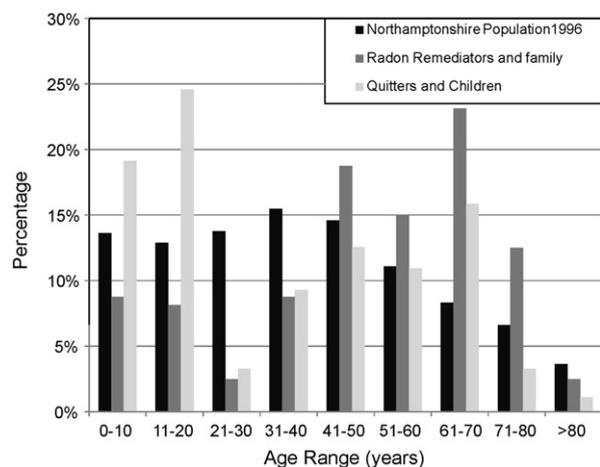


Fig. 1. Age distribution of all occupants of remediated houses, quitters and families, and the Northamptonshire population.

4. Discussion

Smoking Cessation Programmes place emphasis on quitting at an early age, as the British Doctors Study [9]

showed that those who quit successfully by 35 years avoid much of the excess mortality risk due to smoke, those who quit successfully by 50 avoid about half the risk, and those at 60 avoid one third the mortality risk. The age of the occupants when radon remediation is carried out is similarly important, as the degree of risk from radon depends on the total time spent exposed in the home together with the average radon level in the house prior to remediation.

In our study, an analysis of the ages of responders indicates that, although remediators appear to be older than both quitters and the Northamptonshire population, this difference is not statistically significant at the 5% level. However, the age distribution of quitters together with their partners and children has a statistically lower age profile than the population, which is in itself lower than remediators and their families. It is interesting to note that the reduction in health risk when radon is reduced is similar for each member of the family, while for the smoker, the risk to other family members is the lesser one of passive smoking, assuming they do not smoke, or none, if the smoker smokes outside.

In addition, our study shows that remediators have smaller families than quitters, and have lived in their current homes longer. Therefore, participants on the Smoking Cessation Programmes represent a different target population from those who remediate, so there is a potential to extend the reach of a radon remediation initiative.

The questionnaire to quitters also asked about their knowledge of radon, and whether radon, amongst many other factors, played any role in the decision to quit. These results, reported elsewhere [7], showed that few respondents regarded radon as a significant decision factor, and that the direct health concerns as a result of smoking were much more significant as factors affecting the decision to quit. Previously, in a case study in part of Northamptonshire, Phillips et al. [10] demonstrated that householders in a new estate had little knowledge of radon risks, and further work by our group confirms this [11].

Smoking Cessation Programmes have been in operation for longer than radon remediation programmes, and there has been extensive analysis of their efficacy, reflected in many more publications. As a result, Smoking Cessation Programmes have evolved to improve their operation, and to target remaining smokers.

The age profile of UK smokers has changed significantly since 1970 [1], dropping significantly so that people aged 20–24 smoke more than any other age group, which is consistent with the age profile of quitters in our study.

Messer et al., in their study of the California (US) Tobacco Control Program [12], showed that the incidence rate of successful smoking cessation increased from 1980 to 2000, with a greater increase amongst younger smokers, aged 20–34. During that period, the state introduced a Smokers' Helpline, and banned smoking in the workplace in 1995. Gilpin and Pierce [13], in their more extensive study of the whole US population from 1950 to 1990, also showed an increasing incidence of smoking cessation, but also noted that the age group which had higher quit rates varied over the years, for example, middle aged smokers (35–50), had a higher quit rate than younger smokers in 1960–1965.

Solberg et al. [14] studied the educational background of young adult smokers (age 18–24 years) in the US, and concluded that the level of interest in quitting, number of quit attempts, and relapse rates did not depend on educational level, although higher educational level was associated with a lower proportion of smokers. Macy et al. [15], studying a similar group, showed that 33% of long-term quitters who had quit for over 1 year, had relapsed by 5 years. They were less likely to relapse if they were married to a non-smoker, had only one parent who smoked, or worked in a smoke-free building. Tucker et al. [16], also studying young smokers and quitters (23–29 years), found that smokers were more likely to have higher rates of substance abuse, illegal activity, poor mental health and victimisation, but these factors were less relevant to quitting than social transitions and interpersonal factors, race, ethnicity, and health status.

Other studies have shown that quitters were more likely to relapse if they had higher emotional distress, higher nicotine dependence, higher alcohol consumption, and more medical problems [17], and increased post-quit anger [18]. However, Freund et al. [19] report that recent hospitalisation and a diagnosis of heart disease increases the likelihood of cessation.

Cheong et al. [20] studied two recommended ways of quitting—gradual reduction or “cut down”, and abrupt abstinence or “cold turkey”. They noted that abrupt quitters were twice as likely to abstain for a month or more, and suggested it should be the method of choice for those quitting on their own. Perkins and Scott [21] studied use of the nicotine patch for smoking cessation, and noted that women were more likely to relapse.

Mills et al. [22] questioned smokers attending US Emergency Departments and found that 37.8% (441/1168) had children. They found that smokers with children were more interested in quitting, and more confident in doing so. Our study supports these findings, with 61.2% (63/103) of those entering the Smoking Cessation Programme having children under 18 at home, rising to 72.1% (49/68) for continuing quitters at 1 year. Interestingly, our study shows that, if the children are over 18, then the converse is true—that the parent is more likely to have relapsed.

Smoking Cessation Programmes have developed over the years, but it is proving increasingly difficult to reduce smoking rates further, and Twigg et al. suggest that a heterogeneous range of different programmes will be required to reach ‘hard-to-engage’ populations [1]. Bauld et al. [23] compared two types of cessation programme in Glasgow – a group scheme with GP support, and a pharmacy-based scheme – and showed that the demographics of those recruited to each scheme was somewhat different, with a higher proportion of those aged 16–40 attending the pharmacy-based scheme. There was also a significantly higher proportion of people with children, whilst the group scheme had an increased percentage of females. The quit rate at 4 weeks was higher for the group scheme. They showed that those who were more socially deprived were less likely to quit, which concords with other studies, which also note that those in socially deprived areas are more likely to smoke [1]. Of the factors considered in our study, Bauld et al. [23] found a significantly higher cessation rate

in those with partners/spouses ($p=0.046$), but only in the group scheme; whereas those with children had a significantly lower cessation rate ($p=0.003$) but only in the pharmacy scheme. It should be noted that Bauld et al. studied 4-week quitters, whilst the results presented here are for long-term (1-year) quitters, and many authors note that there is a large relapse rate over the first year. For example Zhou et al. [24], in a major international study, note a relapse rate close to 80% in the first quarter, with 60% of the remainder relapsing in the next quarter. Zhou et al. also note that relapse rates vary between countries, with subjects in USA and Canada more likely to relapse than those in France, Spain and UK. Others more likely to relapse include those who have failed to quit before, those with cessation-related sleep disturbance, and with heightened anxiety. These considerations indicate that there will be a core population which is unlikely to be reached by Smoking Cessation Programmes, and that this may be the case for radon remediation programmes even when they are successfully extended to reach other groups in the population.

The approach adopted by radon remediation programmes to date has been through local Environmental Health departments and targeted at remediating the home. Our work, supported by this study, indicates that there is scope for the National Health Service to take up this concern within groups of younger people with larger families. This could be done via publicity at child care centres, schools and health clubs, for example. Smoking Cessation Programmes also provide access to a similar population, who are, presumably, concerned about health risks and ready to take action to reduce them. It would, therefore, seem possible to extend the response to the health risks of radon if quitters were provided with safety and remediation information during their interaction with Smoking Cessation Programmes in radon Affected Areas. This would utilise the greater experience and resources of running Smoking Cessation Programmes.

The next step would be to test this in practise using focus groups and pilot studies. It may be that quitters would become confused by details of a second health risk, and be concerned about taking action in the home, and less concerned about quitting smoking. There are also differences between quitting smoking and remediating radon, Quitting smoking saves money, whilst the householder needs to spend money to remediate if raised levels are found. It is interesting to note that quitters in their questionnaire responses, placed the cost issue as the seventh most significant factor in their decision to quit smoking—below the direct health risks, but above family pressure, and the knowledge of radon [11].

5. Conclusions

This study has confirmed previous indications that the higher motivation to quit in smokers with children at home converts into a higher percentage of smokers with children entering the Smoking Cessation Programme initially and then a statistically significant higher proportion of such smokers continuing to quit at 1 year. Conversely, the presence of young adults over 18 in the home increases the likelihood of relapse before 1 year. The presence of a

partner or parent in the home decreases the likelihood of relapse.

The study also indicates that those joining a Smoking Cessation Programme differ considerably from remediators, and in particular have significantly larger families, while remediators have lived in the same house for a longer time. Thus, they represent a different target group, who do not currently consider radon as a significant risk. There would appear to be the potential to extend the response to the health risks of radon if provided with public health and remediation information during their interaction with the smoking cessation team in radon Affected Areas, although this needs to be evaluated in practice.

The approach of radon remediation programmes to date has been through local Environmental Health departments and targeted at remediating the home. However, this analysis suggests that there is scope for the National Health Service to take up this concern, to target smokers, and to benefit from the expertise of running Smoking Cessation Programmes.

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