

Review of Public Information Programmes to Enhance Home Radon Screening Uptake and Home Remediation

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250 people die every year in Ireland from radon related lung cancer

IT'S IMPORTANT TO TEST YOUR HOME FOR RADON!

2nd biggest cause of lung cancer in Ireland. Smoking is the biggest

25 TIMES Smokers are 25 times more at risk than non-smokers

REFERENCE LEVELS

HOMES & SCHOOLS	WORKPLACES
200Bq/m³	400Bq/m³

110,000 Irish homes are estimated to have radon levels higher than 200Bq/m³

HOW TO TEST YOUR HOME *IT'S EASY & IT'S CHEAP*

- 1 ORDER YOUR RADON DETECTORS**
1800 300 600
www.epa.ie/radiation
- 2** Two small detectors will be posted to your home with instructions
- 3** Place one **IN YOUR BEDROOM**
+ Place the other **IN YOUR LIVING ROOM**

AFTER THREE MONTH'S TESTING PERIOD

- 4** Post the detectors back
You will receive... a reminder by text
- 5** You will then receive a **REPORT** that explains your results

YOUR RADON REPORT

IF THE TESTS SHOW THAT RADON LEVELS IN YOUR HOME ARE HIGH we can give you advice about how to easily reduce these levels

If you have any questions call **1800 300 600**

RADON IS A NATURALLY OCCURRING RADIOACTIVE GAS

Outside radon is diluted to very low levels

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- the contained use and controlled release of Genetically Modified Organisms (GMOs);
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- Monitoring developments abroad relating to nuclear installations and radiological safety.
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- Providing timely and easily accessible environmental information to encourage public participation in environmental decision-making (e.g. *My Local Environment, Radon Maps*).
- Advising Government on matters relating to radiological safety and emergency response.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

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- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

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- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiological Protection
- Office of Communications and Corporate Services

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EPA Research Programme 2014–2020

**Review of Public Information Programmes to
Enhance Home Radon Screening Uptake and
Home Remediation**

(2015-HW-SS-1)

EPA Research Report

Prepared for the Environmental Protection Agency

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ACKNOWLEDGEMENTS

This report is published as part of the EPA Research Programme 2014–2020. The programme is financed by the Irish Government. It is administered on behalf of the Department of the Environment, Community and Local Government by the EPA, which has the statutory function of co-ordinating and promoting environmental research.

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The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

EPA RESEARCH PROGRAMME 2014–2020
Published by the Environmental Protection Agency, Ireland

ISBN: 978-1-84095-632-0

March 2016

Price: Free

Online version

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Executive Summary

The paper was commissioned by the Environmental Protection Agency (EPA) Office of Radiological Protection to review the empirical research literature on the effectiveness of local awareness programmes regarding (1) home radon testing uptake and (2) home remediation rates. Literature was accessed from scientific, medical and social science publication databases (see appendix for more detail on the search strategy).

Chapter 1 presents a general background to radon, with an emphasis on the knowledge, beliefs and behaviours required for successful radon protection.

Chapter 2 highlights how risks are perceived in relation to health threats. It also defines risk perception and outlines the biases that influence how we perceive radon risk; the challenges in making radon risk salient are described.

Chapter 3 describes psychological theory and research regarding how people actually respond to health threats such as radon. It highlights the complexity of how we process information on the threat from radon.

Chapter 4 examines levels of awareness of radon and how such awareness relates to testing and remediation. Among those who are aware of radon, low levels of home radon testing are commonly reported; in addition, when individuals are informed that their homes have high radon levels, remediation rates remain low.

Chapter 5 presents international evidence from programmes designed to increase uptake rates of home radon testing and home remediation rates after testing. Although programmes can increase radon awareness, such knowledge does not result in actual testing or home remediation. However, the quality of the research evidence is weak and more robust studies are required.

Chapter 6 outlines the success of local EPA programmes in the context of the results from the international literature. In general, the EPA programmes

reflect international best practice guidelines regarding the content and process of delivering large-scale community-based multimedia programmes; the effects reported are comparable to those reported elsewhere in the literature.

Chapter 7 discusses the findings from the radon information programmes in light of the psychological barriers to risk perception and action. Findings from health screening and health promotion interventions contextualise the extent to which information programmes can change behaviour related to a personally salient health threat.

Chapter 8 presents three main issues that arise from this review: the role of the state and the individual in radon management; making radon risk and its management visible; and the benefits of matching interventions to the individual's stage of decision-making regarding testing and remediation.

Chapter 9 concludes the report by emphasising that the limits of what can be achieved by mass-media community information programmes need to be borne in mind to ensure that targets are achievable. It is argued that radon information programmes should be targeted to: (1) get non-motivated individuals motivated to test; and (2) get motivated individuals to act (testing and remediation), where appropriate.

Chapter 10 makes recommendations regarding how to enhance radon testing and home remediation rates: (1) segmenting the message to target different sectors of the population, e.g. motivated and non-motivated individuals; (2) engaging general practices in making the threat to health from radon more visible and salient; (3) shifting responsibility solely from the householder and bringing in more government regulation; and finally (4) combining regulation with high-quality information programmes targeted to the different sectors of the population.

1 Background

Lung cancer is the leading cause of cancer-related deaths worldwide. Following tobacco smoke, exposure to radon is the second leading cause of lung cancer. In many countries, including the USA (National Cancer Institute, 2016). The World Health Organization (WHO) notes that radon causes up to 14% of lung cancers worldwide (Zeeb and Shannoun, 2009). Radon can be tested for and homes can be remediated to reduce the associated risk; however, the literature in general indicates low levels of radon testing and home remediation. Despite high levels of awareness of radon (typically above 70% of the population report being aware of radon; see, for example, Larsson *et al.*, 2009), many underestimate the seriousness or long-term health effects of radon exposure. Furthermore, even when individuals are informed that their homes have high radon levels, remediation rates are low. Comprehensive multi-media information programmes to increase radon testing and remediation both nationally and internationally are successful at increasing awareness of radon; however, research consistently finds low levels of radon testing and remediation following such programmes. For example, the Environment Protection Agency (EPA) reports that, of householders who have tested their houses and found them to contain high levels of radon, less than 25% actually go on to remediate their properties (Fenton, 2011). The lack of appropriate testing and remediation by individuals poses profound public health challenges. It is in this context that the present review examines the psychological aspects of how the health risks posed by radon are perceived and managed.

Managing environmental risks, such as radon, can be achieved by government legislation alone, individual action alone or some combination of legislation and individual action. At present in Ireland, radon testing and remediation are the responsibility of the individual: consequently the goal of public awareness communications is to help individuals take appropriate preventive action. The individual is responsible for (1) testing to determine to what extent radon is present, (2) deciding if the level poses a threat, (3) selecting an appropriate remediation strategy, (4) implementing the remediation strategy, and (5) retesting to ensure that remediation has been successful. To ensure that the individual has the requisite knowledge to make an informed decision regarding radon, the government's role is typically to

provide information to individuals regarding the threat radon poses, its assessment and potential remediation strategies. In essence, the state communicates rather than regulates: action regarding testing and remediation is an individual choice.

The standard information provision approach is based on an assumption that individuals will act rationally in relation to the information provided; once you tell people that there is a threat, they will be motivated to test to see if they personally are at risk from the threat, they will test and then they will act to remediate if the test indicates a threat. However, if we break down the process of translating the information into necessary behaviours, there are a number of stages that need to occur for an individual to act following an information programme (Box 1.1).

Box 1.1. Steps required for action to occur after radon information programme

1. I am *exposed* to the information.
2. I *attend* to the information (notice it).
3. I am *interested* in the information.
4. I *understand* the information.
5. I *believe* that there is a threat: the information must be perceived as being *credible*.
6. The threat is *comprehensible*: I understand the threat.
7. I *perceive* it as a possible *risk*: the threat may affect me (I may be *susceptible*) and it may have very negative health consequences for me (it is *severe*).
8. I *believe* that the threat level can be assessed.
9. I *know* how to get the threat level assessed.
10. I *want* to get the threat level assessed.
11. I *act* to get the threat level assessed: **test**.
12. I *understand* the results.
13. I *perceive* that *I am at risk* (I am susceptible to a severe negative outcome).
14. I *want* to reduce this risk.
15. I *know* how to reduce this risk.
16. I *act* to reduce the risk: **remediate**.
17. I *act* to confirm that the risk has been managed: **re-test**.

The above list comprises a mixture of typical awareness programme content and the individual's perceptions, knowledge, motivation and actual behaviour. As can be seen, there are quite a number of steps that need to occur before an individual will test and then remediate. The question immediately arises: *can a mass-media programme result in all of these steps being achieved?*

In addition, it must be noted that this sequence is predicated on the assumption of a rational actor responding to health threat information, i.e. that an informed

individual tends to behave in the best interests of their health (Maziak and Ward, 2009). Such an assumption does not fit with psychological research on risk perception and risk-reducing behaviours: a key theme in this report is that people can respond to health threat information in a sub-rational manner, and that such responses reflect powerful unconscious and deliberate psychological processes. In order to better understand the failures of individuals to take action to assess and then remediate against the threat from radon, the psychology of risk perception needs to be considered.

Key points

- Radon is a threat to the individual's health.
- Education programmes in high-risk areas focus on informing communities about radon and its assessment and remediation.
- A complex interaction of knowledge, perceptions, motivation and actual behaviour is required to produce the desired outcomes of testing and remediation.
- The extent to which an information programme can achieve the desired outcomes requires critical consideration.

2 Risk Perception

Although risk from an epidemiological perspective broadly refers to a quantitative measure of the probability of experiencing some negative outcome, risk from a psychological perspective is a far more complex and nuanced construct. For example, risk perception can be defined as “people’s beliefs, attitudes, judgments and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits.” (Pidgeon, 1992). This definition explicitly highlights the inherent complex multidimensional (cognitive and emotional responses) and context-specific (e.g. community, cultural and social values and behaviours) aspects to risk perception. This contrasts starkly with the formal approach to risk that simply combines two aspects (likelihood of negative outcome and severity of negative outcome). For individuals in the community, risk perception is informed by a wider framing of the issue, derived from their personal experiences in a given context, including how their interpersonal networks respond to the risk (Maibach *et al.*, 2008). Risk perceptions are affected by the norms of the groups with which people identify. In essence, lay risk perception is based on a wider framing of topics, considerations and agendas. Risks are shared and experienced collectively. People look to their social networks for information and guidance, particularly their trusted sources. In summary, *radon risk perception reflects personal experiences and circumstances, and is highly influenced by social context.*

From a psychological perspective, how the individual perceives the risk of radon will impact on their decision-making regarding radon testing and remediation. Perceived risk was associated with both intentions to test as well as actual radon test ordering (Weinstein *et al.*, 1991). Among those in areas of high radon levels, the perception of radon as a health risk is related to intentions to conduct radon testing and remediation (Duckworth *et al.*, 2002). However, a number of well-established biases (Tversky and Kahneman, 1974, 1981) impact on our risk perception of radon, which impede appropriate behavioural responses.

Availability refers to our tendency to judge the likelihood of future events, such as developing lung cancer due to radon, based on how easy it is to imagine them or

to recall similar events in memory. In general, people cannot recall either personal experience of, or hearing of, someone developing lung cancer due to radon – such examples are not available to help guide our thinking of radon risk. Although people can recall hearing of radon, how many will be able to recall someone developing lung cancer due to it? In absence of such memories or associations, the risk will be downplayed or ignored in the majority of the population.

Representativeness refers to how individuals make judgements about the probability or frequency of an event based on its resemblance to their past experiences or assumptions. It reflects the principal means by which judgements are made – whether or not something is a member of a broader category. For example, smoking is commonly accepted as a member of a broader category of things that are risks for lung cancer. Similarly, someone getting lung cancer after a period living next to a nuclear plant fits within these assumptions; however, in the context of radon, getting lung cancer from simply being in one’s own home does not fit these assumptions and experiences. Notably, EPA data (Millward Brown, 2013) show that people worry more about radiation from nuclear plants than their home; consequently, people can negate the risk.

Unrealistic optimism occurs when individuals have unreasonably low estimates of their own susceptibility to harm. For example, Weinstein *et al.* (1988) compared 657 homeowners in New Jersey who had not tested their homes for radon with 141 homeowners who had completed testing. They reported that people who did not test held “optimistic biases” whereby they underestimated the risks associated with their own exposure to radon.

Affect, our emotional response, can have a significant influence on decisions regarding screening and remediation. For example, fear of cancer diagnosis and its symptoms and embarrassment are recurring themes in the literature on barriers to attending cancer screening (Flynn *et al.*, 2011). Similar issues may contribute to the failure to screen for radon. Of note, individuals feel more threatened by a description of radon that assigns radon agency (Dragojetvic *et al.*, 2014): people are more worried by radon that is described as deliberately

targeting a home (“Radon gas invades people’s homes”) than a literal description of radon dissemination into a home (e.g. “Radon gas seeps into people’s homes”). Assigning agency to radon primes an emotional response to the threat. Programmes could attempt to target such emotional aspects of risk perception as this aspect of risk perception has been generally neglected.

In general, a core challenge for communicating radon risk and promoting radon remediation relates to the fact that *radon threat is inherently perceived as either being low or simply non-existent*. As Fisher *et al.* (1991) and Doyle *et al.* (1990) note, radon risk perception is influenced by several factors:

- The *objective level* of risk. In general, the level of risk associated with radon is perceived as being so low that the risk is not understood or appropriately acted upon. For low levels of risk, we tend to dismiss the risk as being too small to worry about.
- The *absence of sensory cues* to alert people to the risk. Cues to action typically help motivate behaviour; in the absence of sensory cues the risk is, in essence, out of mind.
- The risk is *natural*. We perceive man-made technological threats to be more risky than natural threats.
- Experience of the risk is *benign*. People have lived with the risk, sometimes for many decades, without experiencing any side effects or symptoms.
- The effect of the risk is *far removed* from the initial exposure. Lung cancer will develop decades later and, as there are no early symptoms to act as cues, it is easy to delay action.
- Deaths are relatively *undramatic*. They occur singly and can be accounted for using other explanations.
- Risk is not *equivalent* for all individuals. It varies depending upon geographical location, local soil and rock type, house structure and householder behaviour. Radon risk is not equitable, which makes it harder for us to accept.
- We have an *emotional identification* with our homes. It is hard to accept that our home (our physical and psychological place of safety and security) is a threat to our health.
- *Familiarity* of the risk. We are less accepting of unfamiliar risk. Awareness of radon’s health consequences is not uniformly high.

Given these challenges, it is not surprising that radon threats fail to promote appropriate precautionary behaviour. Even where there is awareness of radon, apathy rather than a sense of urgency tends to be reported (Weinstein *et al.*, 1988). Furthermore, even when offered radon tests for free, less than 40% of the residents in an area with high radon levels availed themselves of the offer (Hartman, 1987; cited by Fisher *et al.*, 1991).

Key points on risk perception

- Risk perception is a complex psychological process of meaning-making by the individual.
- Risk perception can influence behaviour if we perceive a credible threat to our health.
- Risk perception is subject to numerous unconscious, cognitive and emotional biases that influence how we process radon information.
- These biases act to minimise our sense of risk.
- Risk perception reflects not only personal experiences and circumstances, but it is highly influenced by social context.

3 Responding to Health Threat Information

In the rational actor approach, individuals should process health threat information in an objective and considered manner, and this appraisal of threat will determine their behaviours in response to being made aware of the threat. Psychological theory and research regarding how people actually respond to health threats such as radon paints a more complex picture of how we process health threat information.

3.1 Health Threat Information Processing Models

3.1.1 *Parallel process approach*

Threat perception can give rise to two parallel processes, namely *fear control* and *danger control* (Leventhal, 1970).

- *Fear control* involves responses that attempt to reduce the unpleasant affect evoked by a fear appeal, such as threat denial or avoidance. Actions conducted in the service of fear control have little or no effect on dealing with the threat.
- *Danger control* involves the selection of responses aimed at reducing or eliminating a threat. In danger control, actions are directed at coping with the threat.

Therefore, the acceptance of a recommendation to test and remediate depends mainly on the process of danger control. However, psychologically, individuals may be dominated by a fear control strategy – for example, by denying that the threat exists, it is possible to manage a fear of cancer and potential embarrassment (i.e. that the house is unsafe), which are possible outcomes upon finding out that the risk is real.

3.1.2 *Protection motivation theory*

Protection motivation theory (PMT) (Rogers, 1983) elaborated the parallel response model's process of danger control by specifying the cognitive appraisal processes that precede people taking action in response to the threat. Rogers identified four components of threat communication that were assumed to motivate individuals to implement a protective action:

1. *severity of a threat* ("Radon poses a serious threat to my health");
2. *probability of the event's occurrence* ("I am likely to develop lung cancer");
3. *response efficacy* (i.e. the efficacy of a protective response in averting the threat; "A radon test will accurately tell me my level of radon and remediation will be effective at managing the risk");
4. *self-efficacy* (i.e. the individual's ability to perform the protective response; "I can successfully perform the behaviours required to obtain a test and to remediate my radon threat").

PMT differentiates between threat appraisal and coping appraisal processes. Threat appraisal is an evaluation of vulnerability to, and severity of, a radon threat. Coping appraisal involves the appraisal of response efficacy, self-efficacy and the costs of adaptive behaviour. Protection motivation will be strongest when the threat is appraised as serious and coping is appraised as effective. However, whether or not such motivation translates into actual behaviour requires additional considerations.

3.1.3 *Extended parallel process*

The extended parallel process model (Witte, 1992) integrated the parallel process model and PMT to propose that exposure to a health threat communication initiates two appraisal processes: *threat appraisal* and *coping appraisal*. Individuals will appraise the threat portrayed in the communication, and the more they believe they are vulnerable to a serious threat, the more motivated they will be to engage in coping appraisal. If the radon threat is perceived as irrelevant ("It affects other houses, not mine") or insignificant ("The threat is so low"), the model proposes that there is no motivation to process the radon information any further, and individuals will simply ignore the remainder of a communication. In contrast, when the radon risk is believed to be serious and relevant, individuals will become scared, and their fear should motivate them to consider their coping alternatives.

The perceived efficacy of the recommended action (i.e. belief testing and remediation will manage the threat)

is proposed to determine whether individuals, who believe that they are vulnerable to a serious risk, will engage in danger control or fear control. Witte (1992) assumes that individuals will mainly engage in danger control when they perceive the recommended action as effective in reducing the threat, and they will mainly engage in fear control when they perceive the recommended action as ineffective, or when they feel unable to perform the recommended action. To control fear, defence motivation is elicited, with individuals using denial, defensive avoidance or reactance to alleviate their fear.

In the context of radon, danger control response would involve behaviours such as ordering a radon test and, if high levels of radon are found, then having a remediation system installed. Fear control processes can arise if the individual may not be able to afford the cost of radon testing or remediation, or may not believe that radon remediation achieves the purported goal. A key tension can arise when people engage in coping responses to reduce fear, as such responses may also inhibit danger control occurring (i.e. stop them taking the required behaviours).

3.2 Defensive Processing

Related to the processes outlined above, individuals often respond defensively to emotive “fear appeals” that aim to instil motivation for behavioural change (e.g. get a radon test). Although from a rational perspective people should respond to such information by adopting behaviours to manage the threat, people often fail to act accordingly (Sherman and Cohen, 2006). For instance, the more personally significant a health message is, the more people are likely to downplay the seriousness of the health risk, question the accuracy of the threatening information or evidence presented in the message and process the information in a biased fashion (e.g. Kunda, 1987; Liberman and Chaiken, 1992; De Wit *et al.*, 2008). Although such defensive processing of threatening health information is likely to keep worries at a distance, it can prevent people from protecting their personal health.

A further challenge arises as a consequence of the fact that health messages are often directed at those who are at risk of incurring adverse consequences (i.e. live in an area with high levels of radon). It is widely accepted that people process a message more objectively and extensively when the message is personally relevant (Petty and Cacioppo, 1986). However, a growing body

of literature suggests that, under some circumstances, personal relevance can *inhibit* objective processing, instead leading to biased, defensive processing, resulting in a decreased motivation to act accordingly (Kunda, 1990; Liberman and Chaiken, 1992). Indeed, these authors suggest that when individuals are presented with health information that threatens them personally, they process this information in a defensive manner to protect their psychological well-being and not their health.

The main audience of health messages is the at-risk population, but these people are also the most difficult to persuade because they often defensively process the information (“You are at risk of developing lung cancer due to radon”). When presented with a message that threatens one’s sense of physical or emotional security, an individual might engage in defensive mechanisms that function to reduce the threat (Leventhal, 1970). People most at risk, those for whom the message is most personally relevant, are typically the ones most likely to employ defensive techniques such as message avoidance (Donohew *et al.*, 1991) or denial of susceptibility (“I am the exception to the rule”; Stuteville, 1970). Increased personal relevance affects the type of processing used and subsequent evaluation of message information (Jemmott *et al.*, 1986; Kunda, 1987; Liberman and Chaiken, 1992). For example, “defensive systematic processing” characterises how those individuals at risk are *more* critical of portions of the persuasive messages linking their behaviour with a threat and *less* critical of the portions of the message that shed doubt on that link (Liberman and Chaiken, 1992). So, for example, an individual will actively try hard to question the evidence for the relationship between radon and lung cancer, but will devote less cognitive effort to evaluate a statement that radon is an odourless gas. Individuals can process information systematically with a bias towards information that maintains the current status quo, which will inhibit their behavioural responses to actually test or remediate.

The psychological factors outlined above must be borne in mind during any attempt to understand how interventions can impact on radon testing and remediation. Public health information programmes not only have to provide information on risk and its management, but they must also overcome pervasive and automatic biases in information processing that will compromise the efficacy of any information programme. The next section considers knowledge of radon and its relationship to testing.

Key points on health threat information processing

- Health threat information is processed cognitively and emotionally.
- Individuals often respond defensively to health threat information that aims to instil motivation for behavioural change.
- Individuals can process information systematically with a bias towards maintaining the status quo, which will inhibit their behaviours to test or remediate.
- Public health information programmes have to consider the pervasive and automatic biases in processing information about health threats.
- In order to get people to adopt radon-protective behaviours, it is essential that they perceive the recommended action as being effective in reducing the threat.

4 Radon Knowledge, Testing and Home Remediation

The literature reports varying levels of awareness of radon; for example, in the National Health Interview Survey, 70.7% of respondents had heard of radon (Larsson *et al.*, 2009). Similar estimates were reported over time, based on large samples from the Washington Behavioral Risk Factor Surveillance System (BRFSS) (Laflamme and Vanderslice, 2004). Of those who have basic knowledge of radon, many underestimate the seriousness or long-term health effects for children exposed to radon (Hill *et al.*, 2006). Similarly, the most recent Irish data show very high levels of awareness (86%) but a very low level of concern: only one in three were concerned about radon in their home (Millward Brown, 2013).

As noted by Ryan and Kelleher (1999), many Irish homes have unacceptably high levels of radon present, but it was perceived at that time that there was no easily accessible information on potential remediation actions. In the first national survey of households in an area characterised by high levels of radon, although the participants had adequate knowledge of radon, less than half of those in an area with high radon levels accurately recalled their radon level. Of the sample of 141 households, nearly three-quarters sought advice; however, only 9% consulted a remediation professional and 6% ($n = 9$ of 141 respondents) overall completed home modification. The main barriers to action were indecision (41%) and expense (29%). Of note, these findings reflect data from Ireland: the EPA surveys (e.g. Millward Brown, 2013) showed that “not convinced there is a risk” (29%) and “concern about cost” (37%) were given as reasons for respondents not remediating.

Among those who received a free radon test informing them that their household levels were high, when questioned by telephone survey 3 months after receipt of their radon screening result, only half correctly interpreted their screening radon level as being in the high range, and only 39% of the participants planned

follow-up radon measurements (Field *et al.*, 1993). The authors noted that receiving radon screening test results indicating high radon levels was not an adequate motivational factor in itself to stimulate further radon assessment or remediation. These findings suggest that free radon screening will not result in a dramatic increase in subsequent homeowner initiated remediation or further recommended radon testing.

Even among those who are aware of the threat posed by radon, low levels of home radon testing are reported. Only 15% of those aware of the risk associated with radon reported having their homes tested in the National Health Interview Survey (Larsson *et al.*, 2009). Similar rates are reported elsewhere (Wang *et al.*, 2000). Furthermore, even when individuals are informed that their homes have high radon levels, remediation rates are low, with reports ranging from 7% (Kennedy *et al.*, 1991) to 15% (Zhang *et al.*, 2011), up to 43% (Riesenfeld *et al.*, 2007) to 60% (Wang *et al.*, 1999).

Among those at high risk, the percentage of respondents who took action to reduce radon levels in their homes (e.g. installing a powered system to provide more ventilation) increased with increasing education level as well as household income level (Wang *et al.*, 1999). Research in the UK notes that those who remediate their homes are older, have fewer children and have fewer smokers in the household than the general population (Denman *et al.*, 2004). Of note, common reasons not to remediate radon levels in homes reported by those with high levels include cost and lack of concern over elevated levels (Wang *et al.*, 1999; Riesenfeld *et al.*, 2007). Similar findings are reported in the Irish context (Millward Brown, 2013).

The next section considers the empirical literature on the effectiveness of public information programmes regarding (1) home radon screening uptake, and (2) home remediation rates.

Key points on radon knowledge and remediation

- The general population frequently reports some level of awareness of radon.
- Among those who are aware of radon, low levels of home radon testing are commonly reported.
- Even when individuals are informed that their homes have high radon levels, remediation rates are low.
- In general, the evidence suggests that free radon screening will not result in a dramatic increase in subsequent homeowner initiated remediation or further recommended radon testing.

5 International Public Information Programmes on Radon

The systematic delivery of information to at-risk populations is important for ensuring clear communication, enhancing understanding of risk and increasing the transparency of risk analysis for decision-making. The goal is to provide useful, relevant and accurate information in an understandable language and format for the target audience. Programmes aim to provide individuals with adequate information about the hazards of radon and how it can be managed so that they can make reasonable estimations of personal risk. However, providing reliable data is only part of the process. If that were all it took, and people were rational, then any two people given the same information and set of circumstances would make similar decisions regarding testing and remediation. In practice this is not the case: human behaviour is far more complex, especially when behavioural choices are made in the context of probabilities and not certainties.

In an audit of England's radon programme, Chow *et al.* (2011) note that, among those houses identified as having high radon levels, the remediation rates nationally were low: around 10–20% reported some form of remediation. A survey of householders in Cornwall and Devon indicated that the proportion of householders who act to reduce their radon levels was also in the range of 10–20% (Bradley and Thomas, 1996). Similarly, low levels of remediation by those who perceived radon as a problem have been reported in other international (Himes *et al.*, 1996) and Irish studies (25% rate reported by Fenton, 2011, on behalf of the Radiological Protection Institute of Ireland).

Of note, Chow *et al.* (2011) report evidence supporting the efficacy of awareness programmes: in a survey of individuals with a high radon reading in their home, those who found the information presented to them by media campaigns clear and useful were nine times more likely to remediate than those who felt the information presented was not useful. Similarly to previous studies, commonly cited reasons for not remediating include not perceiving it as being a risk (Lee and McDonald, 1994; Smith *et al.*, 1995; Bradley and Thomas, 1996) and cost (Lee and McDonald, 1994; Bradley and Thomas, 1996). In general, the number of buildings with effective remedial measures against radon is strikingly low in high-risk areas (Dixon, 2001).

Research studies have examined how different types of risk communication interventions impact on home radon testing and remediation (see Table 5.1).

5.1 General Problems with the Literature on Radon Awareness Intervention

Although numerous evaluations of radon awareness programmes have been conducted in many countries, only a few of these analyses have been published in peer-reviewed journals or in proceedings of international conferences, limiting the capacity of a systematic review to aggregate the research to inform practice.

As with any literature review, the findings of this review are limited by the nature of the available data. Differences in sampling strategy, outcome measures and analyses characterise the literature; furthermore, the interventions vary in terms of format, content, process and outcome assessment. Such variation precludes clear integration of the studies to inform practice. The effects reported vary and, although some interventions report increased radon testing, at present there are few data on the extent to which the education programmes result in increased home remediation. Of note, the available data indicate very low rates of remediation.

For many of the studies cited, there was a noted lack of methodological information provided. Only a few articles with randomised controlled or clinical controlled designs were found. Many studies used questionnaires that had been developed specifically for that particular study and had not been tested for reliability or validity. The data collection methods were often self-response (paper/pencil), and consequently there was a strong possibility of recall bias. At times it is challenging to determine how representative the samples were of target populations. Such limitations severely restrict the strength of conclusions that can be drawn in relation to the efficacy of the radon awareness programmes. There is a critical need for high-quality studies, which are sufficiently powered and use standardised measures, to examine the effects of programmes on objective measures of actual radon testing behaviours and remediation.

Table 5.1. Summary of international studies on radon mediation

Authors	Study	Intervention aim	Intervention	Method	Outcome	Comments
Johnson <i>et al.</i> , 1988	Radon detection monitors placed in 2300 homes: experiment examined sensitivity of people's responses to alternative presentations of the same information on radon risk	To examine how information on radon readings influenced remediation	Information varied in terms of format: qualitative vs quantitative, commanding vs cajoling	RCT	The booklets worked better than the fact sheets, but no single format appeared to be best for all aspects of knowledge of radon, risk information and remediation	No statistical data are presented
Weinstein <i>et al.</i> , 1990	Experiment examining information varying in threat perception and difficulty of reducing radon levels on radon testing	To increase threat perceptions and radon testing rates	Information brochure varying in threat perception (likelihood, severity) and perceived difficulty	Experimental manipulations	Intervention increases risk perception (perceived susceptibility), but no effect on test orders	Change in risk perception was not sufficient to produce a change in behaviour
Doyle <i>et al.</i> , 1990	Evaluation of the effectiveness of an intensive radon information and awareness programme	To increase radon testing and remediation rates	Advertisements in newspapers, TV slots, radon test kits available at 50% discount with free postage	Survey to 920 households who had purchased radon test kits as part of an intensive information and awareness programme	Only 1.2% of the group with radon readings exceeding a set threshold conducted remedial action as a result of this programme; only one-third of the 1.2% conducted a post-remediation retest to confirm that remediation had been effective	Information pamphlets circulated might have encouraged people to take remedial measures themselves rather than professional assistance
Weinstein <i>et al.</i> , 1991	Experiment examining perceived susceptibility message and radon testing rates	To increase perceived susceptibility message and radon testing rates	Personal phone call to people living in high-risk area to say they lived in high-risk area and a personal letter to reinforce the telephone message; letter included form enabling subjects to purchase a reduced price home radon test	RCT: intervention ($n = 300$) vs control ($n = 347$) pre- and post-intervention surveys; t2 survey 2 months post intervention	Intervention increases risk perception (perceived susceptibility), but no effect on test orders	Change in susceptibility was not sufficient to produce behaviour change
Desvouges <i>et al.</i> , 1992	Comparison of two pilot programmes for encouraging radon testing: a targeted mass-media approach and mass media combined with a community-based programme	To increase radon testing	Mass-media information (radio public service announcements, newspaper advertisements, information flier in utility bills) vs mass-media information and community-based programme (radon awareness week, posters and presentations) vs control	Comparison of three communities (information only $n = 432$; information and community $n = 432$; control $n = 307$) using pre- and post surveys	Information and community group vs control = increased awareness, attitudinal changes, knowledge and radon testing (15% vs 5% in the other two conditions)	Not randomly assigned to intervention vs control No assessment of remediation

Table 5.1. Summary of international studies on radon mediation (continued)

Authors	Study	Intervention aim	Intervention	Method	Outcome	Comments
Weinstein <i>et al.</i> , 1998	Experiment examining stage-matched information effects on radon testing	To increase intentions to test and radon testing	Information varied on whether homeowner in high radon area was undecided or had decided to act. All receive a video and then asked about stage of thinking regarding radon testing	Undecided individuals ($n = 546$) and individuals who had decided to test ($n = 1351$) were randomly assigned to stage-matched intervention: undecided (video and cover letter with information on radon vs nothing) and decided to test (video, cover letter with information on radon and a form to order kits vs nothing)	Undecided: stage-matched intervention increases risk perception, but no effect on test orders Decided to act: stage-matched intervention increases radon test orders	Stage-matching proved effective
Poortinga <i>et al.</i> , 2011	Evaluation of locally directed radon roll-out programme between 2001 and 2005 in England and Wales	To increase radon awareness and testing rates	Local authorities, who rolled out the awareness programme	Comparison of local authorities with roll-out ($n = 733$) vs those with no roll-out ($n = 840$) by interview	Residents of participating local authorities had higher levels of radon awareness and were more than twice as likely to have tested their homes for radon as residents of non-participating local authorities	Compared people living in actionable areas vs non-actionable; however, there was a higher rate of testing based on area than by intervention receipt No pre- and post data reported. Hard to attribute effects to the intervention only. The actual rates are not presented
Nissen <i>et al.</i> , 2012	Intervention in primary care	To increase radon testing rates	Primary care providers (i.e. GPs) gave information on radon and usefulness of testing to those who have never tested for it; printed information on radon and coupon for radon testing kit	250 homes in high-risk area received intervention	12 months later 19% had ordered a kit, 15% overall returned the kit; of those with high readings ($n = 6/34$), half ($n = 3$) reported remediation	No comparison group

GP, general practitioner; RCT, randomised controlled trial.

Key points on international public information programmes on radon

- In general, the interventions have an effect on knowledge and intentions with regard to radon testing.
- Evidence of increasing actual testing or remediation is very limited.
- There is evidence to support delivering radon programmes targeted on the basis of whether the individual has decided to test or remediate.
- General practitioners may be effective agents to communicate radon risk.
- Frequently cited reasons for not remediating include not perceiving it as being a risk and cost.
- Purchasing a kit rarely results in eventual remediation.
- Methodological limitations restrict the strength of conclusions that can be drawn in relation to the efficacy of the radon information programmes.
- The lack of routine objective assessment of radon testing, remediation and re-testing following information programmes is particularly problematic for evaluating the programmes' effectiveness.

6 EPA Public Information Programmes on Radon

The EPA has conducted a number of representative surveys of the general public's understanding of and attitudes towards radon (e.g. Millward Brown Lansdowne, 2010; Fenton, 2011; Millward Brown, 2013). The issues raised by participants in these national surveys regarding their non-testing are in line with those expected by models of risk perception – for example, lack of awareness of threat, threat is not salient, lack of urgency over threat, questioning validity and credibility of threat, questioning the remediation cost and the role of the state's fiscal responsibility in relation to radon testing and remediation. Of note, focus groups revealed that, although the threat from radon was not completely unknown, there was little motivation to take it further because of lack of importance placed on it by peers (Millward Brown Lansdowne, 2010).

Even when there are high levels of perceived risk, the likelihood of getting homes tested was low – approximately one-third of people surveyed reported being quite to very likely to test (Millward Brown, 2013). EPA research finds that, in general, people who are not likely to test their homes report that it is not a priority at present and tend to believe that their home is not affected by radon. However, many reported not being aware of how to test for radon in their home, or who to go to in order to get their homes tested, and not knowing enough about radon; these data support the need for awareness programmes. Notwithstanding the need for information provision, the extent to which awareness programmes can address these gaps to change behaviour remains unclear; the awareness programmes can provide knowledge but, as has been noted in this paper, such information may not translate into behavioural changes in the face of psychosocial and financial barriers to action.

In addition, evaluations of EPA awareness programmes have indicated that they are comprehensive multimedia programmes that engage at-risk communities appropriately. However, among the at-risk population, it is readily apparent that any action on radon can be postponed due to a perceived low personal risk; furthermore, it is clear that even those who are prompted to have their home tested generally do not follow through when a high level of radon is found. Surveys undertaken by EPA showed that, of householders who have tested their houses and found them to contain high radon levels, less than 25% actually go on to remediate (Fenton, 2011).

The EPA awareness programmes are broadly aligned in terms of content, delivery and effectiveness with those reported in the international literature. The interventions adhere to the principles arising from a systematic review (Fitzpatrick-Lewis *et al.*, 2010) of communication about environmental health risks (including radon) and the WHO recommendations for risk communication. For example, the programmes:

- come from a trusted source;
- are tailored for the audience;
- are based on the strongest scientific evidence available;
- incorporate text with visuals (pictures, diagrams) with qualitative and quantitative data for print materials;
- disseminate information in the media through multiple sources;
- use multi-modal communication strategies and incorporate an opportunity for the public to have their questions and concerns addressed.

Key points on EPA programmes on radon

- The EPA programmes in areas with high radon levels are broadly comparable to similar multimedia community education programmes in content and process.
- They follow the best practice guidelines for radon risk communication.
- Their level of impact on radon testing and remediation is comparable to those reported in the peer-reviewed empirical literature.

7 Discussion

Risk has a cognitive aspect (i.e. what we know about the risk) and an emotional aspect (i.e. what we feel in terms of dread or fear about it). Until relatively recently health and environmental threat communications have tended to focus on the cognitive aspects (on the assumption that people are rational actors once provided with relevant information), whereas research consistently shows that individuals' actions can be driven by the emotional aspects of risk. As the risk from radon can be perceived as being small, people may understand the information provided by the awareness programme but, if they have more pressing issues (e.g. mortgage repayments) to think about, radon will not be a driver of behaviour. Worry is a finite resource: there is a limit to how much we can worry about before "emotional numbing" sets in. In the context of other concerns, radon can easily be dismissed.

Information will act as a driver of behaviour only if it can overcome the numerous biases that individuals have towards processing risk information. When risks threaten, some cognitive and emotional mechanisms push people towards action; others push them towards inaction. *The threat from radon can easily be downplayed to justify inaction.* For example, as the radon threat is distal, uncertain and only occasionally in the public discourse, actions to alleviate this particular threat can be easily postponed. Furthermore, in the New York radon studies participants believed that they could, at a later point, undo damage they have done to themselves by inaction at present or in the past (Smith, 2001) – further serving to reduce the need to remediate immediately.

In general, decades of health psychology research indicate that even well-designed information and education programmes are seldom adequate to bring about appropriate protective behaviour (Weinstein, 1987). The question as to what is realistically achievable by mass-media interventions needs to be determined, and the costs and benefits of such programmes for public health have to be considered. Over two decades ago Doyle *et al.* (1990) concluded that

... any radon programme targeted at the general population which relies only on information,

awareness and voluntary testing is likely to fail. At the very least, the likely credible mitigation resulting from this program has been so small as to suggest such programs may be a very expensive way for society to achieve radon mitigation. (p. 37)

They suggest that governmental regulation may be preferable in this context. As noted in the WHO report (Zeeb and Shannon, 2009), experience in some countries, such as Sweden, indicates that convincing policymakers to take action through regulatory means may be more effective than risk communication messages targeted at the general public.

Given the issues outlined in this report so far and the low levels of radon testing and remediation reported in the literature, questions arise regarding whether or not:

- information programmes can be adapted to make them more effective;
- information programmes have reached their maximum effectiveness, but should be continued with an acceptance of these limits;
- information programmes have reached their maximum effectiveness and should be discontinued.

These questions are posed to provoke discussion on the value of information programmes, as the current quality of research on this topic is not sufficient to allow firm guidance. The limitations of the literature (outlined in section 5.1) preclude the provision of evidence-based recommendations on the establishment of specific achievable targets for both testing and remediation.

Similar to radon interventions, the goal of public health and health promotion interventions, whether they focus on the individual, community or entire populations, is to change health behaviour(s) by changing relevant knowledge, attitudes and/or structural barriers and facilitators. Consequently, to provide a context for the magnitude of effects reported in the radon literature, it may be informative to compare the effectiveness of radon awareness programmes with general health screening programmes and community-based health interventions aimed at changing risky health behaviours.

The radon awareness programmes have two core aims: (1) to get people to test their homes for radon; and (2) of those with a high level of radon present, to get them to remediate. In terms of testing, interventions are targeted to individuals motivated to act to detect a potential threat: this is akin to screening behaviour. For remediation the goal is to get at-risk individuals to act: this is akin to prevention behaviour.

7.1 Screening

People often do not attend screening for fear of finding out that they are at risk for a negative health outcome that will have negative implications for their sense of self. Similarly, for radon testing, it is clear from research that many individuals falsely believe that remediation is considerably more costly or disruptive than is actually the case (Millward Brown Lansdowne, 2010), and this fear of the full consequences of starting down the road of testing for radon acts as an additional barrier to getting the test done in the first place.

In terms of stages of precautionary behaviour, it is noteworthy that, although general cancer screening awareness programmes have some effect on cancer risk perception, few find any effect on either intentions or self-report behaviour (Vernon, 1999). Meta-analysis of a broad range of communication interventions that

used community-wide mass-media programmes in the USA to promote breast or cervical screening report that they are estimated to change behaviour in approximately 4% of women (Snyder *et al.*, 2004).

7.2 Health Promotion Programmes

The goal for remediation programmes is to get at-risk individuals to act: this is akin to encouraging health-promoting behaviour. The evidence to date suggests that community-based health promotion programmes, using community coalitions and awareness, have limited impact. Evaluations of well-designed, large-scale, community-based general health promotion trials indicate that, overall, these health promotion programmes produce only modest effects in changing risk behaviours; reviews report that many changes were of a magnitude of less than 5% and generally were not larger than 15% (Merzel and D’Afflitti, 2003).

In summary, the data from the reviews of public health interventions, designed to increase action in response to threats that are more familiar, more proximal and more salient than radon, suggest that such programmes have modest measurable effects. Such a benchmark needs to be borne in mind when examining the evidence for a threat that is less familiar, distal and not salient, i.e. radon.

Key points

- Public information programmes may have threshold effects.
- Despite the risks posed by radon, people tend to discount threats that are not salient and immediate.
- Long-term uncertain risk from radon tends not to motivate people to action.
- Expectations regarding the effectiveness of radon information programmes may need to be tempered.
- The effects of radon information programmes are broadly similar in size to community-based health promotion and health screening programmes.

8 Future Possibilities

Having considered the literature on radon, testing, remediation and efficacy of the information interventions, a number of issues can be highlighted. Three main aspects are outlined below.

8.1 State Versus Individual Action

The balance between state action and personal responsibility could be reconsidered. As noted previously, some authors (e.g. Doyle *et al.*, 1990) have argued that, given the low levels of credible remediation resulting from information programmes promoting voluntary testing and remediation, *direct governmental regulation may be preferable* in this context. Indeed, the WHO report (Zeeb and Shannon, 2009) noted that action through regulatory means can be more effective than risk communication messages targeted at the general public. For example, mandatory government regulation could take a number of forms:

- Each home in a high-risk area must get tested and must remediate if the results exceed a designated level.
- Each home in a high-risk area must get tested, but remediation remains at the householder's discretion.
- Each home must have a test result and evidence of remediation prior to sale.
- Each home must have a test result prior to sale.

However, to date, there seems to be little appetite among policymakers in general to pursue such regulations. Consequently, the majority of the approaches reviewed have focused on targeted information programmes in high-risk areas, which place the onus on the individual to act.

Given the empirical and theoretical literature presented, the extent to which an information programme can have a substantive impact on radon protection behaviours requires ongoing critical consideration. As outlined in this review, the evidence suggests that programmes enhance knowledge and can increase risk perceptions but fail to translate into actual testing and remediation behaviours. The effectiveness of programmes designed

to induce households to take action to reduce risk will be influenced by whether or not they accept, and are willing to assume responsibility for, the risk posed by radon. As noted in Millward Brown's (2013) research, some individuals believe that if radon is a health threat then the responsibility lies with the state to address it: such a belief promotes individual inaction.

8.2 Make Radon Risk and its Management Visible

Radon is an invisible threat and consequently can be negated. The potential use of radon monitors in the house gives the radon threat a presence, making it a more salient risk. Making radon a concrete, visible, ongoing issue gives it a presence in the home environment. Such visibility is critically important to provide a visual or auditory aid to remind people to behave in a manner that might otherwise be forgotten (McKenzie-Mohr, 2000). For example, the use of digital detectors provides visible evidence of the level of radon present; an evaluation of 26 low-cost devices reported that such detectors are generally reliable for initial radon tests by homeowners (Chen *et al.*, 2007).

Similar to the threat of radon, the test for radon is largely invisible. The testing behaviour happens out of sight and in private – the testing occurs behind closed doors – so there is no easy way for individuals to know how many others have tested. Resistance to testing for radon could be overcome by appealing to our sense of social norms to instil the perception that others are testing, and that our individual procrastination over testing could make us the odd one out. A visible marker on one's house (e.g. a sticker on the window provided by testing company) to indicate that the house was tested sends a tangible signal to the community that they have tested for radon. Such markers being made more visible will mean that not testing becomes a deviation from the social norm: people may not be comfortable being perceived as atypical or as someone willing to put their family at risk by not testing. Such social competition and herding influences may have a strong impact on testing and remediation behaviour and could be used in the information programmes.

8.3 Stage Theories to Inform Information Programmes

In terms of progressing the information programme approach, as highlighted previously, behaviour change requires the individual to progress through a number of stages. Different models outline different numbers of stages but the present paper focuses on the Precaution Adoption Process Model (PAPM; Weinstein, 1988; Weinstein and Sandman, 2004). This model includes stages along a path from lack of knowledge to the initiation of behaviour and maintenance. In the context of radon, initially people do not know anything about it (stage 1). After they receive information on radon they may be aware but still unengaged, i.e. never considered testing (stage 2). When the matter engages individuals, they reach a decision-making stage (stage 3). The decision-making process may have two outcomes: if the person decides not to get tested at the moment (stage 4) or decide to act to get tested (stage 5). Stage 6 represents the actual behavioural act of testing. At present the responsibility to get a test lies with the person and, as noted in Table 5.1, once individuals decide to test, they need to know how to get the test, the test has to be easily accessed, the test must actually be used, and, in light of what the test results reveal regarding whether or not the levels of radon are dangerous, action may need to be taken. At each of these action points, the individual may fail to proceed; therefore, not all who are motivated to test will actually end up testing. The model assumes that people usually pass through all the stages, but there is no indication of the time spent in each one of them. Movement back and forth among the stages is possible.

The PAPM model has been applied to home radon testing (Weinstein and Sandman, 2004). As noted previously, Weinstein and colleagues (1998) examined how to best facilitate movement between two different transitions:

1. intervention to shift people from being undecided to test, to deciding to test;
2. intervention to shift people from deciding to test, to actually ordering a test.

The interventions differed in their focus and content. In order to move people from being undecided to decided the intervention focused on the individual's level of risk. In order to promote actual testing, the intervention reduced barriers to action by providing information

about do-it-yourself test kits and a test order form. Notably they found that the information about risk helps people to decide to act, whereas it has minimal effects on actual test ordering; information that increases the perceived and actual ease of action helps those who have decided to test. One can readily identify parallel key transition points for radon remediation:

1. shifting people from being undecided to deciding to remediate;
2. shifting people from deciding to remediate to actually remediating.

Stage theories highlight the potential to tailor interventions to different audiences. One could argue that many radon information programmes seem to be primarily focused on individuals who are unaware of radon or are not sufficiently engaged to have thought about testing. These programmes can successfully address the information needs of those at stages 1 and 2 of the PAPM; however, to move people to being motivated to test and then to proceed to testing will require different messages. Whether or not a single programme can successfully encompass such complexity is unclear.

Consequently message segmentation may prove more effective than an approach that considers the target audience to be a singular population. In relation to radon, the general population may reflect different stage sub-populations (e.g. never heard of radon; heard of it but not thinking about testing; thinking about testing; have tested but unsure about remediation; thinking about remediation), each of which requires a different intervention. However, such a level of message segmentation will prove impractical. For simplicity, three distinct groups could be the focus of the interventions:

1. information to raise awareness of radon = increase motivation;
2. information to get people to test = turn motivation into action (test);
3. information to get people to remediate = turn motivation into action (remediate).

Each of these aims need to be considered in the intervention; for example, an emphasis on testing may introduce a complacency that the household has "done something" about radon once it has purchased a test (Himes *et al.*, 1996). This may impede the move to actual remediation.

Key points

- Consider the relative role of the state and the individual in radon threat management.
- Make the risk of high radon levels and the testing for radon visible.
- Split the population into core audiences and tailor messages to different audiences.
- Use stage theories of behaviour change to inform such interventions.

9 Conclusions and Recommendations

9.1 Conclusions: Communicating the Threat from Radon

A multidisciplinary approach, involving ongoing collaboration with experts from the field of psychology, has been advocated as essential to solve the problems associated with a lack of radon remediation (Neznal and Neznal, 2008). A core challenge for risk awareness programmes is to inform the target audience in ways that do not create undue apathy, complacency or overconfidence while also not creating undue stress or alarm (Fitzpatrick-Lewis *et al.*, 2010). For radon, this is quite a complex challenge, as the risk is perceived as distal, uncertain and easily discounted. In general, despite interventions adhering to best practice recommendations for mass communication, the literature is characterised by low levels of actual testing and remediation following information interventions. However, the extent of behavioural impact, although admittedly low, is comparable to other community-based mass-media programmes. The limits of what can be achieved by mass-media community information programmes

needs to be borne in mind to ensure that targets are achievable. As noted earlier, the limitations of the literature preclude the provision of evidence-based recommendations on the establishment of realistically achievable targets for both testing and remediation.

Radon information programmes aim to inform individuals so that appropriate testing and remediation is done. From an information perspective, the interventions are effective: levels of knowledge regarding radon are increased. However, translating this knowledge into testing and remediation behaviour is less common. In general, low rates of testing uptake and even lower rates of home remediation are reported in research evaluating multimedia awareness programmes.

In general, the EPA programmes compare favourably to international best practice recommendations in terms of their content, delivery processes, evaluation and level of impact.

9.2 Recommendations

Ultimately radon awareness programmes have two core aims: (1) get people to test; and (2) for those with a high level of radon present, get them to remediate. In order to help the EPA achieve these goals the following recommendations arise from this review:

- Message segmentation may prove more effective than an approach that considers the target audience to be a singular population. In terms of testing, interventions should be targeted to: (i) get non-motivated individuals motivated to test; (ii) get motivated individuals to test; and (iii) get motivated individuals to remediate.
- Focusing efforts on the motivated individuals may prove more effective in terms of helping meet the aims of increasing actual testing and remediation. Although, from a public health perspective, information provision to the general population should continue, perhaps this aspect could be downscaled to target resources at motivated groups.
- General practices should be active information providers in order to make the health threat of radon more visible and salient. General practitioners

and public health nurses in high-risk areas should routinely ask all patients during a visit about radon testing and remediation for their house; radon should be normalised in discussions about health in a manner similar to smoking. Stage theories of behaviour change can inform such interventions.

- Given the psychological barriers noted in this review, placing the responsibility solely on the individual householder is not supported: increased governmental regulation is required. Such regulation could include requirements that houses in high-risk areas must provide certificates of radon test results (and details of all remediation work conducted) prior to sale. In addition, easily obtained financial incentives should be provided to support remediation work on houses.
- International evidence indicates that convincing policymakers to take action on radon through regulatory means is effective; combining this with high quality information programmes that target householders at different stages of radon testing motivation is recommended.

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Appendix

Methodology

A systematic review of the empirical literature on the effectiveness of public information programmes regarding (1) home radon screening uptake and (2) home remediation rates was conducted. Literature was accessed from scientific, medical and social science databases.

The following *databases* were searched: PubMed, EMBASE; PsycINFO; Psycharticles, Cochrane Library of Systematic Reviews, Campbell Collaboration Library of Systematic Reviews.

The following *search terms* were used: radon, education, information, awareness, screening, health promotion, RCT, controlled trials, health knowledge, attitudes, health beliefs, mitigation, remediation.

Abbreviations

BRFSS	Behavioral Risk Factor Surveillance System
EPA	Environmental Protection Agency
PAPM	Precaution Adoption Process Model
PMT	Protection Motivation Theory

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL

Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaoil a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaoil a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gclóíonn leis na córais sin.

Eolas: Soláthraimid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírthe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.

Tacaíocht: Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaoil atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaoil inbhuanaithe.

Ár bhFreagrachtaí

Ceadúnú

Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaoil:

- saoráidí dramhaíola (*m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistriúcháin dramhaíola*);
- gníomhaíochtaí tionsclaíoch ar scála mór (*m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta*);
- an diantalmhaíocht (*m.sh. muca, éanlaith*);
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe (*OGM*);
- foinsí radaíochta ianúcháin (*m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíoch*);
- áiseanna móra stórála peitрил;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce poiblí, a mhaoirsiú.
 - Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhírú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúcháin.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídionn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaoil.

Bainistíocht Uisce

- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uisce idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéal uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaoil

- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil (*m.sh. tuairisciú tréimhsiúil ar staid Chomhshaoil na hÉireann agus Tuarascálacha ar Tháscairí*).

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn

- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil

- Taighde comhshaoil a chistiú chun brúnna a shainnaint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeraíde, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta

- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaoil in Éirinn (*m.sh. mórphleananna forbartha*).

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a forbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar forbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas

- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaoil ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaoil (*m.sh. Timpeall an Tí, léarscáileanna radóin*).
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a forbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta

- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:

- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- An Oifig um Cosaint Raideolaíoch
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair inní agus le comhairle a chur ar an mBord.

Review of Public Information Programmes to Enhance Home Radon Screening Uptake and Home Remediation

Author: David Hevey

Background

Radon is a naturally occurring radioactive gas. It has no taste, colour or smell. It is formed in the ground by the radioactive decay of uranium which is present in all rocks and soils. The World Health Organisation has categorised radon as a carcinogen, in the same group as asbestos and tobacco smoke.

Identifying Pressures

In Ireland, radon is the second cause of lung cancer (after smoking) and is linked to up to 250 cases per year. It is estimated that 7% of homes exceed the reference level of 200 Bq/m³ and about one third of the country is categorised as high risk.

The EPA has a remit to raise awareness about radon in high risk areas and to encourage homeowners to test and, where necessary, remediate their homes. To this end the EPA has carried out regular awareness campaigns in priority counties. The Government's National Radon Control Strategy endorses the continuation of awareness campaigns in high risk areas. This study has reviewed the literature on the effectiveness of local awareness campaigns regarding home radon testing uptake and home remediation rates in the context of psychological theories of risk perception and preventative behaviours.

Informing Policy

Findings from this study indicate that the EPA programmes reflect international best practice guidelines regarding the content and process of delivering large-scale community-based multimedia programmes; the effects reported are comparable to those reported elsewhere in the literature.

The study identifies the main barriers to higher testing and remediation rates, specifically:

- The role of the state versus the individual in radon management
- Making radon risk and its management visible
- The benefits of matching interventions to the individual's stage of decision-making regarding testing and remediation.

The study also emphasises the limits of what can be achieved by mass-media community information programmes.

Developing Solutions

This study recommends that the following may enhance radon testing and remediation rates:

- Segmenting the message to target different sectors of the population
- Shifting responsibility solely from the householder and bringing in more government regulation and
- Combining regulation with high-quality information programmes targeted to the different sectors of the population.

