A cost-effectiveness analysis of radon protection methods in domestic properties: a comparative case study in Brixworth, Northamptonshire, UK
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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The study compared two regimes for the protection against radon. The first regime involved the installation of radon-proof membranes and sumps in all properties, if 3% or more of existing properties in a geographical area were above the "Action Level" (defined as 200 Becquerels per cubic metre, Bq/m3). The alternative strategy consisted of a series of steps. First, construct all new properties without protection against radon. After construction, test all properties for radon using National Radiological Protection Board (NRPB) protocols. Then protect properties above the Action Level by installing a sump and fan. Finally, monitor the level of radon in these properties to ensure that they are below the Action Level and do not necessitate additional remediation.

Type of intervention
Primary prevention (building regulations for protection from radon radiation).

Economic study type
Cost-utility analysis.

Study population
The study population comprised properties built since 1992 in Brixworth (Northamptonshire, UK) that were protected against radon with membranes and sumps installed during construction. No further inclusion or exclusion criteria were reported.

Setting
The setting was the community. The economic study was carried out in Brixworth, Northamptonshire, UK.

Dates to which data relate
The demographic data were taken from official sources published in 2001 (UK Population Census). The effectiveness data were derived from studies published between 1998 and 2005. Related dates on costs that were derived from actual data were not reported. Some costs were derived from sources published in 2002. The price year was 2004.

Source of effectiveness data
The effectiveness data were derived from a review and synthesis of published studies, augmented by authors' assumptions.

Outcomes assessed in the review
The outcomes assessed were:

the number of properties necessitating remediation (having hypothetical readings above the Action Level);
the distribution of radon levels in the properties;
the log mean and log standard deviation (i.e. arithmetic and geometric means) of radiation levels in properties that had been measured within the postcode sector NN6 9;
the effectiveness of remediation programmes (reduction of radon levels due to sumps and fans);
the reduction in exposure to radon and radiation due to the protective strategies;
the number of estimated lung cancers averted;
the average occupancy of the properties (in hours); and
the number of residents per household.

Study designs and other criteria for inclusion in the review
Not reported.

Sources searched to identify primary studies
Not reported.

Criteria used to ensure the validity of primary studies
Not reported.

Methods used to judge relevance and validity, and for extracting data
The authors do not appear to have assessed the validity of the primary studies.

Number of primary studies included
Overall, the authors used 6 primary studies as sources of the effectiveness estimates.

Methods of combining primary studies
Not reported.

Investigation of differences between primary studies
The authors do not appear to have investigated differences between the primary studies.

Results of the review
The number of properties necessitating remediation was 10.

The arithmetic and geometric mean of radiation levels in properties with the postcode sector NN6 9 were 117 Bq/m³ and 59 Bq/m³, respectively.

The total reduction in exposure was 1,299 Bq/m³ under the current regime (membranes and sumps) and 3,357 Bq/m³ under the alternative regime (test and remediate).

The total reduction in annual dose in all households was 174.43 millisievert under the current regime and 450.80 millisievert under the alternative regime.
The number of lung cancers averted was 0.00611 per year and 0.224 over 40 years with the current regime, and 0.0158 per year and 0.631 over 40 years with the alternative regime.

The average reduction in radon levels due to the installation of sumps and fans was 80.3%.

The average occupancy was 17.28 hours and the number of residents per household was 2.69.

**Methods used to derive estimates of effectiveness**
The authors made assumptions to derive some estimates of effectiveness.

**Estimates of effectiveness and key assumptions**
In order to conduct a comparison, hypothetical readings of radon levels in Brixworth properties without protection against radon were necessary. The estimation procedure used was as follows. Based on the literature, a log-normal distribution of radon levels in the properties was assumed. Based on published log mean and log standard deviation of radiation levels in the properties in the same area, the authors generated a random log-normal distribution of 65 observations (properties in the Brixworth area). The random distribution was re-calculated 1,000 times, and the 65 values generated in each of the random distributions were used to derive a mean for the 65 properties. Individuals were assumed to live up to 40 years after the installation of protective measures.

**Measure of benefits used in the economic analysis**
Health utility (quality-adjusted life-years, QALYs) was the measure of benefit in the economic analysis. To estimate quality of life for residents in the sample with no protective regime, mean utility scores by age group for England’s population (derived using the EuroQol EQ-5D questionnaire, were taken from the Department of Health. Utility scores for patients with lung cancer were taken from the literature. The valuation tool employed was the EuroQol EQ-5D scale. The authors preferred data that used patients’ values rather than professionals’ values. Owing to the lack of available data on health utility, it was reported that only lung cancers averted were considered when estimating changes in QALYs due to protection methods; all other health benefits (e.g. cases of asthma averted) were assumed to be equal in both policies. Further benefits, not combined with costs, were life-years gained and number of cases of lung cancer averted. Cases of skin cancer averted were omitted from the analysis.

**Direct costs**
Intervention costs were included in the analysis. These covered the costs of installing membranes and sumps, testing each property, annual operation of fans and fan replacement every 10 years, and the actual remediation costs per property. The costs and the quantities were reported separately. The costs and resources used were derived from published sources from different dates, but there appear to have been no adjustments for inflation. It was also reported that the actual remediation costs per property were not available for the sample used and that these were based on authors’ assumptions. As the time horizon was more than 2 years, the costs were appropriately discounted. All costs were reported for the price year 2004.

**Statistical analysis of costs**
The costs were treated deterministically.

**Indirect Costs**
The indirect costs were not included in the analysis.

**Currency**
UK pounds sterling (£).
Sensitivity analysis
To investigate the robustness of the results to variability in the data, a one-way sensitivity analysis was conducted on the key assumptions. The parameters tested were the number of residents per household, average occupancy, the period over which the QALYs were spread, arithmetic and geometric mean of radon levels that were used to derive the random distribution, discount rate, utility of patients with lung cancer, percentage reduction in radiation after remediation, and the average cost of remediation. Apart from the number of residents, the method used to select the ranges for sensitivity analysis was not reported. The authors estimated percentage changes in cost per QALY gained for both regimes as a result of variability in the data. Finally, the authors conducted multi-way sensitivity analyses by applying worst-case and best-case assumptions to all parameters reported in one-way sensitivity analyses for both regimes.

Estimated benefits used in the economic analysis
Mean benefits were reported for the Brixworth area (65 properties) and the time horizon for health utility gains was 40 years. Hence, the estimated benefits were appropriately discounted.

In the no radon protection arm, the total QALYs were 5,960.99 for the whole sample. Over the same time horizon, the total QALYs were 5,966.46 in the current regime and 5,975.16 in the alternative regime.

The current regime resulted in 5.48 QALYs gained and the alternative regime in 14.17 QALYs gained.

Based on the assumption that there were 13.51 life-years gained for each case of lung cancer averted, the current regime resulted in 3.299 life-years gained over the 40 years and the alternative regime in 8.526 life-years gained.

Cost results
The total cost for the implementation of the alternative policy in Brixworth (65 properties) was 24,208.

The total cost of installing membranes and sumps in the 65 properties in Brixworth (current policy) was 20,150.

Synthesis of costs and benefits
The cost per QALY gained was reported for the two policies.

The current regime resulted in a cost of 6,182 per QALY gained and the alternative regime resulted in a cost of 2,869 per QALY gained.

The sensitivity analyses demonstrated that the results were most sensitive to changes in utility of lung cancer.

Analyses of percentage changes demonstrated that the estimated cost per QALY gained in the alternative regime was subject to greater percentage changes, compared with the current regime, when the arithmetic and geometric mean used to estimate the random sample and the discount rate were varied.

The worst-case scenario analysis resulted in a cost of 56,531 per QALY gained for the current regime and 36,650 per QALY gained for the alternative regime.

The best-case scenario resulted in a cost of 1,893 per QALY gained in the current regime and 892 per QALY gained in the alternative regime.

Authors' conclusions
The alternative regime "is more cost-effective for a sample of properties in Brixworth, Northamptonshire, UK".

CRD COMMENTARY - Selection of comparators
The installation of membranes and sumps in all properties located in areas where more than 3% of the properties are...
above the Action Level seems to represent current practice in the authors' setting. The choice of the comparator used (i.e. the alternative regulatory regime) was explicitly justified and details of the comparator used were reported. However, the existence of further alternative policies was not discussed. If there are any, which is likely, it would mean that this study was only a partial analysis.

**Validity of estimate of measure of effectiveness**
A systematic review of the literature was not undertaken. The data from available studies were used selectively and the validity of the primary studies was not assessed. The methods used to derive measures of benefit were reported, but it would appear that the authors did not adopt a weighting scheme to adjust for differences in sample size. In addition, they did not investigate differences between the primary studies. Some estimates of effectiveness were based on authors' calculations. The methods used to derive these estimates were reported and were referenced to published literature.

**Validity of estimate of measure of benefit**
The authors used health utility (QALYs) as the measure of benefit in the economic analysis. The utility estimates were taken from the literature and were based on patients' values. The valuation method was the EQ-5D. However, the health benefits and related health utility due to protection against radon were restricted to cases of lung cancer averted, which might have resulted in an underestimation.

**Validity of estimate of costs**
Although the perspective adopted in the economic analysis was not explicitly reported, it was not societal as no indirect costs were included. Only intervention costs were included in the analysis; as summary costs were reported for each category, it was not explicit whether some categories of costs (e.g. labour costs) were included. Inspection costs in the current regime were also omitted, although their inclusion would have strengthened the study findings. As the analysis did not include the cost of formal care (e.g. the cost of treating lung cancer cases), the cost-effectiveness of the intervention might have been underestimated. Most of the costs estimates were taken from published sources. The authors' assumption about the actual remediation cost per property was explicitly justified. Authors' assumptions were also investigated in sensitivity analyses. The costs were treated deterministically and the robustness of cost estimates from published sources, or quantities of resources used, were not investigated in sensitivity analyses. This may limit the interpretation of the study findings. The costs were not adjusted for inflation, but discounting and the price year were appropriately reported.

**Other issues**
The authors did not compare their results with those from other studies, but this might have been due to a lack of studies in the same area. The authors discussed the issue of the generalisability of the results and possible limitations. The study involved properties from an area characterised as a Radon Affected Area and this was reflected in the authors' conclusions. The authors reported a number of limitations to their study. For example, most of the estimates on radon levels for pre- and post-remediation were imputed, which might have introduced some uncertainty. In addition, readings of radon levels in occupied properties were not accounted for in the analysis because of relevant measurement constraints.

**Implications of the study**
The authors did not make explicit recommendations for changes in policy or practice. However, they recommended that future research should investigate the occupancy effect on radon levels and the cost-effectiveness of alternative protective policies. The latter should be done by conducting pilot studies in new housing developments in Radon Affected Areas that will account for the effect of householders' non-compliance with and their inconvenience from each policy, as well as the impact of stricter building inspection on improving membrane installation.

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