National Institute for Health and Care Excellence

FINAL

Indoor air quality at home

[A] Evidence reviews for indoor air quality at home: Cost effectiveness outcomes

NICE guideline NG149

Evidence reviews

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Final

These evidence reviews were developed by York Health Economics Consortium

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Review question 1 - what individual or building factors are associated with increased exposure to poor indoor air quality at home?

Introduction

People spend up to 90% of their lives indoors and 60% of that time at home. To minimize the health risks from pollutants occurring in homes, exposures to these pollutants should be controlled.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

Economic evidence

No published economic evidence was considered for this review as the RQ is not addressed by economic outcomes.

Economic model

See economic modelling report by York Health Economic Consortium.

Evidence statements

No economic evidence was considered for this review as the RQ is not addressed by economic outcomes.

Signs, and symptoms and referral by health and social care professionals (RQ 2)

Review question

Review question 2 - What signs and symptoms should prompt healthcare professionals to consider exposure to poor indoor air quality at home in people presenting to health services?

Introduction

People spend up to 90% of their lives indoors and 60% of that time at home. To minimize the health risks from pollutants occurring in homes, exposures to these pollutants should be controlled.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

Economic evidence

No published economic evidence was considered for this review as the RQ is not addressed by economic outcomes.

Economic model

See economic modelling report by York Health Economic Consortium.

Evidence statements

No economic evidence was considered for this review as the RQ is not addressed by economic outcomes.

Material and structural interventions (RQ 3.1)

Review question

Review question 3.1 - what are the effective material and structural interventions to prevent or reduce the health impacts of poor indoor air quality at home?

Introduction

People spend up to 90% of their lives indoors and 60% of that time at home. Exposure to indoor air pollutants including nitrogen dioxide (NO^2), carbon monoxide (CO), particulate matter (PM), biological agents and volatile organic compounds (VOCs) is widespread. These pollutants are associated with respiratory and other diseases and premature death.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

Economic evidence

Included studies

9,555 records were assessed against the eligibility criteria.

9,488 records were excluded based on information in the title and abstract, mostly due to ineligible outcomes, study design, population or setting. One reviewer assessed all of the records and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 100%.

The full-text papers of 67 studies were retrieved and assessed and five studies were assessed as meeting the eligibility criteria for research question 3.1. One reviewer assessed all of the full texts and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 85.7%. The reviewers initially disagreed about one record, but this disagreement was resolved between the two reviewers through discussion

Five economic studies were eligible [1-3][5-6]. These are summarised in the health economic evidence profile in appendix I and the health economic evidence tables below in Table 1 and in appendix H.

Excluded studies

62 full text studies were excluded for this question. The studies and the reasons for their exclusion are listed in Appendix K – Excluded studies. Studies were excluded for the following reasons: ineligible outcomes (n=22), ineligible study design (n=18), ineligible patient population (n=11), ineligible setting (n=7), ineligible intervention (n=2), ineligible country (n=1), non-English language (n=1). The selection process is shown in Appendix G.

Summary of studies included in the economic evidence review

Table 1: Summary of studies included in the economic evidence review for effective material and structural interventions – RQ 3.1

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
Aldred 2016 (USA) Population: Single family homes in 12 American cities (city based analysis).[a] Interventions: Commercially available activated carbon filters in the heating, ventilation and air conditioning (HVAC) systems of single family homes to reduce indoor ozone levels; Comparator not specified [b]	Potentially serious limitations [c]	Not applicable [d]	None	Not reported	Not reported	Not reported	Median disability-adjusted life-years (DALYs) gained per 100,000 people in homes with activated carbon filters: ranged from approximately 5 in Phoenix to around 1 in Buffalo [e]	Cost benefit ratios were generated based upon a DALY dollar value taken from a distribution (not specified) Ratios had mean values below 1 for all cities (i.e. activated carbon filters were not cost-effective) but median values were between 1 and 2 for all cities.	The model was run using a Monte Carlo simulation which captured stochastic uncertainty. The lower bound ratio generated from model runs were all zero with the upper bounds ranging between 6 and 13 depending on the city. Scenario analysis showed that the benefits of carbon filtration would be highest in homes with efficient HVAC systems and carbon filters, low ozone reactivity and with high occupancy.
Chau 2008 (Hong Kong)	Potentially serious limitations [h]	Not applicable [i]	None	Not reported	Not reported	Not reported	Not reported	Benefit to cost ratio for air cleaning [j]	Sensitivity analysis explored the impact of changing the

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
Population: Adults (15-64) and elderly people (>64) living in residential apartments in Hong Kong. [f] Interventions: Air cleaners to remove ambient particulate matter (PM_{10}); Comparator was spending 1 hour or 4 hours more/less time at home [g]								Adults: always below one (i.e. air cleaning is not cost-effective) except for if the air cleaner is used with windows closed only in cool season. Older people: above one the whole year provided windows are closed.	thermal comfort days over 5 years on the health benefits from air cleaning. This was not as important as the number of days windows were open.
Edwards 2011 (UK) Population: Children aged 5-14 with moderate or severe asthma in Wrexham. [k] Interventions: Ventilation systems fitted into the roof space of houses [l]; Comparator was delayed-	Minor limitations [m]	Directly applicable [n]	None	Intervention: £2,217 per person (including £1,718 cost of delivering the intervention) Control: £560 per person [o]	Not reported	Intervention was £1,657 more costly than the control	Mean improvement with intervention: 7.07 PedsQL points Severe asthma: 9.67 points Moderate asthma: 4.56 points	Intervention ICER: £234 per unit change (1 point improvement) in PedsQL Severe asthma: £165 per unit change Moderate asthma: £379 per unit change	The results were constructed by bootstrapping RCT results. For children with moderate or severe asthma, there is a 97.5% chance that the intervention is cost-effective at a value of a PedsQL point of £590.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
intervention ("Control"), who received the housing modification after the end of the trial								Cost of moving a child from the severe to moderate group with the intervention was £12,300 per child	Scenario analysis suggested that the ICER for the intervention in London would be £294 per PedsQL point and in Northern Ireland £166 per point.
Kattan 2005 (USA) Population: Children aged 5-11 with asthma and positive skin test to an indoor allergen in seven urban locations across the USA. [p] Interventions: Environmental Counsellors (EC) delivering 6 environmental modules to families with one child that had asthma that focused on remediation of exposure to dust mites, passive	Minor limitations [r]	Partially applicable [s]	None	Intervention: $4,704 per person (health costs plus intervention costs of $1,472 per child) Control: $3,662 per person (health costs only) [t]	Symptom free days (SFDs) over two years Intervention group: 566.6 Control group: 528.8	Intervention was $1,042 more costly than control	Intervention generated 27.8 more SFDs vs control, over two years	Intervention ICER: $27.57 per SFD gained	The ICER was generated by bootstrapping. 100% of iterations had an ICER below $100 per SFD. Scenario analysis of the number of unscheduled visits and symptom days before the intervention showed that these variables did not significantly change the ICER.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
smoking, cockroaches, pets, rodents, and mould [q]; No intervention ("Control") - families in the control group received visits only for evaluation at six-month intervals									
Turcotte 2014 (USA) Population: Families with at least one child aged under 15 with asthma in Massachusetts USA. Interventions: "Healthy Homes": A health and environmental assessment involving environmental assessor and home health assessment workers covering	Potentially serious limitations [v]	Partially applicable [w]	None	Intervention costs: $192 per child with a decrease in 4 week urgent care costs of $419 per child.	Not reported	Not reported	Not reported	The cost benefit analysis indicated that there could be annual urgent healthcare savings of $5,053 per child from the intervention compared to a cost of $192 per child	No uncertainty analysis was conducted

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
education and home modifications to identify and address asthma triggers in the home. On the back of the assessment a plan was developed delivered over 4-9 visits over a 12 month period. [u]									

CBA: cost-benefit analysis; CHW: community health worker; DALY: disability-adjusted life-year; EC: environmental counsellors; HVAC: heating, ventilation and air conditioning; ICER: incremental cost-effectiveness ratio; PM: particulate matter; SFD: symptom free day

(a) City specific age distributions were used but no detail was provided on the population modelled.
(b) Implicitly the comparator is HVAC without carbon filtration
(c) The study did not report unit costs, did not include healthcare costs and had no real world data about the effectiveness of the intervention.
(d) The study was based on a technology that is not widely used in the UK nor is likely to be. The perspective is unclear. It does not consider healthcare costs.
(e) Data read from a graph.
(f) No detail was provided on the modelled population.
(g) Outside if elderly, in an office if an adult.
(h) The study did not report unit costs, did not consider the costs of the intervention and had no real world data about the effectiveness of the intervention.
(i) The study was based on climactic factors in a country very different to the UK. It did not consider intervention costs.
(j) No costs were assumed for behavioural change and as a result, no cost benefit ratios were produced for this intervention.
(k) Intervention group: mean age 9.59 years, 44% female. Control group: mean age 9.57 years, 45% female (taken from the primary trial publication).
(l) Improvements were also made to bring central heating systems to a defined standard, including installing new systems if required.
(m) The time horizon was only 12 months and so may not capture the full benefits of the intervention.
(n) No applicability issues
(o) Costs included in the analysis were primary care visits and consultations, primary care prescribing, NHS secondary care attendances and the cost of the intervention to the local authority, including housing adaptations.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty

(p) Intervention group: mean age 7.6 years, 36.9% female. Control: mean age 7.7 years, 37.8% female (main trial publication).

(q) The modules were tailored to the environmental risk and allergen skin test sensitivity of each child and included both education and demonstration of remediation techniques. The ECs made a median of 5 home visits over the 12-month period. All subjects in the intervention were given dust mite remediation strategies and were provided with impermeable mattress and pillow covers. Families of children exposed to environmental tobacco smoke were given high-efficiency particulate air (HEPA) filters and education regarding reduction of exposure. The intervention was in the first year of the study with follow up in the second year.

(r) The time horizon was only 2 years and so may not capture the full benefits of the intervention. Unit costs were not fully reported.

(s) The study was based in the USA where different costs may limit generalisability. The perspective is unclear. The cost sources are not fully clear.

(t) Costs included in the analysis were scheduled and unscheduled clinic visits, emergency department visits, inpatient stays and asthma medications and intervention costs.

(u) The plan could include integrated pest management, commercial cleaning, providing healthy home cleaning equipment and supplies (e.g., vacuums with high-efficiency particulate absorption filters, green cleaning chemicals), education, and, in some cases, structural interventions. 6 months after the initial home assessment and at least 1 month after completing the intervention a brief reassessment was undertaken to reinforce the healthy homes education and replenish supplies as needed.

(v) This was a pre-post observational study and did not undertake sensitivity analysis.

(w) This study was based in the USA where different costs may limit generalisability. The perspective is unclear. The source of costs for the intervention is unclear.

Economic model

See economic modelling report by York Health Economic Consortium.

Evidence statements

- One modelling study (Aldred 2016) in the USA assessed the costs and benefits of activated carbon filters in home air conditioning systems that reduce indoor ozone levels. The median predicted cost benefit ratios were between 1 and 2 for the 12 cities studied. The intervention was likely to be cost-effective when DALYs saved were considered. Scenario analysis showed that the benefits of carbon filtration would be highest in homes with efficient heating ventilation and air conditioning systems and carbon filters, low ozone reactivity and with high occupancy. This analysis was assessed to be not applicable to the study question with potentially serious limitations.
- One modelling study (Chau 2008) in Hong Kong assessed the health benefit gains from air cleaners to remove ambient particulate matter and from encouraging adults and older people (>64 years) to spend more or less time out of the house. The benefit to cost ratio for air cleaning was always below 1 for adults (i.e. not cost-effective) except if the air cleaner was used with windows closed, only in the cool season; and above 1 for older people the whole year provided windows are closed. Encouraging adults to spend more time out of the house and older people to spend more time in the house, was likely to be cost-effective. This analysis was assessed to be not applicable to the study question with potentially serious limitations.
- One cost-effectiveness analysis based upon an RCT (Edwards 2011) from the UK reported that fitting ventilation systems into roof spaces of homes with children with asthma would incur costs but would potentially be cost-effective. This study contains data relevant to the subgroups of interest. This analysis was assessed to be directly applicable to the study question with only minor limitations.
- One cost-effectiveness analysis based upon an RCT (Katton 2005) from the USA reported that educational and home modification interventions in homes with children with asthma would incur costs but would possibly be cost effective in terms of the cost per symptom free day. This study contains data relevant to the subgroups of interest. This analysis was assessed to be partially applicable to the study question with only minor limitations.
- One cost consequences and cost benefit analysis (Turcotte 2014) based upon an observational study from the USA reported that educational and home modification interventions in homes with children with asthma would be cost saving after 12 months due to reductions in the need for urgent care. In addition, there would be significant improvements in measurements of asthma quality of life. This study contains data relevant to the subgroups of interest. This analysis was assessed to be partially applicable to the study question with potentially serious limitations.

Occupant behaviour interventions (RQ 3.2)

Review question

Review question 3.2 - what are the effective occupant behaviour interventions to reduce or prevent the health impacts of poor indoor air quality at home?

Introduction

People spend up to 90% of their lives indoors and 60% of that time at home. Exposure to indoor air pollutants including nitrogen dioxide (NO2), carbon monoxide (CO), particulate matter (PM), biological agents and volatile organic compounds (VOCs) is widespread. These pollutants are associated with respiratory and other diseases and premature death.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

Economic evidence

Included studies

9,555 records were assessed against the eligibility criteria.

9,488 records were excluded based on information in the title and abstract, mostly due to ineligible outcomes, study design, population or setting. One reviewer assessed all of the records and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 100%.

The full-text papers of 67 studies were retrieved and assessed and three studies were assessed as meeting the eligibility criteria for research question 3.2. One reviewer assessed all of the full texts and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 85.7%. The reviewers initially disagreed about one record, but this disagreement was resolved between the two reviewers through discussion

Three economic studies were eligible [3, 4, 6]. These are summarised in the health economic evidence profile in appendix I and the health economic evidence tables below in Table 2 and in appendix H.

Excluded studies

64 full text studies were excluded for this question. The studies and the reasons for their exclusion are listed in Appendix K – Excluded studies. Studies were excluded for the following reasons: ineligible outcomes (n=24), ineligible study design (n=18), ineligible patient population (n=11), ineligible setting (n=7), ineligible intervention (n=2), ineligible country (n=1), non-English language (n=1). The selection process is shown in Appendix G.

Summary of studies included in the economic evidence review

Table 2: Summary of studies included in the economic evidence review for occupant behaviour interventions – RQ 3.2

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
Kattan 2005 (USA) Population: Children aged 5-11 with asthma and positive skin test to an indoor allergen in seven urban locations across the USA. [a] Interventions: Environmental Counsellors (EC) delivering 6 environmental modules to families with one child that had asthma that focused on remediation of exposure to dust mites, passive smoking,	Minor limitations [c]	Partially applicable [d]	None	Intervention: $4,704 per person (health costs plus intervention costs of $1,472 per child) Control: $3,662 per person (health costs only)[e]	Symptom free days (SFDs) over two years Intervention group: 566.6 Control group: 528.8	Intervention was $1,042 more costly than control	Intervention generated 27.8 more SFDs vs control, over two years	Intervention ICER: $27.57 per SFD gained	The ICER was generated by bootstrapping. 100% of iterations had an ICER below $100 per SFD. Scenario analysis of the number of unscheduled visits and symptom days before the intervention showed that these variables did not significantly change the ICER.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
cockroaches, pets, rodents, and mould [b]; No intervention ("Control") - families in the control group received visits only for evaluation at six-month intervals									
Krieger 2005 (USA) Population: Children aged 4-12 with persistent asthma in low income households in Seattle USA. [f] Interventions: "High Intensity" support: 1-year-long intervention provided by community health workers (CHWs) [g]; "Low-intensity" support: a	Potentially serious limitations [i]	Partially applicable [j]	None	Not reported	Not reported	Marginal cost of high intensity intervention: $1,124 per child with savings of between $57 and $80 every two months on urgent care costs	Not reported	Estimated total savings over 4 years: $1,316 to $1,849	No uncertainty analysis was conducted

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
single CHW visit [h]									
Turcotte 2014 (USA) Population: Families with at least one child aged under 15 with asthma in Massachusetts USA. Interventions: "Healthy Homes": A health and environmental assessment involving environmental assessor and home health assessment workers covering education and home modifications to identify and address asthma triggers in the home. On the	Potentially serious limitations [l]	Partially applicable [m]	None	Intervention costs: $192 per child with a decrease in 4 week urgent care costs of $419 per child.	Not reported	Not reported	Not reported	The cost benefit analysis indicated that there could be annual urgent healthcare savings of $5,053 per child from the intervention compared to a cost of $192 per child	No uncertainty analysis was conducted

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
back of the assessment a plan was developed delivered over 4-9 visits over a 12 month period. [k]									

CBA: cost-benefit analysis; CHW: community health worker; DALY: disability-adjusted life-year; EC: environmental counsellors; HVAC: heating, ventilation and air conditioning; ICER: incremental cost-effectiveness ratio; PM: particulate matter; SFD: symptom free day

(a) Intervention group: mean age 7.6 years, 36.9% female. Control: mean age 7.7 years, 37.8% female (main trial publication).

(b) The modules were tailored to the environmental risk and allergen skin test sensitivity of each child and included both education and demonstration of remediation techniques. The ECs made a median of 5 home visits over the 12-month period. All subjects in the intervention were given dust mite remediation strategies and were provided with impermeable mattress and pillow covers. Families of children exposed to environmental tobacco smoke were given high-efficiency particulate air (HEPA) filters and education regarding reduction of exposure. The intervention was in the first year of the study with follow up in the second year.

(c) The time horizon was only 2 years and so may not capture the full benefits of the intervention. Unit costs were not fully reported.

(d) The study was based in the USA where different costs may limit generalisability. The perspective is unclear. The cost sources are not fully clear.

(e) Costs included in the analysis were scheduled and unscheduled clinic visits, emergency department visits, inpatient stays and asthma medications and intervention costs.

(f) Asthma severity: 63.8% moderate or severe in intervention group. Age: high intensity intervention: mean age 7.4 years, 44.2% female. Low intensity intervention: mean age 7.3 years, 38.2% female.

(g) High-intensity support: CHWs conducted a structured home environmental assessment at the first visit. Each assessment finding generated specific actions for the participant and CHW: these formed an action plan. The CHW made 4 to 8 additional visits to encourage completion of the action plan, provide education and social support. Resources were provided to reduce exposures (allergy control pillow and mattress encasements, low-emission vacuums, commercial-quality door mats, cleaning kits, referral to smoking cessation counselling, roach bait, rodent traps).

(h) Low intensity support: the home environmental assessment, an action plan, limited education, and bedding encasements

(i) The study only considered use of urgent healthcare and did not undertake sensitivity analysis.

(j) The study was based in the USA where different costs may limit generalisability. The perspective is unclear. Only urgent healthcare costs were considered.

(k) The plan could include integrated pest management, commercial cleaning, providing healthy home cleaning equipment and supplies (e.g., vacuums with high-efficiency particulate absorption filters, green cleaning chemicals), education, and, in some cases, structural interventions. 6 months after the initial home assessment and at least 1 month after completing the intervention a brief reassessment was undertaken to reinforce the healthy homes education and replenish supplies as needed.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty

(l) This was a pre-post observational study and did not undertake sensitivity analysis.
(m) This study was based in the USA where different costs may limit generalisability. The perspective is unclear. The source of costs for the intervention is unclear.

Economic model

See economic modelling report by York Health Economic Consortium.

Evidence statements

- One cost-effectiveness analysis based upon an RCT (Katton 2005) from the USA reported that educational and home modification interventions in homes with children with asthma would incur costs but would possibly be cost effective in terms of the cost per symptom free day. This study contains data relevant to the subgroups of interest. This analysis was assessed to be partially applicable to the study question with only minor limitations.
- One cost benefit analysis (Krieger 2005) based upon an RCT from the USA reported that educational and home modification interventions in homes with children with asthma would incur costs n the short term but may be cost saving after 12 months. This study contains data relevant to the subgroups of interest. This analysis was assessed to be partially applicable to the study question with potentially serious limitations.
- One cost consequences and cost benefit analysis (Turcotte 2014) based upon an observational study from the USA reported that educational and home modification interventions in homes with children with asthma would be cost saving after 12 months due to reductions in the need for urgent care. In addition, there would be significant improvements in measurements of asthma quality of life. This study contains data relevant to the subgroups of interest. This analysis was assessed to be partially applicable to the study question with potentially serious limitations.

Ventilation in homes whilst maintaining adequate energy and thermal performance (RQ 3.3)

Review question

Review question 3.3 - how can ventilation in homes be designed or used to prevent or reduce the health impacts of poor indoor air quality whilst maintaining adequate energy and thermal performance?

Introduction

People spend up to 90% of their lives indoors and 60% of that time at home. Exposure to indoor air pollutants including nitrogen dioxide (NO2), carbon monoxide (CO), particulate matter (PM), biological agents and volatile organic compounds (VOCs) is widespread. These pollutants are associated with respiratory and other diseases and premature death. There are competing needs for increased ventilation, adequate heating, sufficient indoor environmental quality and the drive for energy efficiency.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

Economic evidence

Included studies

9,555 records were assessed against the eligibility criteria.

9,488 records were excluded based on information in the title and abstract, mostly due to ineligible outcomes, study design, population or setting. One reviewer assessed all of the records and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 100%.

The full-text papers of 67 studies were retrieved and assessed and six studies were assessed as meeting the eligibility criteria for research question 3.3. One reviewer assessed all of the full texts and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 85.7%. The reviewers initially disagreed about one record but this was resolved between the two reviewers through discussion

Three economic studies were eligible [1, 2, 5]. These are summarised in the health economic evidence profile in appendix I and the health economic evidence tables below in Table 3 and in appendix H.

Excluded studies

64 full text studies were excluded for this question. The studies and the reasons for their exclusion are listed in Appendix K – Excluded studies. Studies were excluded for the following reasons: ineligible outcomes (n=24), ineligible study design (n=18), ineligible

patient population (n=11), ineligible setting (n=7), ineligible intervention (n=2), ineligible country (n=1), non-English language (n=1). The selection process is shown in Appendix G.

Summary of studies included in the economic evidence review

Table 3: Summary of studies included in the economic evidence review for ventilation in homes whilst maintaining adequate energy and thermal performance – RQ 3.3

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
Aldred 2016 (USA) Population: Single family homes in 12 American cities (city based analysis).[a] Interventions: Commercially available activated carbon filters in the heating, ventilation and air conditioning (HVAC) systems of single family homes to reduce indoor ozone levels; Comparator not specified [b]	Potentially serious limitations [c]	Not applicable [d]	None	Not reported	Not reported	Not reported	Median disability-adjusted life-years (DALYs) gained per 100,000 people in homes with activated carbon filters: ranged from approximately 5 in Phoenix to around 1 in Buffalo [e]	Cost benefit ratios were generated based upon a DALY dollar value taken from a distribution (not specified). Ratios had mean values below 1 for all cities (i.e. activated carbon filters were not cost-effective) but median values were between 1 and 2 for all cities.	The model was run using a Monte Carlo simulation which captured stochastic uncertainty. The lower bound ratio generated from model runs were all zero with the upper bounds ranging between 6 and 13 depending on the city. Scenario analysis showed that the benefits of carbon filtration would be highest in homes with efficient HVAC systems and carbon filters, low ozone reactivity and with high occupancy.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
Chau 2008 (Hong Kong) Population: Adults (15-64) and elderly people (>64) living in residential apartments in Hong Kong. [f] Interventions: Air cleaners to remove ambient particulate matter (PM_{10}); Comparator was spending 1 hour or 4 hours more/less time at home [g]	Potentially serious limitations [h]	Not applicable [i]	None	Not reported	Not reported	Not reported	Not reported	Benefit to cost ratio for air cleaning [j] Adults: always below one (i.e. air cleaning is not cost-effective) except for if the air cleaner is used with windows closed only in cool season. Older people: above one the whole year provided windows are closed.	Sensitivity analysis explored the impact of changing the thermal comfort days over 5 years on the health benefits from air cleaning. This was not as important as the number of days windows were open.
Edwards 2011 (UK) Population: Children aged 5-14 with moderate or severe asthma in Wrexham. [k]	Minor limitations [m]	Directly applicable [n]	None	Intervention: £2,217 per person (including £1,718 cost of delivering the intervention)	Not reported	Intervention was £1,657 more costly than the control	Mean improvement with intervention: 7.07 PedsQL points Severe asthma: 9.67 points Moderate	Intervention ICER: £234 per unit change (1 point improvement) in PedsQL Severe asthma: £165 per unit change	The results were constructed by bootstrapping RCT results. For children with moderate or severe asthma, there is a 97.5% chance that the intervention is cost-effective at a

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
Interventions: Ventilation systems fitted into the roof space of houses [l]; Comparator was delayed-intervention ("Control"), who received the housing modification after the end of the trial				Control: £560 per person [o]			asthma: 4.56 points	Moderate asthma: £379 per unit change The cost of moving a child from the severe to moderate group with the intervention was £12,300 per child	value of a PedsQL point of £590. Scenario analysis suggested that the ICER for the intervention in London would be £294 per PedsQL point and in Northern Ireland £166 per point.

CBA: cost-benefit analysis; CHW: community health worker; DALY: disability-adjusted life-year; EC: environmental counsellors; HVAC: heating, ventilation and air conditioning; ICER: incremental cost-effectiveness ratio; PM: particulate matter; SFD: symptom free day

(a) City specific age distributions were used but no detail was provided on the population modelled.
(b) Implicitly the comparator is HVAC without carbon filtration
(c) The study did not report unit costs, did not include healthcare costs and had no real world data about the effectiveness of the intervention.
(d) The study was based on a technology that is not widely used in the UK nor is likely to be. The perspective is unclear. It does not consider healthcare costs.
(e) Data read from a graph.
(f) No detail was provided on the modelled population.
(g) Outside if elderly, in an office if an adult.
(h) The study did not report unit costs, did not consider the costs of the intervention and had no real world data about the effectiveness of the intervention.
(i) The study was based on climactic factors in a country very different to the UK. It did not consider intervention costs.
(j) No costs were assumed for behavioural change and as a result, no cost benefit ratios were produced for this intervention.
(k) Intervention group: mean age 9.59 years, 44% female. Control group: mean age 9.57 years, 45% female (taken from the primary trial publication).
(l) Improvements were also made to bring central heating systems to a defined standard, including installing new systems if required.
(m) The time horizon was only 12 months and so may not capture the full benefits of the intervention.
(n) No applicability issues

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty

(o) Costs included in the analysis were primary care visits and consultations, primary care prescribing, NHS secondary care attendances and the cost of the intervention to the local authority, including housing adaptations.

Economic model

See economic modelling report by York Health Economic Consortium.

Evidence statements

- One modelling study (Aldred 2016) reported that activated carbon filters in home air conditioning systems in the USA were likely to be cost-effective when DALYs saved were considered. This analysis was assessed to be not applicable to the study question with potentially serious limitations.
- One modelling study (Chau 2008) reported that air cleaning devices and encouraging adults to spend more time out of the house and older people to spend more time in the house was likely to be cost-effective in Hong Kong. This analysis was assessed to be not applicable to the study question with potentially serious limitations.
- One cost-effectiveness analysis based upon an RCT (Edwards 2011) from the UK reported that fitting ventilation systems into roof spaces of homes with children with asthma would incur costs but would potentially be cost-effective. This study contains data relevant to the subgroups of interest. This analysis was assessed to be directly applicable to the study question with only minor limitations.

Strategies for raising awareness of the risks of poor indoor air quality at home (RQ 4)

Review question

Review question 4 - what are the effective strategies for raising awareness of the risks of poor indoor air quality at home?

Introduction

People spend up to 90% of their lives indoors and 60% of that time at home. Exposure to indoor air pollutants including nitrogen dioxide (NO2), carbon monoxide (CO), particulate matter (PM), biological agents and volatile organic compounds (VOCs) is widespread. These pollutants are associated with respiratory and other diseases and premature death.

Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in appendix A.

Declarations of interest were recorded according to NICE's 2014 conflicts of interest policy.

Economic evidence

Included studies

9,555 records were assessed against the eligibility criteria.

9,488 records were excluded based on information in the title and abstract, mostly due to ineligible outcomes, study design, population or setting. One reviewer assessed all of the records and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 100%.

The full-text papers of 67 studies were retrieved and assessed and one study was assessed as meeting the eligibility criteria for research question 4. One reviewer assessed all of the full texts and a second reviewer blind-screened 10%. The level of agreement between the two reviewers was 85.7%. The reviewers initially disagreed about one record, but this disagreement was resolved between the two reviewers through discussion.

One economic study was eligible [4]. This is summarised in the health economic evidence profile in appendix I and the health economic evidence tables below in Table 4 and in appendix H.

Excluded studies

66 full text studies were excluded for this question. The studies and the reasons for their exclusion are listed in Appendix K – Excluded studies. Studies were excluded for the following reasons: ineligible outcomes (n=26), ineligible study design (n=18), ineligible patient population (n=11), ineligible setting (n=7), ineligible intervention (n=2), ineligible country (n=1), non-English language (n=1). The selection process is shown in Appendix G.

Summary of studies included in the economic evidence review

Table 4: Summary of the study included in the economic evidence review for raising awareness of the risks of poor indoor air quality at home – RQ 4

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty
Krieger 2005 (USA) Population: Children aged 4-12 with persistent asthma in low income households in Seattle USA. [a] Interventions: "High Intensity" support: 1-year-long intervention provided by community health workers (CHWs) [b]; "Low-intensity" support: a single CHW visit [c]	Potentially serious limitations [d]	Partially applicable [e]	None	Not reported	Not reported	Marginal cost of high intensity intervention: $1,124 per child with savings of between $57 and $80 every two months on urgent care costs	Not reported	Estimated total savings over 4 years: $1,316 to $1,849	No uncertainty analysis was conducted

CHW: community health worker

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Cost-effectiveness	Uncertainty

(a) Asthma severity: 63.8% moderate or severe in intervention group. Age: high intensity intervention: mean age 7.4 years, 44.2% female. Low intensity intervention: mean age 7.3 years, 38.2% female.

(b) High-intensity support: CHWs conducted a structured home environmental assessment at the first visit. Each assessment finding generated specific actions for the participant and CHW: these formed an action plan. The CHW made 4 to 8 additional visits to encourage completion of the action plan, provide education and social support. Resources were provided to reduce exposures (allergy control pillow and mattress encasements, low-emission vacuums, commercial-quality door mats, cleaning kits, referral to smoking cessation counselling, roach bait, rodent traps).

(c) Low intensity support: the home environmental assessment, an action plan, limited education, and bedding encasements

(d) The study only considered use of urgent healthcare and did not undertake sensitivity analysis.

(e) The study was based in the USA where different costs may limit generalisability. The perspective is unclear. Only urgent healthcare costs were considered.

Economic model

See economic modelling report by York Health Economic Consortium.

Evidence statements

- One cost benefit analysis (Krieger 2005) based upon an RCT from the USA reported that educational and home modification interventions in homes with children with asthma would incur costs n the short term but may be cost saving after 12 months. This study contains data relevant to the subgroups of interest. This analysis was assessed to be partially applicable to the study question with potentially serious limitations.

References

Aldred JR, Darling E, Morrison G, Siegel J, Corsi RL. Benefit-cost analysis of commercially available activated carbon filters for indoor ozone removal in single-family homes. Indoor Air. 2016;26(3):501-12.

Chau CK, Hui WK, Tse MS. Valuing the health benefits of improving indoor air quality in residences. Sci Total Environ. 2008;394(1):25-38.

Kattan M, Stearns SC, Crain EF, Stout JW, Gergen PJ, Evans R, 3rd, et al. Cost-effectiveness of a home-based environmental intervention for inner-city children with asthma. J Allergy Clin Immunol. 2005;116(5):1058-63.

Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County Healthy Homes Project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. Am J Public Health. 2005;95(4):652-9.

Edwards RT, Neal RD, Linck P, Bruce N, Mullock L, Nelhans N, et al. Enhancing ventilation in homes of children with asthma: cost-effectiveness study alongside randomised controlled trial. Br J Gen Pract. 2011;61(592):e733-41.

Turcotte DA, Alker H, Chaves E, Gore R, Woskie S. Healthy homes: in-home environmental asthma intervention in a diverse urban community. Am J Public Health. 2014;104(4):665-71.

Appendices

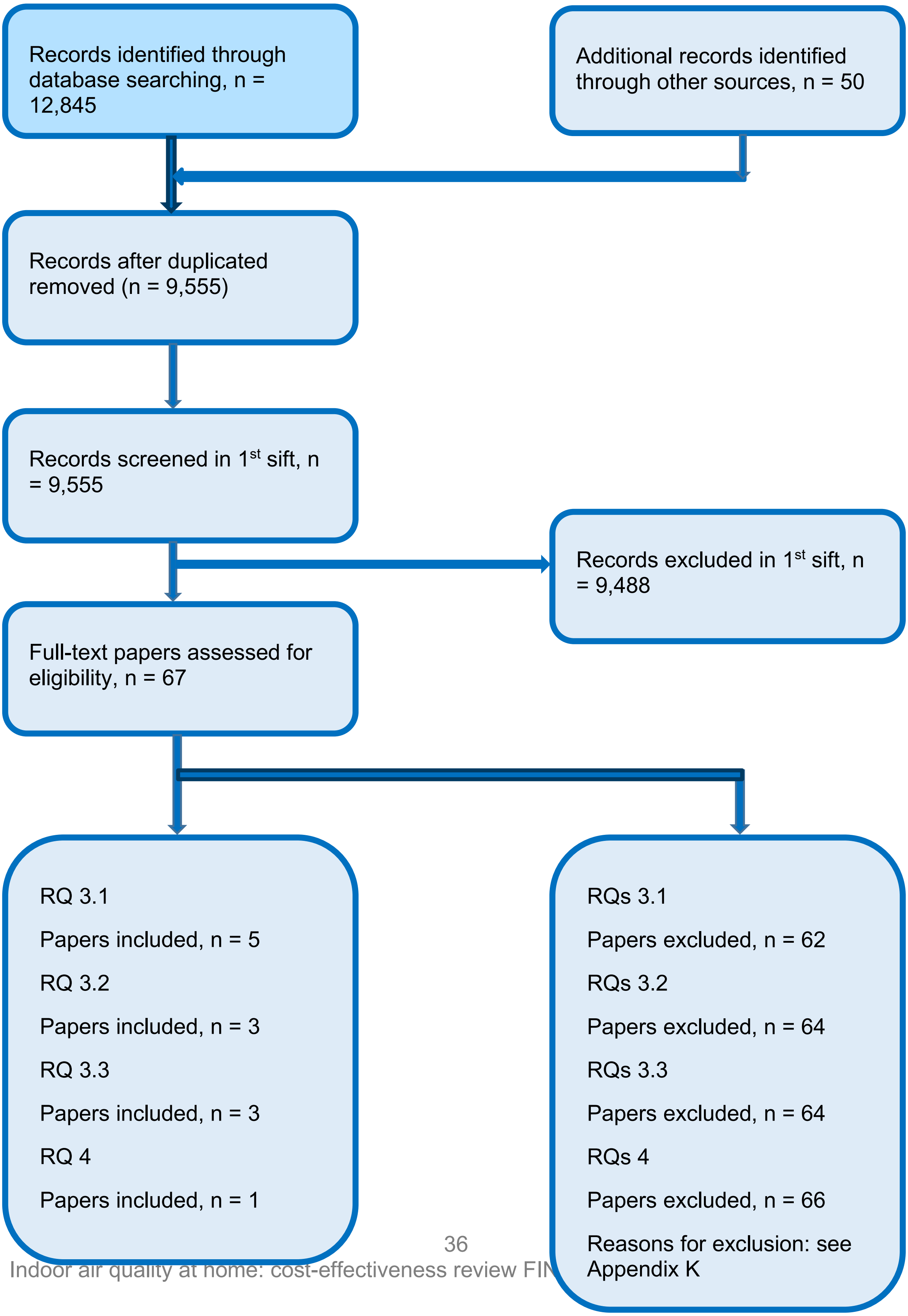
Appendix A – Review protocols

For each review question the same protocols were used for both the effectiveness and cost-effectiveness reviews.

Appendix G – Economic evidence study selection

The following flowchart shows the record selection process for all eight review questions.

Figure 1: Flow chart of economic evidence study selection for the guideline



Appendix H – Economic evidence tables

Table 5: Summary of studies included in the economic evidence review for indoor air quality interventions for RQ 3.1, 3.2, 3.3 and 4

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
Aldred 2016 (USA) Population: Single family homes in 12 American cities (city based analysis).[a] Interventions: Commercially available activated carbon filters in the heating, ventilation and air conditioning (HVAC) systems of single family homes to reduce indoor ozone levels;	Potentially serious limitations [c]	Not applicable [d]	None	Not reported	Not reported	Not reported	Median disability-adjusted life-years (DALYs) gained per 100,000 people in homes with activated carbon filters: ranged from approximately 5 in Phoenix to around 1 in Buffalo [e]	Cost benefit ratios were generated based upon a DALY dollar value taken from a distribution (not specified) Ratios had mean values below 1 for all cities (i.e. activated carbon filters were not cost-effective) but median values were between 1 and 2 for all cities.	The model was run using a Monte Carlo simulation which captured stochastic uncertainty. The lower bound ratio generated from model runs were all zero with the upper bounds ranging between 6 and 13 depending on the city. Scenario analysis showed that the benefits of carbon filtration would be highest in homes with efficient HVAC systems and carbon filters, low

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
Comparator not specified [b]									ozone reactivity and with high occupancy.
Chau 2008 (Hong Kong) Population: Adults (15-64) and elderly people (>64) living in residential apartments in Hong Kong. [f] Interventions: Air cleaners to remove ambient particulate matter (PM_{10}); Comparator was spending 1 hour or 4 hours more/less time at home [g]	Potentially serious limitations [h]	Not applicable [i]	None	Not reported	Not reported	Not reported	Not reported	Benefit to cost ratio for air cleaning [j] Adults: always below one (i.e. air cleaning is not cost-effective) except for if the air cleaner is used with windows closed only in cool season. Older people: above one the whole year provided windows are closed.	Sensitivity analysis explored the impact of changing the thermal comfort days over 5 years on the health benefits from air cleaning. This was not as important as the number of days windows were open.
Edwards 2011 (UK)	Minor limitations [m]	Directly applicable [n]	None	Intervention: £2,217 per person (including	Not reported	Intervention was £1,657 more costly	Mean improvement with intervention:	Intervention ICER: £234 per unit change (1	The results were constructed by bootstrapping RCT results. For

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
Population: Children aged 5-14 with moderate or severe asthma in Wrexham. [k] Interventions: Ventilation systems fitted into the roof space of houses [l]; Comparator was delayed-intervention ("Control"), who received the housing modification after the end of the trial				£1,718 cost of delivering the intervention) Control: £560 per person [o]		than the control	7.07 PedsQL points Severe asthma: 9.67 points Moderate asthma: 4.56 points	point improvement) in PedsQL Severe asthma: £165 per unit change Moderate asthma: £379 per unit change Cost of moving a child from the severe to moderate group with the intervention was £12,300 per child	children with moderate or severe asthma, there is a 97.5% chance that the intervention is cost-effective at a value of a PedsQL point of £590. Scenario analysis suggested that the ICER for the intervention in London would be £294 per PedsQL point and in Northern Ireland £166 per point.
Kattan 2005 (USA) Population: Children aged 5-11 with asthma and positive skin test to an indoor allergen in seven	Minor limitations [r]	Partially applicable [s]	None	Intervention: $4,704 per person (health costs plus intervention costs of $1,472 per child)	Symptom free days (SFDs) over two years Intervention group: 566.6	Intervention was $1,042 more costly than control	Intervention generated 27.8 more SFDs vs control, over two years	Intervention ICER: $27.57 per SFD gained	The ICER was generated by bootstrapping. 100% of iterations had an ICER below $100 per SFD. Scenario analysis of the number of

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
urban locations across the USA. [p] Interventions: Environmental Counsellors (EC) delivering 6 environmental modules to families with one child that had asthma that focused on remediation of exposure to dust mites, passive smoking, cockroaches, pets, rodents, and mould [q]; No intervention ("Control") - families in the control group received visits only for evaluation at six-month intervals				Control: $3,662 per person (health costs only) [t]	Control group: 528.8				unscheduled visits and symptom days before the intervention showed that these variables did not significantly change the ICER.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
Krieger 2005 (USA) Population: Children aged 4-12 with persistent asthma in low income households in Seattle USA. [u] Interventions: "High Intensity" support: 1-year-long intervention provided by community health workers (CHWs) [v]; "Low-intensity" support: a single CHW visit [w]	Potentially serious limitations [x]	Partially applicable [y]	None	Not reported	Days with symptoms (2 weeks): baseline; exit High-intensity group: 8.0; 3.2 Low-intensity group: 7.8; 3.9 Caregiver quality-of-life score: baseline; exit High-intensity group: 4.0; 5.6 Low-intensity group: 4.4; 5.4	Marginal cost of high intensity intervention: $1,124 per child with savings of between $57 and $80 every two months on urgent care costs	Not reported	Estimated total savings over 4 years: $1,316 to $1,849. Savings were from hospital admissions, emergency department visits, and unscheduled clinic visits.	No uncertainty analysis was conducted

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
					Urgent health services use (2 months) (%): baseline; exit High-intensity group: 23.4; 8.4 Low-intensity group: 20.2; 16.4				
Turcotte 2014 (USA) Population: Families with at least one child aged under 15 with asthma in Massachusetts USA. Interventions: "Healthy Homes":	Potentially serious limitations [aa]	Partially applicable [bb]	None	Intervention costs: $192 per child with a decrease in 4 week urgent care costs of $419 per child.	Not reported	Not reported	Not reported	The cost benefit analysis indicated that there could be annual urgent healthcare savings of $5,053 per child from the intervention compared to a cost of $192 per child	No uncertainty analysis was conducted

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty
A health and environmental assessment involving environmental assessor and home health assessment workers covering education and home modifications to identify and address asthma triggers in the home. On the back of the assessment a plan was developed delivered over 4-9 visits over a 12 month period. [z]									

CBA: cost-benefit analysis; CHW: community health worker; DALY: disability-adjusted life-year; EC: environmental counsellors; HVAC: heating, ventilation and air conditioning; ICER: incremental cost-effectiveness ratio; PM: particulate matter; SFD: symptom free day

(a) City specific age distributions were used but no detail was provided on the population modelled.

(b) Implicitly the comparator is HVAC without carbon filtration

(c) The study did not report unit costs, did not include healthcare costs and had no real world data about the effectiveness of the intervention.

(d) The study was based on a technology that is not widely used in the UK nor is likely to be. The perspective is unclear. It does not consider healthcare costs.

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty

(e) Data read from a graph.
(f) No detail was provided on the modelled population.
(g) Outside if elderly, in an office if an adult.
(h) The study did not report unit costs, did not consider the costs of the intervention and had no real world data about the effectiveness of the intervention.
(i) The study was based on climactic factors in a country very different to the UK. It did not consider intervention costs.
(j) No costs were assumed for behavioural change and as a result, no cost benefit ratios were produced for this intervention.
(k) Intervention group: mean age 9.59 years, 44% female. Control group: mean age 9.57 years, 45% female (taken from the primary trial publication).
(l) Improvements were also made to bring central heating systems to a defined standard, including installing new systems if required.
(m) The time horizon was only 12 months and so may not capture the full benefits of the intervention.
(n) No applicability issues
(o) Costs included in the analysis were primary care visits and consultations, primary care prescribing, NHS secondary care attendances and the cost of the intervention to the local authority, including housing adaptations.
(p) Intervention group: mean age 7.6 years, 36.9% female. Control: mean age 7.7 years, 37.8% female (main trial publication).
(q) The modules were tailored to the environmental risk and allergen skin test sensitivity of each child and included both education and demonstration of remediation techniques. The ECs made a median of 5 home visits over the 12-month period. All subjects in the intervention were given dust mite remediation strategies and were provided with impermeable mattress and pillow covers. Families of children exposed to environmental tobacco smoke were given high-efficiency particulate air (HEPA) filters and education regarding reduction of exposure. The intervention was in the first year of the study with follow up in the second year.
(r) The time horizon was only 2 years and so may not capture the full benefits of the intervention. Unit costs were not fully reported.
(s) The study was based in the USA where different costs may limit generalisability. The perspective is unclear. The cost sources are not fully clear.
(t) Costs included in the analysis were scheduled and unscheduled clinic visits, emergency department visits, inpatient stays and asthma medications and intervention costs.
(u) Asthma severity: 63.8% moderate or severe in intervention group. Age: high intensity intervention: mean age 7.4 years, 44.2% female. Low intensity intervention: mean age 7.3 years, 38.2% female.
(v) High-intensity support: CHWs conducted a structured home environmental assessment at the first visit. Each assessment finding generated specific actions for the participant and CHW: these formed an action plan. The CHW made 4 to 8 additional visits to encourage completion of the action plan, provide

Study	Limitations	Applicability	Other comments	Costs	Effects	Incremental cost	Incremental effects	Economic analysis outcomes	Uncertainty

education and social support. Resources were provided to reduce exposures (allergy control pillow and mattress encasements, low-emission vacuums, commercial-quality door mats, cleaning kits, referral to smoking cessation counselling, roach bait, rodent traps).

(w) Low intensity support: the home environmental assessment, an action plan, limited education, and bedding encasements

(x) The study only considered use of urgent healthcare and did not undertake sensitivity analysis.

(y) The study was based in the USA where different costs may limit generalisability. The perspective is unclear. Only urgent healthcare costs were considered.

(z) The plan could include integrated pest management, commercial cleaning, providing healthy home cleaning equipment and supplies (e.g., vacuums with high-efficiency particulate absorption filters, green cleaning chemicals), education, and, in some cases, structural interventions. 6 months after the initial home assessment and at least 1 month after completing the intervention a brief reassessment was undertaken to reinforce the healthy homes education and replenish supplies as needed.

(aa) This was a pre-post observational study and did not undertake sensitivity analysis.

(bb) This study was based in the USA where different costs may limit generalisability. The perspective is unclear. The source of costs for the intervention is unclear.

Appendix I – Health economic evidence profiles

Table 6: Health economic evidence profiles of studies included in the economic evidence review for indoor air quality interventions for RQ 3.1, 3.2, 3.3 and 4

Study	**Aldred 2016**			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: CBA **Study design:** Decision tree **Approach to analysis:** Economic evaluation using an integrated chemistry, health, benefit and cost model populated with published data or assumptions. The models were based upon the effectiveness of carbon filters on reducing ozone in single-family homes and the impact of ozone on health. DALYs were calculated which were	**Population:** Single family homes in 12 American cities (city-based analysis) **Cohort settings:** Not reported in detail. City specific age distributions were used. **Intervention 1:** Commercially available activated carbon filters in the heating, ventilation and air conditioning (HVAC) systems of single family homes to	**Total costs:** Not reported **Currency & cost year:** US$ 2014 **Cost components incorporated:** Cost differential between conventional and particle filters. No healthcare costs were considered.	**DALYs.** Median DALYs gained per 100,000 people in homes with activated carbon filters: ranged from approximately 5 in Phoenix to around 1 in Buffalo [read from graph].	**Full incremental analysis** Cost benefit ratios were generated based upon a DALY dollar value taken from a distribution (not specified). Ratios had mean values below 1 for all cities (meaning that activated carbon filters were not cost-effective), but the median values were between 1 and 2 for all cities. **Analysis of uncertainty** The model was run using Monte Carlo simulation which captured stochastic uncertainty. The lower bound ratio generated from model runs were all zero with the upper bounds ranging between 6 and 13 depending on the city. Scenario analysis showed that the benefits of carbon filtration would be highest in homes with efficient HVAC systems and carbon filters, low ozone reactivity and with high occupancy.

Study	Aldred 2016			
Study details	Population & interventions	Costs	Health outcomes	Cost effectiveness
valued and compared to the costs of ownership of a carbon filter. **Perspective:** Societal **Time horizon:** Unclear but appears to be lifetime **Treatment effect duration:** The study implicitly assumes that carbon removal devices will maintain their effect over lifetime **Discounting:** Not conducted	reduce indoor ozone levels. **Intervention 2:** Not specified but implicitly HVAC without carbon filtration			
Data sources				
Health outcomes: DALYs calculated in model using DALY values for health outcomes from published literature. **Quality-of-life weights:** DALY weights for mortality and respiratory disease drawn from literature. **Cost sources:** Unclear but appears to be from published sources.				
Comments				
Source of funding: Primary funding was the American Society of Heating, Refrigerating, and Air Conditioning Engineers. **Limitations:** Limitations acknowledged by authors: The study only considered ozone and not other secondary organic aerosols for which DALY impacts are unknown. There is little research on how carbon filters operate in the real world. Relationship between HVAC run-time and building age is unknown. Actual cost of carbon filters and operating costs may have been over estimated but this is unknown. **Other:** None				
Overall applicability: Not applicable **Overall quality:** Potentially serious limitations				
Abbreviations: CBA: cost-benefit analysis; DALY: disability-adjusted life-year; HVAC: heating, ventilation and air conditioning				

Study	Chau 2008			
Study details	Population & interventions	Costs	Health outcomes	Cost effectiveness
Economic analysis: CBA **Study design:** Decision tree **Approach to analysis:** Decision tree used separate 'human comfort' and 'indoor microenvironment' components and was populated with published data and assumptions to estimate the costs and health benefits associated with using an air cleaner or changing behaviour in terms of time spent in the home [a] **Perspective:** Individual and societal **Time horizon:** 5 years **Treatment effect duration:** Implicitly assumes that interventions do not decline in efficacy over time	**Population:** Adults (15-64) and elderly people (>64) living in residential apartments in Hong Kong **Cohort settings:** Not reported **Intervention 1:** Air cleaners to remove ambient particulate matter (PM_{10}) **Intervention 2:** Spending 1 hour or 4 hours more/less time at home (outside if elderly, in an office if an adult)	**Potential cost savings** For air cleaners used throughout the year if windows were closed over 5 years Adult: HK$2,072 Elderly person: HK$1,700 For air cleaners used throughout the year if windows were half open over 5 years Adult: HK$919 Elderly person: HK$736 **Behavioural changes** Health benefit for adults, if they spent between 1 hour and 4 hours less in the home per day: between about HK$125 and HK$675 per individual [read from graph] Health benefit, for an older person if they spent between 1 hour and 4	None	**Full incremental analysis** Results are given as benefit to cost ratios for air cleaning. These are always below one (meaning air cleaning is not cost-effective) for adults unless the air cleaner is used with windows closed only in cool season. For older people the ratio is above one for the whole year provided windows are closed. [b] **Analysis of uncertainty** Sensitivity analysis explored the impact of changing the thermal comfort days over 5 years on the health benefits from air cleaning and found that this was not as important as the number of days that windows were open.

Study	Chau 2008			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Discounting: 10% (costs and benefits)		hours more in the home per day: between about HK$100 and HK$400 per individual [read from graph]. **Currency & cost year:** HK$ 2006 **Cost components incorporated:** Mortality, restricted activity and hospital admissions. The cost of air cleaners and of behaviour modifications were not included.		
Data sources				
Health outcomes: No health outcomes reported. **Quality-of-life weights:** Not applicable. **Cost sources:** Hong Kong Medical Association				
Comments				
Source of funding: University Grant Council of Hong Kong and the Hong Kong Polytechnic University. **Limitations:** Limitations acknowledged by the authors: They only considered external sources of indoor air pollution. **Other:** None				
Overall applicability: Not applicable **Overall quality:** Potentially serious limitations				

Abbreviations: CBA: cost-benefit analysis; HK: Hong Kong

(a) Relocation to a cleaner air area was also considered, but this is outside of the scope of this review.

(b) No costs were assumed for behavioural change and so no cost benefit ratios were produced for this intervention.

Study	Edwards 2011			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: CEA **Study design:** Trial based analysis (no model was produced) **Approach to analysis:** Economic evaluation using data collected as part of a RCT on installing roof space ventilation in homes with children with asthma. Bootstrapping was used to generate confidence intervals. **Perspective:** NHS and personal social services (PSS) **Time horizon:** 12 months **Treatment effect duration:** Not relevant **Discounting:** Not relevant (12 month time horizon)	**Population:** Children aged 5-14 with moderate or severe asthma in Wrexham, UK. **Cohort settings:** Intervention: mean age 9.59 years, 44% female. Control: mean age 9.57 years, 45% female **Intervention 1:** Ventilation systems fitted into the roof space of houses. Improvements were also made to bring central heating systems to a defined standard, including installing new systems if required. **Intervention 2:** Delayed-intervention ("control"), housing	**Mean cost per patient:** Intervention: £2,217 per person (including £1,718 cost of delivering intervention) Control: £560 per person **Currency & cost year:** UK£ (the cost year not explicit but it appears to be 2006) **Cost components incorporated:** Primary care visits, primary care prescribing, secondary care attendances, cost of intervention including housing adaptations.	**PedsQL - specific quality of life measure for asthma in children** Mean improvement with intervention: 7.07 PedsQL points (9.67 points for severe asthma and 4.56 for moderate asthma)	**Full incremental analysis** ICER, Intervention: £234 per unit change (1 point) in PedsQL (£165 per unit change for severe asthma and £379 for moderate asthma). The cost of moving a child from the severe to moderate group with the intervention was £12,300 per child. **Analysis of uncertainty** The results were constructed by bootstrapping RCT results. For children with moderate or severe asthma, there is a 97.5% chance that the intervention is cost-effective at a value of a PedsQL point of £590. Scenario analysis suggested that the ICER for the intervention in London would be £294 per PedsQL point and in Northern Ireland would be £166 per point.

Study	Edwards 2011			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
	modification was received after the end of the trial.			
Data sources				
Health outcomes: Drawn directly from trial. **Quality-of-life weights:** Not reported. **Cost sources:** Resource use from Client Service Receipt Inventory (survey of parents of children on the trial), valued using PSSRU unit costs and NHS reference costs.				
Comments				
Source of funding: Wrexham County Borough Council and National Public Health Service for Wales. **Limitations:** Limitations acknowledged by authors: Follow up was for one year only and the study did not look at benefits to siblings and parents, nor did it measure children's respiratory function. **Other:** None				
Overall applicability: Directly applicable **Overall quality:** Minor limitations				
Abbreviations: CEA: cost effectiveness analysis; ICER: incremental cost-effectiveness ratio; PSS: personal social services; PSSRU: Personal Social Services Research Unit; RCT: randomised controlled trial				

Study	Kattan 2005			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: CEA **Study design:** Trial based analysis (no model was produced) **Approach to analysis:** Economic evaluation using data collected as part of an RCT of	**Population:** Children aged 5-11 years with asthma and positive skin test to an indoor allergen in 7 urban locations across the USA. **Cohort settings:**	**Mean cost per patient:** Intervention: $4,704 per person (health costs plus intervention costs of $1,472 per child) Control: $3,662 per person (health costs only) **Currency & cost year:** US$ 2001	**Symptom free days (SFDs), over 2 years** Intervention: 566.6 Control: 528.8	**Full incremental analysis** The ICER was $27.57 per SFD gained with the intervention **Analysis of uncertainty** The ICER was generated by bootstrapping. 100% of iterations had an ICER below $100 per SFD. Scenario analysis of the number of unscheduled visits and symptom days before

Study	Kattan 2005			
Study details	Population & interventions	Costs	Health outcomes	Cost effectiveness
behaviour advice accompanied by adaptations in homes with children with asthma. Bootstrapping was used to generate confidence intervals. **Perspective:** Health insurer (Medicaid) **Time horizon:** 2 years **Treatment effect duration:** Not relevant **Discounting:** Not conducted (only a two year time horizon)	Intervention: mean age 7.6 years, 36.9% female. Control: mean age 7.7 years, 37.8% female **Intervention 1:** Environmental counsellors (ECs) delivered 6 environmental modules to families with one child who had asthma. The modules focused on remediation exposure to dust mites, passive smoking, cockroaches, pets, rodents, and mould. [a] **Intervention 2:** No intervention ("Control"). Families in the control group received visits only for evaluation at six-	**Cost components incorporated:** Scheduled and unscheduled clinic visits, emergency department visits, inpatient stays and asthma medications. Intervention costs.		the intervention showed that these variables did not significantly change the ICER.

Study	Kattan 2005			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
	month intervals throughout the study.			
Data sources				
Health outcomes: Drawn directly from trial. **Quality-of-life weights:** Not applicable. **Cost sources:** Not reported				
Comments				
Source of funding: (US) National Institute of Allergy and Infectious Diseases, (US) National Institutes of Health, DHHS, and the (US) National Institute of Environmental Health Sciences, National Institutes of Health, DHHS. **Limitations:** Limitations acknowledged by authors: The study only looked at the benefits to one child when multiple children with asthma were in some homes. A longer follow up period may have captured more benefits. Two environmental counsellors were at each visit when one may have sufficed. There was no way to estimate the economic benefit of reduction in lost school days. **Other:** None				
Overall applicability: Partially applicable **Overall quality:** Minor limitations				

Abbreviations: CEA: cost effectiveness analysis; EC: environmental counsellor; HEPA: high-efficiency particulate air; RCT: randomised controlled trial; SFD: symptom free day

(a) The modules were tailored to the environmental risk and allergen skin test sensitivity of each child and included both education and demonstration of remediation techniques. The ECs made a median of 5 home visits over the 12-month period. All participants in the intervention were given dust mite remediation strategies and were provided with impermeable mattress and pillow covers. Families of children exposed to environmental tobacco smoke were given high-efficiency particulate air (HEPA) filters and education about reducing exposure. The intervention was in the first year of the study with follow up in the second year.

Study	Krieger 2005			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: Cost consequences	**Population:** Children aged 4-12 years with persistent asthma (63.8% had moderate or severe	**Mean cost per patient:** Marginal cost of high intensity intervention: $1,124 per child with savings of between $57	**Days with symptoms** 2 weeks: baseline; exit High-intensity group: 8.0; 3.2	**Full incremental analysis** Estimated total savings over 4 years: between $1,316 and $1,849. Savings were from hospital admissions, emergency department visits, and unscheduled clinic visits.

Study	Krieger 2005			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Study design: Trial based analysis (no model was produced) **Approach to analysis:** Economic evaluation using data collected as part of an RCT of an intensive intervention of behaviour advice given with adaptations in homes with children with asthma or a low intensity intervention. Bootstrapping was used to generate confidence intervals. **Perspective:** Health insurer (Medicaid) **Time horizon:** 4 years **Treatment effect duration:** The study explicitly assumes that interventions do not decline in efficacy over time **Discounting:** 3% per annum	asthma in the intervention group) in low income households in Seattle USA. **Cohort settings:** High intensity: mean age 7.4 years, 44.2% female. Low intensity: mean age 7.3 years, 38.2% female. **Intervention 1:** "High Intensity" support: 1-year-long intervention was provided by community health workers (CHWs) who conducted a structured home environmental assessment at the first visit. Each assessment generated a specific action plan for the participant and CHW.	and $80 every two months on urgent care costs **Currency & cost year:** US$ 2001 **Cost components incorporated:** Intervention and adaptation costs. Emergency department visits.	Low-intensity group: 7.8; 3.9 **Caregiver quality-of-life score** Baseline; exit High-intensity group: 4.0; 5.6 Low-intensity group: 4.4; 5.4 **Urgent health services use** 2 months (%): baseline; exit High-intensity group: 23.4; 8.4 Low-intensity group: 20.2; 16.4	**Analysis of uncertainty** Not conducted

Study	Krieger 2005			
Study details	Population & interventions	Costs	Health outcomes	Cost effectiveness
	The CHW made 4–8 additional visits to encourage completion of the action plan, and to provide education and social support. [a] **Intervention 2:** "Low-intensity" support: a single CHW visit, which consisted of the home environmental assessment, an action plan, limited education, and bedding encasements. [b]			
Data sources				
Health outcomes: Drawn directly from trial. **Quality-of-life weights:** Not applicable. **Cost sources:** Published literature and Medicaid database				
Comments				
Source of funding: Primary funding from the (US) National Institute of Environmental Health Sciences. **Limitations:** Limitations acknowledged by authors: The study was 'open label'. Loss to follow up was 22%. There was no 'usual care' comparison group. Only 23% of participants had allergen testing and not all remediation actions that were needed could be funded. **Other:** None				
Overall applicability: Partially applicable **Overall quality:** Potentially serious limitations				

Abbreviations: CHW: community health worker; RCT: randomised controlled trial;

(a) Resources were provided to reduce exposures (allergy control pillow and mattress encasements, low-emission vacuums, commercial-quality door mats, cleaning kits, referral to smoking cessation counselling, roach bait, rodent traps).

Study	Turcotte 2014			
Study details	Population & interventions	Costs	Health outcomes	Cost effectiveness
Economic analysis: Cost consequences and CBA **Study design:** Trial based analysis (no model was produced) **Approach to analysis:** Economic evaluation using data collected as part of an RCT of behaviour advice given with adaptations in homes with children with asthma. Bootstrapping was used to generate confidence intervals. **Perspective:** Health insurer **Time horizon:** 12 months **Treatment effect duration:** Not relevant **Discounting:** Not relevant (12 month time horizon)	**Population:** Families with at least one child aged under 15 years with asthma in Massachusetts USA. **Cohort settings:** Mean age: 5.97 years Female: 45.3% **Intervention:** "Healthy Homes": A health and environmental assessment involving an environmental assessor and home health assessment workers covering education and home modifications to identify and address asthma triggers in the home. Based on the assessment a plan was developed and	**Mean cost per patient:** Intervention: $192 per child. Reports a decrease in 4 week urgent care costs of $419 per child **Currency & cost year:** US$ (cost year not reported) **Cost components incorporated:** Cost of intervention and remedial actions. Cost of urgent care (emergency department visit and hospitalisation) and office visits to doctors.	No aggregate health outcome was reported	**Full incremental analysis** No cost-effectiveness ratios were produced as the study was a cost consequences study with limited CBA. The CBA indicated that there could be annual urgent healthcare savings of $5,053 per child from the intervention compared to a cost of $192 per child. **Analysis of uncertainty** Not conducted

Study	Turcotte 2014			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
	delivered over 4-9 visits over a 12 month period. [a]			
Data sources				
Health outcomes: Drawn directly from trial. **Quality-of-life weights:** Not applicable. **Cost sources:** Massachusetts Department of Public Health for emergency department and hospitalisations. Assumption for office visits to doctors. Unclear for intervention.				
Comments				
Source of funding: US Department of Housing and Urban Development, Office of Healthy Homes and Lead Hazard Control. **Limitations:** Limitations acknowledged by authors: The study was observational with no control group using a simple pre-post analysis design. A whole year of follow up data was not collected (only 4 weeks) and questionnaire responses were not validated against health records. It was unclear which parts of the intervention were the most useful. Loss to follow up of 30%. CHSA is not validated in the age range of the study. **Other:** None				
Overall applicability: Partially applicable **Overall quality:** Potentially serious limitations				

Abbreviations: CBA: cost benefit analysis; RCT: randomised controlled trial;

(a) The plan could include integrated pest management, commercial cleaning, providing healthy home cleaning equipment and supplies (e.g., vacuums with high-efficiency particulate absorption filters, green cleaning chemicals), education, and, in some cases, structural interventions. 6 months after the initial home assessment and at least 1 month after completing the intervention a brief reassessment was undertaken to reinforce the healthy homes education and replenish supplies as needed.

Appendix K – Excluded studies

Economic studies

Table 7: Summary of studies excluded from the economic evidence review for the indoor air quality interventions

Reference	Reason for exclusion	RQs
Aldred JR, Darling E, Morrison G, Siegel J, Corsi RL. Benefit-cost analysis of commercially available activated carbon filters for indoor ozone removal in single-family homes. Indoor Air. 2016;26(3):501-12.	Ineligible outcomes.	3.2, 4
Ambrey CL, Fleming CM, Chan AY-C. Estimating the cost of air pollution in South East Queensland: an application of the life satisfaction non-market valuation approach. CA Cancer J Clin. 2014;97(0):172-81.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Bayer P, Keohane N, Timmins C. Migration and hedonic valuation: the case of air quality. Cambridge, MA: National Bureau of Economic Research; 2006. Available from: http://www.nber.org/papers/w12106.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Boulanger G, Bayeux T, Mandin C, Kirchner S, Vergriette B, Pernelet-Joly V, et al. Socio-economic costs of indoor air pollution: a tentative estimation for some pollutants of health interest in France. Environ Int. 2017;104:14-24.	Ineligible study design.	3.1, 3.2, 3.3, 4
Byfield DA. Poor quality of indoor air affects costs, productivity. Health facilities management. 1989;2(6):14-15, 17passim.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Chau CK, Hui WK, Tse MS. Valuing the health benefits of improving indoor air quality in residences. Sci Total Environ. 2008;394(1):25-38.	Ineligible outcomes.	3.2, 4
Coskeran T, Denman A, Phillips P, Tornberg R. A cost-effectiveness analysis of radon protection methods in domestic properties: a comparative case study in Brixworth, Northamptonshire, UK. J Environ Radioact. 2006;91(1-2):73-89.	Ineligible intervention.	3.1, 3.2, 3.3, 4

Reference	Reason for exclusion	RQs
Coskeran T, Denman AR, Phillips PS, Gillmore GK. A critical comparison of the cost-effectiveness of domestic radon remediation programmes in three counties of England. J Environ Radioact. 2002;62(2):129-44.	Ineligible intervention.	3.1, 3.2, 3.3, 4
Denman AR, Sinclair J, Phillips PS, Crockett RGM, Groves-Kirkby CJ. The cost effectiveness of radon reduction programmes in domestic housing in England and Wales: the impact of improved radon mapping and housing trends. Environ Int. 2013;59:73-85.	Ineligible study design.	3.1, 3.2, 3.3, 4
Di Turi S, Stefanizzi P. Energy analysis and refurbishment proposals for public housing in the city of Bari, Italy. Energy Policy. 2015;79(0):58-71.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Dickie M, Gerking S. Willingness to pay for ozone control: inferences from the demand for medical care. J Environ Econ Manage. 1991;21(1):1-16.	Ineligible setting.	3.1, 3.2, 3.3, 4
Edwards RT, Neal RD, Linck P, Bruce N, Mullock L, Nelhans N, et al. Enhancing ventilation in homes of children with asthma: cost-effectiveness study alongside randomised controlled trial. Br J Gen Pract. 2011;61(592):e733-41.	Ineligible outcomes.	3.2, 4
Farbotko C, Waitt G. Residential air-conditioning and climate change: voices of the vulnerable. Health Promot J Austr. 2011;22 Spec No:S13-6.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Fisk WJ, Chan WR. Health benefits and costs of filtration interventions that reduce indoor exposure to PM2.5 during wildfires. Indoor Air. 2017;27(1):191-204.	Ineligible setting.	3.1, 3.2, 3.3, 4
Georges L, Massart C, Van Moeseke G, De Herde A. Environmental and economic performance of heating systems for energy-efficient dwellings: case of passive and low-energy single-family houses. Energy Policy. 2012;40(1):452-64.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Ginevan ME. Radon as an indoor air pollutant. Stat Sci. 1988;3(3):371-73.	Ineligible study design.	3.1, 3.2, 3.3, 4
Giovanis E, Ozdamar O. The Impact of air pollution on health problems in Britain. IJSE. 2016;8(2):163-86.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Govier J. Cost considerations when controlling air quality. Med Device Technol. 2005;16(1):20-3.	Ineligible study design.	3.1, 3.2, 3.3, 4
Gray A, Read S, McGale P, Darby S. Lung cancer deaths from indoor radon and the cost effectiveness and potential of policies to reduce them. BMJ (Clinical research ed.). 2009;338:a3110.	Ineligible patient population.	3.1, 3.2, 3.3, 4

Reference	Reason for exclusion	RQs
Hamilton TL, Phaneuf DJ. An integrated model of regional and local residential sorting with application to air quality. JESM. 2015;74(0):71-93.	Ineligible setting.	3.1, 3.2, 3.3, 4
Hitaj C, Lynch L, McConnell KE, Tra CI. The value of ozone air quality improvements to renters: evidence from apartment building transactions in Los Angeles county. Ecol Econ. 2018;146(0):706-21.	Ineligible setting.	3.1, 3.2, 3.3, 4
Jeuland M, Pattanayak SK, Bluffstone R. The economics of household air pollution. Palo Alto, CA: Reviews A; 2015. 81-108. Available from: https://www.annualreviews.org/doi/abs/10.1146/annurev-resource-100814-125048. a	Ineligible study design.	3.1, 3.2, 3.3, 4
Johnson L, Ciaccio C, Barnes CS, Kennedy K, Forrest E, Gard LC, et al. Low-cost interventions improve indoor air quality and children's health. Allergy Asthma Proc. 2009;30(4):377-85.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Johnson MM, Williams R, Fan Z, Lin L, Hudgens E, Gallagher J, et al. Participant-based monitoring of indoor and outdoor nitrogen dioxide, volatile organic compounds, and polycyclic aromatic hydrocarbons among MICA-Air households. Atmos Environ. 2010;44(38):4927-36.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Jones AP. Indoor air quality and health. Atmos Environ. 1999;33(28):4535-64.	Ineligible study design.	3.1, 3.2, 3.3, 4
Katona T, Kanyar B, Somlai J. Cost assessment of ventilation and averted dose due to radon in dwellings. J Environ Radioact. 2005;79(2):223-30.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Kattan M, Stearns SC, Crain EF, Stout JW, Gergen PJ, Evans R, et al. Cost-effectiveness of a home-based environmental intervention for inner-city children with asthma. J Allergy Clin Immunol. 2005;116(5):1058-63.	Ineligible outcomes.	3.3, 4
Kelly JA, Fu M, Clinch JP. Residential home heating: the potential for air source heat pump technologies as an alternative to solid and liquid fuels. Energy Policy. 2016;98:431-42.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Kennedy CA, Gray AM. Cost effectiveness analysis of radon remediation programmes. Sci Total Environ. 2001;272(1-3):9-15.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Knibbs LD, Woldeyohannes S, Marks GB, Cowie CT. Damp housing, gas stoves, and the burden of childhood asthma in Australia. Med J Aust. 2018;208(7):299-302.	Ineligible outcomes.	3.1, 3.2, 3.3, 4

Reference	Reason for exclusion	RQs
Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County Healthy Homes Project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. Am J Public Health. 2005;95(4):652-9.	Ineligible outcomes.	3.1, 3.3
Lanphear BP, Aligne CA, Auinger P, Weitzman M, Byrd RS. Residential exposures associated with asthma in US children. Pediatrics. 2001;107(3):505-11.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Larsson LS. Risk-reduction strategies to expand radon care planning with vulnerable groups. Public Health Nurs. 2014;31(6):526-36.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Leung GM, Ho LM, Lam TH. The economic burden of environmental tobacco smoke in the first year of life. Arch Dis Child. 2003;88(9):767-71.	Ineligible study design.	3.1, 3.2, 3.3, 4
Lima Azevedo I, Morgan MG, Palmer K, Lave LB. Reducing U.S. residential energy use and CO2 emissions: how much, how soon, and at what cost? Environ Sci Technol. 2013;47(6):2502-11.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Logue JM, Price PN, Sherman MH, Singer BC. A method to estimate the chronic health impact of air pollutants in U.S. residences. Environ Health Perspect. 2012;120(2):216-22.	Ineligible study design.	3.1, 3.2, 3.3, 4
Max W, Sung H-Y, Shi Y. The cost of secondhand smoke exposure at home in California. Tob Control. 2015;24(2):205-10.	Ineligible study design.	3.1, 3.2, 3.3, 4
McNamara ML, Thornburg J, Semmens EO, Ward TJ, Noonan CW. Reducing indoor air pollutants with air filtration units in wood stove homes. Sci Total Environ. 2017;592:488-94.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
McNeil MA, Bojda N. Cost-effectiveness of high-efficiency appliances in the U.S. residential sector: a case study. Energy Policy. 2012;45(1):33-42.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Mehta S, Shahpar C. The health benefits of interventions to reduce indoor air pollution from solid fuel use: a cost-effectiveness analysis. Energy Sustain Dev. 2004;8(3):53-59.	Ineligible country.	3.1, 3.2, 3.3, 4
Meijer A, Huijbregts MAJ, Reijnders L. Human health damages due to indoor sources of organic compounds and radioactivity in life cycle impact assessment of dwellings - part 1: characterisation factors. Int J Life Cycle Ass. 2005;10(5):309-16.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Mikulic D, Bakaric IR, Slijepcevic S. The economic impact of energy saving retrofits of residential and public buildings in Croatia. Energy Policy. 2016;96(0):630-44.	Ineligible outcomes.	3.1, 3.2, 3.3, 4

Reference	Reason for exclusion	RQs
Milner J, Chalabi Z, Vardoulakis S, Wilkinson P. Housing interventions and health: quantifying the impact of indoor particles on mortality and morbidity with disease recovery. Environ Int. 2015;81:73-9.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Milner J, Shrubsole C, Das P, Jones B, Ridley I, Chalabi Z, et al. Home energy efficiency and radon related risk of lung cancer: modelling study. BMJ (Clinical research ed.). 2014;348:f7493.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Moeller DW, Fujimoto K. Cost evaluation of control measures for indoor radon progeny. Health Phys. 1984;46(6):1181-93.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Moller P. Excess winter mortality, wood fires and the uncertainties associated with air pollutants. N Z Med J. 2011;124(1330):58-65.	Ineligible study design.	3.1, 3.2, 3.3, 4
Morishima T, Imanaka Y, Otsubo T, Hayashida K, Watanabe T, Tsuji I. Burden of household environmental tobacco smoke on medical expenditure for Japanese women: a population-based cohort study. J Epidemiol. 2013;23(1):55-62.	Ineligible study design.	3.1, 3.2, 3.3, 4
Moseley C. Indoor air quality problems: a proactive approach for new or renovated buildings. Journal of Environmental Health. 1990;53(3):19-23.	Ineligible study design.	3.1, 3.2, 3.3, 4
Nicolle-Mir L. Socio-economic cost of indoor air pollution in France: assessment of six pollutants. ERS. 2018;17(2):104-06.	Ineligible language.	3.1, 3.2, 3.3, 4
Ownby DR. Pet dander and difficult-to-control asthma: the burden of illness. Allergy Asthma Proc. 2010;31(5):381-4.	Ineligible study design.	3.1, 3.2, 3.3, 4
Park H, Kwon H. Effects of consumer subsidy on household fuel switching from coal to cleaner fuels: a case study for anthracites in Korea. Energy Policy. 2011;39(3):1687-93.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Petersen ML, Larsen T. Cost-benefit analyses of radon mitigation projects. J Environ Manage. 2006;81(1):19-26.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Ramos GFP, van Asselt ADI, Kuiper S, Severens JL, Maas T, Dompeling E, et al. Cost-effectiveness of primary prevention of paediatric asthma: a decision-analytic model. Eur J Health Econ. 2014;15(8):869-83.	Ineligible setting.	3.1, 3.2, 3.3, 4
Ruokamo E. Household preferences of hybrid home heating systems--a choice experiment application. Energy Policy. 2016;95(0):224-37.	Ineligible outcomes.	3.1, 3.2, 3.3, 4

Reference	Reason for exclusion	RQs
Savolahti M, Karvosenoja N, Tissari J, Kupiainen K, Sippula O, Jokiniemi J. Black carbon and fine particle emissions in Finnish residential wood combustion: emission projections, reduction measures and the impact of combustion practices. Atmos Environ. 2016;140:495-505.	Ineligible setting.	3.1, 3.2, 3.3, 4
Sharpe RA, Thornton CR, Nikolaou V, Osborne NJ. Fuel poverty increases risk of mould contamination, regardless of adult risk perception & ventilation in social housing properties. Environ Int. 2015;79:115-29.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Shrubsole C, Das P, Milner J, Hamilton IG, Spadaro JV, Oikonomou E, et al. A tale of two cities: comparison of impacts on CO2 emissions, the indoor environment and health of home energy efficiency strategies in London and Milton Keynes. Atmos Environ. 2015;120:100-08.	Ineligible study design.	3.1, 3.2, 3.3, 4
Smith KR, Bruce N, Balakrishnan K, Adair-Rohani H, Balmes J, Chafe Z, et al. Millions dead: how do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. Annu Rev Public Health. 2014;35:185-206.	Ineligible study design.	3.1, 3.2, 3.3, 4
Stigum H, Strand T, Magnus P. Should radon be reduced in homes? A cost-effect analysis. Health Phys. 2003;84(2):227-35.	Ineligible patient population.	3.1, 3.2, 3.3, 4
Tse MS, Chau CK, Lee WL. Assessing the benefit and cost for a voluntary indoor air quality certification scheme in Hong Kong. Sci Total Environ. 2004;320(2-3):89-107.	Ineligible setting.	3.1, 3.2, 3.3, 4
Tuomainen M, Tuomainen A, Liesivuori J, Pasanen AL. The 3-year follow-up study in a block of flats - experiences in the use of the Finnish indoor climate classification. Indoor Air. 2003;13(2):136-47.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Turcotte DA, Alker H, Chaves E, Gore R, Woskie S. Healthy homes: in-home environmental asthma intervention in a diverse urban community. Am J Public Health. 2014;104(4):665-71.	Ineligible outcomes.	3.3, 4
Turk BH, Prill RJ, Fisk WJ, Grimsrud DT, Sextro RG. Effectiveness of radon control techniques in fifteen homes. J Air Waste Manag Assoc. 1991;41(5):723-34.	Ineligible outcomes.	3.1, 3.2, 3.3, 4
Wang S, Ang HM, Tade MO. Volatile organic compounds in indoor environment and photocatalytic oxidation: state of the art. Environ Int. 2007;33(5):694-705.	Ineligible study design.	3.1, 3.2, 3.3, 4
Wang Y, Ju C, Stark AD, Teresi N. Radon mitigation survey among New York State residents living in high radon homes. Health Phys. 1999;77(4):403-9.	Ineligible outcomes.	3.1, 3.2, 3.3, 4

Reference	Reason for exclusion	RQs
Warner JO. Use of temperature-controlled laminar airflow in the management of atopic asthma: clinical evidence and experience. Ther Adv Respir Dis. 2017;11(4):181-88.	Ineligible study design.	3.1, 3.2, 3.3, 4
Wu F, Jacobs D, Mitchell C, Miller D, Karol MH. Improving indoor environmental quality for public health: impediments and policy recommendations. Environ Health Perspect. 2007;115(6):953-7.	Ineligible study design.	3.1, 3.2, 3.3, 4

Appendix M – Health economic quality assessment

Study identification **Aldred JR, Darling E, Morrison G, Siegel J, Corsi RL. Benefit-cost analysis of commercially available activated carbon filters for indoor ozone removal in single-family homes. Indoor Air. 2016;26(3):501-12.**		
Guidance topic: Indoor Air Quality At Home		**Question no: 3.1 & 3.3**
Section 1: Applicability (relevance to specific review questions and the NICE reference case)	**Yes/partly/no/unclear/NA**	**Comments**
1.1 Is the study population appropriate for the review question?	Yes	All people
1.2 Are the interventions appropriate for the review question?	Yes	Equipment to clean air
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	No	US study based upon home air conditioning units which are uncommon in the UK
1.4 Are the perspectives clearly stated and are they appropriate for the review question?	No	Not stated and it is not clear from whose perspective the costs of adaptation would be incurred
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	Yes	DALYs. Mean per patient was not provided. Median DALYs gained per 100,000 people in homes with activated carbon filters ranged from approximately 5 in Phoenix to around 1 in Buffalo (read from graph).
1.6 Are all future costs and outcomes discounted appropriately?	No	Not conducted
1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	NA	QALYs were not used
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	No	Does not look at costs to the healthcare system
1.9 Overall judgement: Not applicable		

Other comments: The study was based on technology that is not widely used in the UK nor is likely to be. The perspective is unclear. The study does not consider healthcare costs.		
Section 2: Study limitations (the level of methodological quality)	**Yes/partly/no/unclear/NA**	**Comments**
2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	Yes	A decision model was used
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	Partly	Unclear but appears to be lifetime
2.3 Are all important and relevant outcomes included?	Yes	DALYs. Mean per patient was not provided. Median DALYs gained per 100,000 people in homes with activated carbon filters ranged from approximately 5 in Phoenix to around 1 in Buffalo (read from graph).
2.4 Are the estimates of baseline outcomes from the best available source?	Unclear	Drawn from published literature
2.5 Are the estimates of relative intervention effects from the best available source?	No	No real world data on effectiveness were provided
2.6 Are all important and relevant costs included?	No	Does not look at costs to the healthcare system
2.7 Are the estimates of resource use from the best available source?	Yes	Drawn from published literature
2.8 Are the unit costs of resources from the best available source?	No	Unit costs were not provided
2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	Yes	Cost benefit ratios were provided
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	Yes	Extensive sensitivity analyses were performed
2.11 Is there any potential conflict of interest?	Partly	Funded by air conditioning industry
2.12 Overall assessment: Minor limitations		
Other comments: The study did not report unit costs, did not include healthcare costs and had no real world data on the effectiveness of the intervention.		
DALY: disability-adjusted life-year; QALY: quality-adjusted life-year		

Study identification Chau CK, Hui WK, Tse MS. Valuing the health benefits of improving indoor air quality in residences. Sci Total Environ. 2008;394(1):25-38.		
Guidance topic: Indoor Air Quality At Home		**Question no: 3.1 & 3.3**
Section 1: Applicability (relevance to specific review questions and the NICE reference case)	**Yes/partly/no/unclear/NA**	**Comments**
1.1 Is the study population appropriate for the review question?	Yes	Older people
1.2 Are the interventions appropriate for the review question?	Yes	Equipment to clean air
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	No	Hong Kong study with a different climate, housing and healthcare system to the UK
1.4 Are the perspectives clearly stated and are they appropriate for the review question?	No	Not stated and it was not clear from whose perspective the costs of adaptation would be incurred
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	Partly	No aggregate health outcome was reported
1.6 Are all future costs and outcomes discounted appropriately?	Yes	10% (costs and benefits)
1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	NA	QALYs were not used
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	No	The cost of interventions was not considered
1.9 Overall judgement: Not applicable		
Other comments: Study was based on climactic factors in a country very different to the UK. The study does not consider intervention costs.		
Section 2: Study limitations (the level of methodological quality)	**Yes/partly/no/unclear/NA**	**Comments**
2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	Yes	Decision model was used
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	Yes	5 years
2.3 Are all important and relevant outcomes included?	Partly	No aggregate health outcome was reported

2.4 Are the estimates of baseline outcomes from the best available source?	Yes	Drawn from published literature
2.5 Are the estimates of relative intervention effects from the best available source?	No	No real world data on effectiveness
2.6 Are all important and relevant costs included?	No	Cost of interventions was not considered
2.7 Are the estimates of resource use from the best available source?	No	No cost of intervention was considered
2.8 Are the unit costs of resources from the best available source?	No	Unit costs of intervention were not provided
2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	Yes	Cost benefit ratios were provided
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	Yes	Although not extensive, the sensitivity analyses performed were appropriate
2.11 Is there any potential conflict of interest?	No	No conflicts were identified
2.12 Overall assessment: Potentially serious limitations		
Other comments: The study did not report unit costs, did not consider the costs of the intervention and provided no real world data on the effectiveness of the intervention.		
QALY: quality-adjusted life-year		

Study identification **Edwards RT, Neal RD, Linck P, Bruce N, Mullock L, Nelhans N, et al. Enhancing ventilation in homes of children with asthma: cost-effectiveness study alongside randomised controlled trial. Br J Gen Pract. 2011;61(592):e733-41.**		
Guidance topic: Indoor Air Quality At Home		**Question no: 3.1 & 3.3**
Section 1: Applicability (relevance to specific review questions and the NICE reference case)	**Yes/partly/no/unclear/NA**	**Comments**
1.1 Is the study population appropriate for the review question?	Yes	Children with asthma
1.2 Are the interventions appropriate for the review question?	Yes	Equipment to clean air
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	Yes	UK study

1.4 Are the perspectives clearly stated and are they appropriate for the review question?	Yes	NHS and PSS
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	Yes	PedsQL – an asthma specific quality of life measure - as well as healthcare resource use
1.6 Are all future costs and outcomes discounted appropriately?	NA	Not relevant (12 month time horizon)
1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	NA	QALYs were not used
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	Yes	A full range of costs were considered appropriately and valued
1.9 Overall judgement: Directly applicable		
Other comments: No applicability issues		
Section 2: Study limitations (the level of methodological quality)	**Yes/partly/no/unclear/NA**	**Comments**
2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	NA	Not a model
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	Partly	Only 12 months, so it was unclear if benefits would persist
2.3 Are all important and relevant outcomes included?	Yes	PedsQL – an asthma specific quality of life measure - as well as healthcare resource use
2.4 Are the estimates of baseline outcomes from the best available source?	Yes	Directly from patients
2.5 Are the estimates of relative intervention effects from the best available source?	Yes	A RCT
2.6 Are all important and relevant costs included?	Yes	A full range of costs were considered
2.7 Are the estimates of resource use from the best available source?	Yes	From the trial itself
2.8 Are the unit costs of resources from the best available source?	Yes	Standard UK sources: Department of Health, PSSRU, NHS Information Centre

2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	Yes	ICERs were calculated
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	Yes	Bootstrapping and scenario analysis
2.11 Is there any potential conflict of interest?	No	No conflicts were identified
2.12 Overall assessment: Minor limitations		
Other comments: The time horizon was only 12 months and therefore may not capture the full benefits of the intervention.		
ICER: incremental cost-effectiveness ratio; PSS: personal social services; PSSRU: Personal Social Services Research Unit; QALY: quality-adjusted life-year		

Study identification **Kattan M, Stearns SC, Crain EF, Stout JW, Gergen PJ, Evans R, 3rd, et al. Cost-effectiveness of a home-based environmental intervention for inner-city children with asthma. J Allergy Clin Immunol. 2005;116(5):1058-63.**		
Guidance topic: Indoor Air Quality At Home		**Question no: 3.1 & 3.2**
Section 1: Applicability (relevance to specific review questions and the NICE reference case)	**Yes/partly/no/unclear/NA**	**Comments**
1.1 Is the study population appropriate for the review question?	Yes	Children with asthma
1.2 Are the interventions appropriate for the review question?	Yes	Equipment and interventions to clean air and remove allergens. Behavioural advice
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	Partly	US study. Although allergens and intervention may be relevant to the UK setting, costs may not be generalisable.
1.4 Are the perspectives clearly stated and are they appropriate for the review question?	Partly	Not stated but it appears to be the public health insurer (Medicaid).
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	Yes	Symptom free days and healthcare usage were presented
1.6 Are all future costs and outcomes discounted appropriately?	NA	Not conducted (but only a two year time horizon)

1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	NA	QALYs were not used
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	Partly	A full range of costs were considered, but the sources of the costs were not reported.
1.9 Overall judgement: Partially applicable		
Other comments: The study was undertaken in the USA where different costs may limit generalisability. The perspective was unclear. Cost sources were not fully described.		
Section 2: Study limitations (the level of methodological quality)	**Yes/partly/no/unclear/NA**	**Comments**
2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	NA	Not a model
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	Partly	Only 2 years so unclear if the benefits would persist
2.3 Are all important and relevant outcomes included?	Yes	Symptom free days and healthcare usage were presented
2.4 Are the estimates of baseline outcomes from the best available source?	Yes	Directly from patients
2.5 Are the estimates of relative intervention effects from the best available source?	Yes	RCT
2.6 Are all important and relevant costs included?	Yes	A full range of costs were considered
2.7 Are the estimates of resource use from the best available source?	Yes	From the trial itself
2.8 Are the unit costs of resources from the best available source?	No	Unit costs were not provided
2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	Yes	ICERs were calculated
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	Yes	Bootstrapping and scenario analysis
2.11 Is there any potential conflict of interest?	No	No conflicts were identified
2.12 Overall assessment: Minor limitations		

Other comments: The time horizon was only 2 years and so may not capture the full benefits of the intervention. Unit costs were not fully reported.
ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life-year; RCT: randomised controlled trial

Study identification **Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County Healthy Homes Project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. Am J Public Health. 2005;95(4):652-9.**		
Guidance topic: Indoor Air Quality At Home		**Question no: 3.2 & 4**
Section 1: Applicability (relevance to specific review questions and the NICE reference case)	**Yes/partly/no/unclear/NA**	**Comments**
1.1 Is the study population appropriate for the review question?	Yes	Children with asthma
1.2 Are the interventions appropriate for the review question?	Yes	Equipment and interventions to clean air and remove allergens. Behavioural advice.
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	Partly	US study. Although allergens and the intervention may be relevant to a UK setting, the costs may not be generalisable.
1.4 Are the perspectives clearly stated and are they appropriate for the review question?	Partly	Not stated, but it appears to be the public health insurer (Medicaid).
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	No	Only urgent care costs were presented
1.6 Are all future costs and outcomes discounted appropriately?	Yes	3% per annum
1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	NA	QALYs were not used.
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	Yes	A full range of costs were considered appropriately and valued
1.9 Overall judgement: Partially applicable		

Other comments: The study was conducted in the USA where different costs to the UK may limit its generalisability. The perspective was unclear. Only urgent healthcare costs were considered.		
Section 2: Study limitations (the level of methodological quality)	**Yes/partly/no/unclear/NA**	**Comments**
2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	NA	Not a model
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	Yes	4 years
2.3 Are all important and relevant outcomes included?	No	Only urgent care costs were presented
2.4 Are the estimates of baseline outcomes from the best available source?	Yes	Directly from patients
2.5 Are the estimates of relative intervention effects from the best available source?	Yes	RCT
2.6 Are all important and relevant costs included?	Yes	A full range of costs was considered
2.7 Are the estimates of resource use from the best available source?	Yes	From the trial itself
2.8 Are the unit costs of resources from the best available source?	Yes	Standard US sources in the health services literature: Medicaid data for children with asthma from Sullivan et al, national data on charges for asthma care from Weiss et al, data from a health maintenance organisation from Lozano et al, Washington State Medicaid data, medical centre cost data from Stroupe et al.
2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	NA	Not a CEA or CUA
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	No	Not conducted
2.11 Is there any potential conflict of interest?	No	No conflicts were identified
2.12 Overall assessment: Potentially serious limitations		
Other comments: The study only considered the use of urgent healthcare and did not undertake sensitivity analysis.		
CEA: cost-effectiveness analysis; CUA: cost-utility analysis; QALY: quality-adjusted life-year; RCT: randomised controlled trial		

Study identification **Turcotte DA, Alker H, Chaves E, Gore R, Woskie S. Healthy homes: in-home environmental asthma intervention in a diverse urban community. Am J Public Health. 2014;104(4):665-71.**		
Guidance topic: Indoor Air Quality At Home		**Question no: 3.1 & 3.2**
Section 1: Applicability (relevance to specific review questions and the NICE reference case)	**Yes/partly/no/unclear/NA**	**Comments**
1.1 Is the study population appropriate for the review question?	Yes	Children with asthma
1.2 Are the interventions appropriate for the review question?	Yes	Equipment and interventions to clean air and remove allergens. Behavioural advice.
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	Partly	US study. Although allergens and the intervention may be relevant to a UK setting, the costs may not be generalisable.
1.4 Are the perspectives clearly stated and are they appropriate for the review question?	Partly	Not stated but it appears to be a public health insurer (Medicaid).
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	Partly	No aggregate health outcome was reported, but a range of patient outcomes were presented
1.6 Are all future costs and outcomes discounted appropriately?	NA	Not relevant (12 month time horizon)
1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	NA	QALYs were not used
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	Partly	A full range of costs were considered and appropriately valued except for the intervention costs where the source was unclear
1.9 Overall judgement: Partially applicable		
Other comments: The study was based in the USA where different costs may limit generalisability to the UK. The perspective was unclear. The source of costs for the intervention was unclear.		
Section 2: Study limitations (the level of methodological quality)	**Yes/partly/no/unclear/NA**	**Comments**

2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	NA	Not a model
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	Partly	Only 12 months so it is unclear if benefits would persist.
2.3 Are all important and relevant outcomes included?	Partly	No aggregate health outcome was reported, but a range of patient outcomes were presented.
2.4 Are the estimates of baseline outcomes from the best available source?	Yes	Directly from patients
2.5 Are the estimates of relative intervention effects from the best available source?	No	Pre-post study with no control
2.6 Are all important and relevant costs included?	Partly	A full range of costs was considered
2.7 Are the estimates of resource use from the best available source?	Yes	From the trial itself
2.8 Are the unit costs of resources from the best available source?	Yes	Standard US sources: Massachusetts Department of Public Health for hospitalization for asthma
2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	NA	Not a CEA or CUA
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	No	Not conducted
2.11 Is there any potential conflict of interest?	No	No conflicts were identified
2.12 Overall assessment: Potentially serious limitations		
Other comments: This was a pre-post observational study and did not undertake sensitivity analysis.		
CEA: cost-effectiveness analysis; CUA: cost-utility analysis; QALY: quality-adjusted life-year		