

Can policies targeting the physical structure of a home improve health?

Answer: Evidence on interventions seeking to improve the physical structure of housing suggests that efforts to increase warmth and energy efficiency, prevent injury, reduce chemical agent exposure, and control asthma are associated with improvements in general health, mental health, and/or respiratory outcomes. Evidence on the repair and removal of dampness and mold also suggests improvements in health outcomes, though the evidence is of lower quality. Although drawing on a smaller evidence base, a systematic review of green building practices found improvements in indoor environmental quality and health outcomes for vulnerable populations. A key limitation in this literature is that most studies rely heavily on self-reported health outcomes instead of more objective measures of indoor environmental quality or independently verified clinical markers. In addition, available evidence focuses on specific interventions, rather than the policies intended bring about those interventions. Not all such policies may be 100 percent effective when implemented.

Policy context

AcademyHealth undertook this review from the perspective of a local policymaker considering policies to improve housing conditions for populations at risk of disease or other adverse health conditions. A growing body of evidence has documented the link between poor housing conditions and health, noting the harmful effects of exposure to physical, chemical, or structural hazards in the home. This review looked for evidence about the impact of policies targeting the prevention or mitigation of such hazards on health.

Supporting evidence

We identified one primary research study¹ that found that two states with lead laws were 79% less likely than a state without such legislation to have new lead poisoning cases. AcademyHealth also found systematic reviews² evaluating the health impacts of six types of interventions that address hazards in the home:

- **Warmth and energy efficiency.** We found one systematic review⁴ suggesting that building warmth and energy efficiency can improve general health, respiratory outcomes, and mental health outcomes.
- **Asthma control:** Two systematic reviews^{13, 14} found that a home audit leading to reductions in allergens and other irritants in the home can improve asthma symptoms in children, though evidence on the impact for adults is limited.
- **Injury prevention.** One systematic review¹⁵ found that home smoke alarms and requiring safe temperatures for hot water heaters is associated with improved health outcomes.
- **Chemical agent exposure.** A systematic review¹⁶ found that (1) radon air mitigation using active soil depressurization, (2) integrated pest management, and (3) lead hazard control can reduce exposure and improve health outcomes.
- **Green buildings.** AcademyHealth identified one systematic review⁵ that suggests green buildings lead to improved indoor environmental quality and health outcomes.
- **Dampness and mold.** We found two systematic reviews^{3, 13} suggesting that while studies have shown that interventions targeting dampness and mold can improve respiratory outcomes, that evidence is of low to very low quality.

Limitations

- Systematic reviews report that variation in interventions, sample populations, and outcome measures limit efforts to quantitatively combine data across studies and assess the overall impact.
- Many studies rely on self-reported rather than independently verified measures of health or indoor environmental quality.
- We did not identify any systematic reviews examining the health impacts of policies targeting the physical structure of a home, but instead focused on evaluations of housing interventions to inform future policy decisions. In the real world, enacted policies may not result in total compliance or successful implementation of such interventions.
- With one exception, this rapid evidence review does not include primary research not included in peer-reviewed systematic reviews.

AcademyHealth conducted this rapid review over a two-week period using an established protocol that emphasizes timeliness, efficiency, and responsiveness to policymakers' needs. It synthesizes peer-reviewed systematic reviews published within the last 10 years and peer-reviewed primary studies published since the most recent systematic review. A primary analyst undertook and revised the review. Two additional AcademyHealth analysts and an external housing policy expert provided input on the initial findings and draft report. Appendix 3 lists the search terms and databases used in this rapid review.

Appendix 1: Definition of Terms

Green Building—The planning, design, construction, and operations of buildings that focus on optimizing several key factors: energy use, water use, indoor environmental quality, material selection, and the building's effects on its site, although definitions can vary.⁶

Indoor Environmental Quality—The conditions inside a building—air quality, lighting, thermal conditions, ergonomics—and their effects on occupants or residents.⁷

Integrated Pest Management—Integrated pest management is an approach to pest control that focuses on prevention and careful use of pesticides as needed. It employs a variety of pest management methods that are informed by inspection, monitoring, and reporting on the needs of the specific location.²¹

Radon Air Mitigation—Radon air mitigation is a process used to reduce radon gas concentrations in buildings. One method of reducing the concentration is using active soil depressurization, which pulls radon from beneath the house and vents it to the outside.²⁰

Sick Building Syndrome—Various symptoms experienced by building occupants that appear to be linked to time spent in that building and cannot be attributed to a specific illness.⁹

Appendix 2: Summary of Evidence

Because we did not find *systematic reviews* evaluating the health impacts of housing *policies* targeting the physical structure of a home, the topic this rapid review seeks to address, we sought and analyzed two other types of studies: (a) *systematic reviews* of the health impacts of *actual changes* to the physical structure of a home; and (b) *primary research studies* from the past five years evaluating *policies* targeting the physical structure of a home. This appendix summarizes these studies.

AcademyHealth's two-week rapid evidence review process relies on systematic reviews, if available. While we did not identify any systematic reviews examining the impact of housing-focused policies on health, we did find one primary study¹ addressing this issue. It found that two states with lead laws were 79% less likely than a state without legislation to have new lead poisoning cases. While there are differences between the lead laws in stringency and length of time since passage, findings from the study suggest that enforced lead laws reduce new instances of lead contamination in homes regardless of the law's severity or age.

Although there is limited evidence directly evaluating the health implications of housing-focused policies, AcademyHealth did identify² systematic reviews evaluating the health impacts of six types of interventions that address structural, chemical, and biological hazards in the home.

Many of the studies in these systematic reviews focus on interventions that target vulnerable populations in public housing in both the United States and abroad. A key limitation is that this literature relies heavily on self-reported health outcomes instead of more objective measures of indoor environmental quality or independently verified clinical markers.

Dampness and Mold

A systematic review³ evaluating the impact of repairing buildings damaged by dampness and mold on respiratory outcomes found that these types of interventions decrease asthma-related symptoms and respiratory infections compared to no intervention in adults. Review authors noted that the intensity of the interventions varied across the studies evaluated (e.g., some involve surface-level cleaning of visible mold while others involve a retro-fitted insulation package). However, the differences in intensity and "completeness" of the repair did not result in a difference in respiratory symptoms. Authors noted that the quality of evidence varied from low to very low quality based on use of the tool GRADE¹⁰, a Cochrane¹¹ approach for assessing the quality of evidence and the strength of recommendations. Authors note that the studies were set up differently and measured different health outcomes, making it difficult to draw definitive conclusions. An earlier systematic review¹³ of interventions targeting exposure to biological hazards came to similar conclusions, noting that the elimination of moisture intrusion and leaks and removal of mold have been shown to reduce asthma symptoms and medication use among adults, though apart from several larger randomized controlled trials, many studies in this area have small sample sizes and less rigorous designs.

Warmth and Energy Efficiency

A systematic review⁴ evaluating improvements to the physical structure of homes and the practice of moving individuals into new or refurbished homes found that interventions targeting warmth and energy efficiency can lead to improvements in general health, mental health, and respiratory outcomes, particularly when interventions are targeted at individuals with inadequate warmth and those with chronic respiratory disease. These interventions included moving individuals into warmer or more energy efficient housing, or refurbishing their existing home. Review authors note that this positive impact comes from the higher quality studies examined according to the GRADE approach¹⁰ and that the lower quality studies included no contradictory evidence. Most of the higher quality studies were conducted in the United Kingdom or New Zealand. Differences in study design and methods as well as variations in the intervention, sample, context, and outcomes measured limited efforts to quantitatively combine the health impacts observed in these studies.

Asthma Control

Two systematic reviews^{13,14} focused on reducing asthma-related triggers in the home, such as allergens and other irritants, found that multi-component interventions – or those involving a home visit combined with at least one other type of intervention, e.g., installation of air filters, de-humidifiers, patching of holes – can successfully reduce asthma symptom days among children. One review¹⁴ found that the combined effect of these strategies reduced asthma symptoms by 0.8 days per two weeks in children. The number of asthma acute care physician visits was reduced by .57 visits per year. Few studies in both reviews looked at outcomes among adults with asthma, and results were inconsistent. The second review¹³ found moderate evidence for one other intervention: controlling cockroaches in the home through integrated pest management (IPM), or the repair of structural defects that allow roaches to gain access to homes. This review reports that randomized controlled trials of IPM show reductions in the presence of cockroaches in the home, though the studies do not report health outcomes; the remaining body of evidence is of lower quality and found only modest improvements in health outcomes. Evidence from this review on dampness and mold mitigation is reported in the above section.

Injury Prevention

A systematic review¹⁵ evaluating interventions to improve safety and injury-related outcomes in the home found evidence for three interventions, though only two relate to the physical structure of the home. First, five studies within the systematic review show that working smoke alarms reduce death and injuries from residential fires, though authors note that additional evidence is needed to determine the most effective methods of increasing the presence of alarms in homes. Second, review authors found limited evidence on the impact of policies requiring preset hot water temperatures for water heaters in homes. According to the review, several primary studies in states with policies requiring new hot water heaters to have safe temperature presets found reductions in tap water burn injuries among children, though these studies relied on 1983 data. The authors noted that more evidence is needed from states with both mandated policies and voluntary compliance measures.

Exposure to Chemical Agents

A systematic review¹⁶ of interventions to reduce exposure to chemical agents in the home found evidence to support four interventions, though one of these, smoke-free policies, does not relate to the physical structure of the home. For the other three interventions, the authors found that: (1) radon air mitigation through active soil depressurization can lead to a reduction in radon exposure levels that meets the Environmental Protection Agency guidelines, though no health outcomes were reported in the review; (2) integrated pest management, also cited in the asthma control section, can reduce pesticide exposure and lead to a lack of detectable pesticide levels in blood samples of residents; and (3) various multi-component interventions can reduce lead contamination and blood lead levels in children. The authors note that the specific interventions employed are often combined with interventions addressing other hazards (e.g., interventions to reduce asthma symptoms among children) and include building replacement, paint stabilization, paint removal, and cleaning.

Green Buildings

A systematic review of green buildings⁵ found three studies evaluating the impact of green building practices on health outcomes among vulnerable populations, defined as those living in public housing. Authors concluded that green buildings had improved indoor environmental quality, in that they reduced levels of volatile organic compounds, allergens, nitrogen

dioxide, and particulate matter. One study found reductions in self-reported asthma respiratory problems among children and adults for 18 months after they moved from public housing into the renovated green housing space. A second study looking at public housing found a 47% reduction in self-reported sick building syndrome symptoms (e.g., situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building) among green housing tenants after moving from conventional public housing. A third study used a validated survey of physical and mental health combined with objective measurements of allergens and found that cockroach allergen and mouse allergen registered significant sustained reductions three months after the intervention. The 58 individuals who participated in both measurements reported an overall improvement in health of 8%. Review authors noted that the literature lacks studies in which participants are not aware of being placed in green housing, and that most studies rely solely on self-reported measures of health outcomes as opposed to more objective clinical measures or other measures such as indoor environmental quality measurements.

Appendix 3: Search Terms and Databases

The following list shows the basic Boolean search term strategy used for the review. Searches were modified based on search functions within each database used.

Policy terms:

housing AND (policy* OR "local policy*" OR "law*" OR "local laws") AND "health outcomes"

housing AND policy* AND ("environmental health" OR "environmental disparities")

housing AND ("health disparities")

housing AND policy* AND "indoor environment"

"housing policy" AND health

(housing OR "housing code" OR "building code") AND health AND (incentive OR regulation* OR intervention OR policy* OR outcome*)

Housing intervention terms:

health AND housing AND intervention* AND (asthma OR "respiratory health" OR lead OR "lead poisoning" OR "pesticide*" OR "injury*" OR "fire" OR "air quality")

("building codes" OR "housing codes") AND ("health outcomes" OR "health status" OR health)

("built structure" OR "physical structure") AND health

("health outcomes" OR health) AND ("housing code" OR "building code") AND ("vulnerable populations" OR "low income")

("housing codes" OR "building codes" OR "housing policy" or "housing") AND ("environmental disparities" OR "environmental health")

("green housing" OR "green building") AND (health OR "health outcomes")

Databases: Health Systems Evidence, the Cochrane Library, EPPI-Centre Reviews, PubMed, Web of Science Core Collection, ProQuest Social Science Database, and EBSCO Social Sciences Full Text.

Appendix 4: Included Studies

As described in Appendix 2, studies included in this review fall into two categories: (a) *systematic reviews* of the health impacts of *actual changes* to the physical structure of a home; and (b) *primary research studies* from the past five years evaluating *policies* targeting the physical structure of a home. This appendix summarizes these studies in two tables.

Table 4a: Systematic reviews of actual changes to the physical structure of a home

| Author and date | Focus of review | Methods | Relevant findings | Limitations and quality of the evidence as reported by the author | AMSTAR Quality Rating ¹⁹ |
|--|---|--|---|--|-------------------------------------|
| Allen et al., 2015⁵ | Impact of green building design on indoor environmental quality and human health. | <p>Date range: Not specified (most relevant literature is from within the last 15 years).</p> <p>Inclusion criteria: Articles and studies must be peer-reviewed papers or government reports, evaluations of green buildings, data on indoor environmental quality perception or measurements, or data on health, comfort, productivity, or well-being. Studies not limited to housing (e.g., includes office buildings).</p> <p>Quality or strength of evidence assessment: Not specified.</p> | <p>Studies included: 17 studies</p> <p>Effect on health outcomes:</p> <p>Green buildings improved environmental quality, reducing levels of volatile organic compounds, formaldehyde, allergens, nitrogen dioxide, and particulate matter. Findings suggest that elements of green building design that seek to improve environmental quality reduce exposure to contaminants that have been linked to adverse health effects</p> <p>Three studies specific to vulnerable populations (e.g., those living in public housing) were included:</p> <p>One study found reductions in self-reported asthma respiratory problems (e.g., emphysema, hay fever, sinusitis, and chronic bronchitis) among children and adults 18 months after moving from public housing into the renovated green housing space.</p> <p>A second study looking at public housing found a 47% reduction in self-reported sick building syndrome symptoms among green housing tenants after moving from conventional public housing. Environmental sampling also showed significantly lower PM2.5, NO2, and nicotine in green homes compared to conventional apartments, despite air-exchange rate being lower in the green homes. Other benefits include fewer reports of pests, fewer water-related issues, and fewer inadequate ventilation issues.</p> <p>A third study used a validated survey of physical and mental health with objective measurements of</p> | <p>Limitations:</p> <p>No studies blind occupants to their exposure group (i.e., individuals in the studies were aware if they were placed in improved or green housing).</p> <p>Most studies rely on self-reported and subjective measures to determine impact on health outcomes.</p> | 8/11 |

| Author and date | Focus of review | Methods | Relevant findings | Limitations and quality of the evidence as reported by the author | AMSTAR Quality Rating ¹⁹ |
|--|---|--|---|---|-------------------------------------|
| | | | <p>allergens. Measurements were taken at baseline and one year after study subjects moved to a renovated space certified LEED Gold.⁸ Cockroach allergen (and mouse allergen) registered significant sustained reductions three months after the intervention. The 58 individuals who participated in both measurements reported an overall improvement in health of 8%.</p> | | |
| <p>Sauni et al., 2015³</p> | <p>Impact of repairing buildings damaged by dampness and mold on respiratory symptoms and asthma.</p> | <p>Date range: No date limitations.</p> <p>Inclusion criteria: Randomized controlled trials (RCTs), cluster-RCTs (cRCTs), interrupted time series studies, and controlled before-after (CBA) studies. Buildings other than homes (e.g., office spaces, schools) were also included.</p> <p>Exclusion criteria: Prospective studies without a control group. Did not exclude based on language.</p> <p>Quality or strength of evidence assessment: Used Cochrane “Risk of Bias” tool to assess methodological quality of studies.¹² Used Cochrane GRADE¹⁰ tool to evaluate the quality of the evidence and the strength of recommendations.</p> | <p>Studies included: 12 studies were included: two RCTs, one cluster RCT, and nine cost benefit analysis studies. The interventions varied from thorough renovation to cleaning only.</p> <p>Effect on health outcomes:</p> <p>The authors found moderate to very low-quality evidence that repairing mold-damaged houses and offices decreases asthma-related symptoms and respiratory infections compared to no intervention in adults.</p> <p>The review pooled results from three high quality studies and found significant improvements in asthma symptoms in adults when mold removal was compared with no intervention.</p> | <p>The quality of evidence varied from very low to moderate quality.</p> <p>Many different symptoms were measured and studies were set up differently, which makes comparison difficult.</p> <p>Double-blinding and placebo controls are difficult to include in the designs of studies examining the effects of moisture remediation in damaged buildings.</p> <p>Variation in follow-up time may not be enough to detect improvement or lack thereof of respiratory symptoms.</p> | <p>10/11</p> |
| <p>Thompson et al., 2013⁴</p> | <p>Impact of “rehousing” and housing improvement on health.</p> | <p>Date range: No date limitations, though studies relevant to this review are from the past 30 years.</p> <p>Inclusion criteria: Studies which assessed change in any health outcome following an improvement to</p> | <p>Studies included: Thirty-nine studies which reported quantitative or qualitative data, or both, were included in the review.</p> <p>Effect on health outcomes:</p> <p><i>Warmth and energy efficiency improvements:</i> Among the higher quality studies, those looking at warmth and energy efficiency interventions suggest improvements</p> | <p>Authors were unable to complete at least two of the required fields for the Hamilton tool to assess bias, suggesting there is a considerable risk of bias and that the overall quality of the evidence is poor, and in many</p> | <p>10/11</p> |

| Author and date | Focus of review | Methods | Relevant findings | Limitations and quality of the evidence as reported by the author | AMSTAR Quality Rating ¹⁹ |
|--|--|--|---|--|-------------------------------------|
| | | <p>the physical structure of the house were included. Studies conducted in high, middle, and low income countries were included.</p> <p>Exclusion criteria: Cross-sectional studies were excluded as correlations are not able to shed light on changes in outcomes. Studies reporting only socio-economic outcomes or indirect measures of health, such as health service use, were excluded. Excluded interventions included improvements to mobile homes; modifications for mobility or medical reasons; air quality; lead removal; radon exposure reduction; allergen reduction or removal; and furniture or equipment. The study of these and other air pollutants has been well established and there are existing measures and documented strategies for limiting exposure.</p> <p>Quality or strength of evidence assessment: Used Cochrane “Risk of Bias” tool to assess methodological quality of studies.¹² Used Cochrane GRADE¹⁰ tool to evaluate the quality of the evidence and the strength of recommendations.</p> | <p>in general health, respiratory health, and mental health, particularly for those with chronic respiratory disease.</p> <p>Two RCTs from New Zealand found improvements in all the general health and respiratory health measures assessed, many of which were statistically significant. Both of these studies included children and targeted households known to have inadequate warmth and at least one household member with a diagnosed respiratory condition.</p> <p><i>Rehousing or retrofitting:</i> The higher quality studies (Grade A or B) within this group all evaluated programs in the United Kingdom involving neighborhood renewal. These studies produced no clear evidence on the health impacts of the interventions evaluated. Although some studies reported improvements in general health and mental health, only one study produced a statistically significant finding, and others reported no overall change.</p> | <p>cases, the level of potential bias is largely unknown.</p> <p>Very little quantitative synthesis was possible due to variations in the study methods, the interventions tested, and the outcomes of interest.</p> <p>The majority of identified studies come from the United Kingdom (n = 21, or 66%), suggesting a gap in the evidence for other countries and contexts.</p> <p>Many studies did not provide sufficient detail on the baseline characteristics of the homes or the health status of the individuals. This means it was hard to assess differences in the potential to benefit (e.g., understanding differences in the housing and health status at baseline in each study would be important for understanding the impact of each intervention for populations with differing health needs).</p> | |
| Crocker et al., 2011 ¹⁴ | <p>Effectiveness of environmental interventions for reducing asthma morbidity.</p> | <p>Date range: 1996-2008</p> <p>Inclusion criteria: (1) primary, peer-reviewed studies (2) meets <i>Community Guide</i> minimum research quality standards for design and</p> | <p>Note: This systematic review looked at both structural and non-structural interventions to reduce asthma triggers, including educational interventions; however, only relevant findings related to structural interventions are reported here.</p> | <p>Interventions in this review were heterogeneous—the outcomes and effects collected across studies varied, making it difficult in some cases to</p> | <p>10/11</p> |

| Author and date | Focus of review | Methods | Relevant findings | Limitations and quality of the evidence as reported by the author | AMSTAR Quality Rating ¹⁹ |
|---|--|---|---|---|-------------------------------------|
| | | <p>execution; (3) evaluates at least one home visit, (4) targets more than one asthma trigger; (5) includes more than one intervention component (in particular an environmental component); (6) includes at least one health outcome.</p> <p>Exclusion criteria: Studies that evaluated primary prevention of asthma or occupational asthma.</p> <p>Quality or strength of evidence assessment: Authors used <i>Community Guide</i> standards and processes for rating studies based on study design and execution.¹⁸</p> | <p>Studies included: Twenty-three studies, of which 20 focused on children and adolescents and three focused on adults.</p> <p>Effect on health outcomes:</p> <p>This review found that interventions involving home visits combined with other moderate changes to the housing structure (e.g., installation of air filters, dehumidifiers, patching of holes) might successfully reduce asthma symptom days by 0.8 days per two weeks in children. The number of asthma acute care visits were reduced by .57 visits per year.</p> <p>Only three studies looked at outcomes among adults with asthma, and results were inconsistent.</p> <p>There are few studies on the impact of larger structural changes (e.g., replacement of ventilation systems, roofing), and among those studies, there was no clear evidence that those larger changes had a greater impact on health outcomes than more modest changes.</p> | <p>combine and summarize. As a result, authors used descriptive statistics to represent the combined effect of interventions instead of meta-analysis.</p> <p>Because this review evaluated multi-component interventions, it was difficult to isolate the specific impact of each intervention, thus limiting the authors' ability to draw conclusions about the specific benefit of any one intervention.</p> | |
| <p>Jacobs et al., 2010¹⁷</p> <p>This systematic review was published as a series of five papers: a summary of methods and findings (cited above) and four supporting papers, each focused on a particular housing-related health risk. Three of the supporting papers are relevant to this rapid review and are cited below:</p> | <p>Systematic review series (four articles in total) on the effectiveness of housing interventions associated with exposure to biological and chemical agents, structural injury hazards, and community level interventions.</p> | <p>Date range: 1990-2007</p> <p>Inclusion criteria: A team of non-government researchers and experts in this field formed five separate panels evaluating different housing interventions related to (1) asthma, (2) injury related structural deficiencies, (3) chemical agents, (4) neighborhood level interventions, and (5) drinking water and sewage treatment. Note: Findings from the fifth panel were not included in the Jacobs 2010 summary. These panels created a prioritized list of interventions to search for within each category.</p> | <p>Studies included: A complete list of included studies for each supporting article can be found in each article's reference list.</p> <p>Effect on health outcomes:</p> <p><u>Biological agents:</u> (Krieger et al., 2010¹³) Three interventions have sufficient evidence of effectiveness. (1) Multi-component, in-home tailored interventions for asthma (e.g., home environmental assessment for asthma pillow covers, use of high-efficiency particulate air vacuums and filters, minor repairs, and cleaning) have been shown to reduce asthma symptoms and health care use. (2) Cockroach control through integrated pest management: Repairing structural defects that allow roaches to gain access has been shown to reduce exposure to cockroaches, though several rigorous RCT studies do not report on health outcomes, and the remaining body of evidence is of lower quality and found only modest improvements in health outcomes. (3) Interventions that combine elimination of moisture</p> | <p>Authors mentioned that having at least 2 readers for each article would have been preferred.</p> <p>Panelists had limited time to review articles in preparation for the in-person meeting.</p> <p>Limited studies from outside the US were included.</p> | 6/11 |

| Author and date | Focus of review | Methods | Relevant findings | Limitations and quality of the evidence as reported by the author | AMSTAR Quality Rating ¹⁹ |
|--|-----------------|--|---|---|-------------------------------------|
| <p>Biological agents: Krieger et al., 2010¹³</p> <p>Injury-related structural deficiencies: DiGuseppi et al., 2010¹⁵</p> <p>Chemical agents: Sandel et al., 2010¹⁶</p> <p>Findings from the fourth supporting article (Lindberg et al., 2010),²² which focused on neighborhood-level health risks, were not relevant to or included in this rapid evidence review.</p> | | <p>Exclusion criteria: Studies not published in English. While most studies reviewed by panelists were conducted in the U.S., panelists did consider non-U.S. studies.</p> <p>Quality or strength of evidence assessment: At least one panelist reviewed each publication. Panelists evaluated each publication by using a structured review instrument and review procedure adapted from the <i>Community Guide</i>¹⁸ (see figure in publication for adapted instrument used). Panelists reviewed more than 170 studies in advance of an in-person meeting, for which each panel prepared an assessment of the body of literature that was given to the full group of experts from other panels. Deliberations from the in-person meeting were used to form the findings of this review.</p> | <p>intrusion and leaks and removal of mold have been shown to reduce asthma symptoms and medication use, though apart from several larger RCTs, several studies in this area have small sample sizes and less rigorous designs.</p> <p><u>Injury-related structural deficiencies:</u> (DiGuseppi et al., 2010)¹⁶ Three of the 17 interventions studied had sufficient evidence for implementation. (1) Working smoke alarms: Five studies show that working alarms reduce death and injuries from residential fires, (2) Four-sided pool fencing: Three studies and one systematic review found that fencing surrounding a pool decreases risk of childhood drowning; in one study, the risk of drowning was three times lower in a pool with complete fencing. (3) Preset safe hot water temperatures: While the evidence is limited, several primary studies found reductions in tap water burn injuries in states with policies requiring new hot water heaters to have safe temperature presets. More evidence is needed from states with voluntary compliance measures.</p> <p><u>Chemical agents:</u> (Sandel et al., 2010)¹⁶ Four of the 14 interventions reviewed had sufficient evidence to demonstrate effectiveness. (1) Radon air mitigation using active soil depressurization: Seven studies report that using this technique leads to radon exposure levels that meet Environmental Protection Agency guidelines; no health outcomes were reported in the review. (2) IPM to reduce pesticide exposure: One study found that this intervention leads to lower levels of insecticides in the home and lack of detectable pesticide levels in blood samples of residents. (3) Smoke-free home policies: Primary studies and several government and grey reports cite that smoke-free policies lead to lower levels of second-hand smoke exposure. (4) Residential lead hazard control: The review cites the large literature base indicating that residential lead hazard control is effective in reducing lead contamination and blood lead levels in children. The specific interventions employed are multi-faceted and include building replacement, paint stabilization, paint removal, and cleaning.</p> | | |

Table 4b: Primary research studies evaluating policies

| Author, date, and title | Methods | Study population | Key features of intervention | Relevant findings | Limitations in the study as reported by the author |
|--|---|--|--|---|--|
| <p>Kennedy et al., 2014¹</p> <p>Primary prevention of lead poisoning in children: a cross-sectional study to evaluate state specific lead-based paint risk reduction laws in preventing lead poisoning in children.</p> | <p>A cross-sectional study was conducted to compare lead poisoning among children at residential addresses identified between 2000 and 2009, in two states with and one state without laws to prevent childhood lead poisoning among children younger than 72 months.</p> | <p>682 residential addresses across three states: Mississippi (MS), Ohio (OH), and Massachusetts (MA).</p> | <p>To determine whether the lead laws were effective in preventing subsequent cases of lead poisoning detected in privately-owned residential addresses after the identification of a possible lead contaminant.</p> | <p>The two states with lead laws, MA and OH, were 79% less likely than the one without legislation, MS, to have residential addresses with subsequent lead poisoning cases among children younger than 72 months.</p> <p>The MA lead law is more stringent and has been enforced for a longer period of time than the OH law.</p> <p>Despite these differences, this study suggests that enforced lead laws of varying stringency can effectively reduce subsequent lead poisoning among children younger than 72 months.</p> | <p>Demographic and environmental data was unavailable at the address level, which may have limited the ability to adequately control for external factors.</p> <p>Individuals moving away from the addresses selected may have limited the ability to capture the true exposure experiences of individuals who may have been diagnosed with lead exposure.</p> <p>Other possible confounding factors include the inability to control for certain ecological factors, like differences across states in the number of privately owned rental and owner occupied addresses.</p> |

Endnotes

1. Kennedy, C., Lordo, R., Sucusky, M. S., Boehm, R., & Brown, M. J. (2014). Primary prevention of lead poisoning in children: a cross-sectional study to evaluate state specific lead-based paint risk reduction laws in preventing lead poisoning in children. *Environmental Health*, 13, 93. <http://doi.org/10.1186/1476-069X-13-93>
2. Note: AcademyHealth excluded a systematic review if (1) it was already incorporated into a more recent systematic review, or (2) its primary focus was evaluating external area or neighborhood level factors (e.g., neighborhood safety, pollution, walkability) or the impact of educational interventions (e.g., proper cleaning practices).
3. Sauni R, Verbeek JH, Uitti J, Jauhiainen M, Kreiss K, Sigsgaard T. Remediating buildings damaged by dampness and mould for preventing or reducing respiratory tract symptoms, infections and asthma. *Cochrane Database of Systematic Reviews* 2015, Issue 2. Art. No.: CD007897. DOI: 10.1002/14651858.CD007897.pub3.
4. Thomson H, Thomas S, Sellstrom E, Petticrew M. Housing improvements for health and associated socio-economic outcomes. *Cochrane Database of Systematic Reviews* 2013, Issue 2. Art. No.: CD008657. DOI: 10.1002/14651858.CD008657.pub2.
5. Allen, J. G., MacNaughton, P., Laurent, J. G. C., Flanigan, S. S., Eitland, E. S., & Spengler, J. D. (2015). Green Buildings and Health. *Current Environmental Health Reports*, 2(3), 250–258. <http://doi.org/10.1007/s40572-015-0063-y>
6. US Green Building Council. What is green building? 2014. Retrieved from: <http://www.usgbc.org/articles/what-green-building>
7. US Green Building Council. What is indoor environmental quality? 2014. Retrieved from: <http://www.usgbc.org/articles/green-building-101-what-indoor-environmental-quality>
8. US Green Building Council. LEED. [No date]. Retrieved from: <http://www.usgbc.org/leed>
9. Joshi, S. M. (2008). The sick building syndrome. *Indian Journal of Occupational and Environmental Medicine*, 12(2), 61–64. <http://doi.org/10.4103/0019-5278.43262>
10. Cochrane. GRADE approach to evaluating the quality of evidence: a pathway. [No Date]. Retrieved from: <http://training.cochrane.org/path/grade-approach-evaluating-quality-evidence-pathway>
11. Note: The Cochrane Collaboration, now called Cochrane, is an independent, non-profit, non-governmental organization consisting of a global independent network of researchers, health care professionals, patients, and other individuals who produce systematic reviews and other synthesized research evidence, which is published in the Cochrane Library. Retrieved from: <http://www.cochrane.org/about-us>
12. Cochrane. Assessing risk of bias in included studies. [No date]. Retrieved from: <http://methods.cochrane.org/bias/assessing-risk-bias-included-studies>. Source cited in review: Higgins JPT, Green S (editors). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from www.cochrane-handbook.org. Chichester, UK: John Wiley & Sons, Ltd.
13. Krieger J, Jacobs DE, Ashley PJ, et al. Housing Interventions and Control of Asthma-Related Indoor Biologic Agents: A Review of the Evidence. *Journal of public health management and practice* : JPHMP. 2010;16(5 0):S11-S20. doi:10.1097/PHH.0b013e3181ddcbd9.
14. Crocker DD, Kinyota S, Dumitru GG, Ligon CB, Herman EJ, Ferdinands JM, Hopkins DP, Lawrence, BM, Sipe TA, Task Force on Community Preventive Services. Effectiveness of home-based, multi-trigger, multicomponent interventions with an environmental focus for reducing asthma morbidity: a Community Guide systematic review. *Am J Prev Med*2011;41(2S1):S5-32.
15. DiGuseppi C, Jacobs DE, Phelan KJ, Mickalide A, Ormandy D. Housing Interventions and Control of Injury-Related Structural Deficiencies: A Review of the Evidence. *Journal of public health management and practice* : JPHMP. 2010;16(5 Suppl):S34-S43. doi:10.1097/PHH.0b013e3181e28b10.
16. Sandel M, Baeder A, Bradman A, et al. Housing interventions and control of health-related chemical agents: A review of the evidence. *Journal of Public Health Management and Practice*. 2010;16(5 Suppl):S24-33.
17. Jacobs DE, Brown MJ, Baeder A, Scalia Sucusky M, Margolis S, Hershovitz J, Kolb L, Morley, RL. A Systematic Review of Housing Interventions and Health: Introduction, Methods, and Summary Findings. *J Public Health Management Practice*, 2010, September (Suppl), S3–S8.
18. Zaza S, Carande-Kulis V, Sleet DA, et al. Methods for conducting systematic reviews of the evidence of effectiveness and economic efficiency of interventions to reduce injuries to motor vehicle occupants. *Am J Prev Med* 2001;21(4S):S23–S30. www.thecommunityguide.org/mvoi/mvoi-AJPM-methods.pdf.
19. Note: Reviewer completed using the “A Measurement Tool to Assess Systematic Reviews” AMSTAR Checklist available at http://amstar.ca/Amstar_Checklist.php

20. Environmental Protection Agency. A Citizen's Guide to Radon: The Guide to Protecting Yourself and Your Family from Radon. 2012. Retrieved from: <https://www.epa.gov/radon/citizens-guide-radon-guide-protecting-yourself-and-your-family-radon>
21. Environmental Protection Agency. Introduction to Integrated Pest Management. N.D. Retrieved from: <https://www.epa.gov/managing-pests-schools/introduction-integrated-pest-management>
22. Lindberg RA, Shenassa ED, Acevedo-Garcia D, Popkin SJ, Villaveces A, Morley RL. Housing interventions at the neighborhood level and health: a review of the evidence. *J Public Health Manag Pract.* 2010 Sep-Oct;16(5 Suppl):S44-52.