Valuing Deep Retrofits

How better residential buildings can lower healthcare costs in Alberta

May 2025

Raidin Blue, Ceileigh McAllister, Rachel Sutton

revised June 2025

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Raidin Blue

Ceileigh McAllister • Rachel Sutton

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Contributors: Heidi Hamm

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The Pembina Institute
#802, 322 – 11 Avenue SW
Calgary, AB T2R 0C5
403-269-3344

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The Pembina Institute recognizes that the work we steward and those we serve span the lands of many Indigenous Peoples. We respectfully acknowledge that our organization is headquartered in the traditional territories of Treaty 7, comprising the Blackfoot Confederacy (Siksika, Piikani and Kainai Nations); the Stoney Nakoda Nations (Goodstoney, Chiniki and Bearspaw First Nations); and the Tsuut'ina Nation. These lands are also home to the Otipemisiwak Métis Government (Districts 5 and 6).

These acknowledgements are part of the start of a journey of several generations. We share them in the spirit of truth, justice and reconciliation, and to contribute to a more equitable and inclusive future for all.

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Executive summary

Protecting the health and safety of Albertans through energy-efficient solutions like deep retrofits has never been more important. How we insulate, heat, and cool our homes and businesses impacts more than just our utility bills. Poor-quality housing — characterized by inadequate insulation, poor ventilation, and outdated heating and cooling systems — can harm respiratory, cardiovascular, and mental health.

This report demonstrates how deep retrofits can improve quality of life and reduce healthcare expenditures. Factoring in healthcare cost savings alongside energy cost savings strengthens the business case for deep retrofits by highlighting non-energy benefits such as improved health and safety, greater building resilience, reduced insurance costs, and improved affordability for building owners and occupants. Now is the time to reframe deep retrofits as the pathway to healthier homes and healthcare cost savings for Albertans.

Our analysis showcases several international examples of how retrofit programs significantly lowered healthcare and energy costs. Alberta, in collaboration with municipalities, community organizations, industry associations and others, can achieve these same outcomes by (1) filling in data gaps on the relationship between building conditions and health outcomes, (2) including health-related indicators in retrofit programs, and (3) investing in retrofits that improve health, particularly in vulnerable households. These three actions would advance the business case for deep retrofits while ensuring investments in retrofits leave no one behind.

1. Introduction

Canadians spend around 90% of their time indoors, which means their health is affected by building quality. Poor-quality buildings can harm respiratory, cardiovascular, and mental health, causing illness and potentially premature death and generating healthcare costs. In this report, we demonstrate how deep retrofits can improve quality of life and decrease healthcare expenditures.

Energy efficiency has traditionally been the driving factor behind deep retrofits because they reduce energy and maintenance costs. However, the impetus for deep retrofits needs to be broadened to include non-energy benefits such as better health, greater resiliency, reduced insurance costs, and enhanced affordability. It is time to reframe deep retrofits as a way not just to save energy, but also to create healthier homes and healthcare savings.

Our earlier research, *Healthy Buildings in a Changing Climate*, discussed how deep retrofits provide immediate health benefits during acute events, such as by reducing exposure to wildfire smoke and extreme heat.[1] In this report, we expand on that work by exploring the chronic health impacts of poor-quality housing on Albertans and how deep retrofits can mitigate those risks.

For ease of understanding, we have converted all financial amounts from published research into 2024 Canadian dollars.

[1] Raidin Blue and Betsy Agar, *Healthy Buildings in a Changing Climate: Improving health with multi-unit residential building retrofits* (Pembina Institute, 2024). https://www.pembina.org/pub/healthy-buildings-changing-climate

2. The relationship between buildings and health

Poor-quality buildings fail to provide safe, healthy, and comfortable environments. While there is no set definition for poor-quality buildings, they may be characterized as having inadequate insulation; outdated heating, ventilation, and air conditioning (HVAC) systems; and insufficient weatherproofing. All of these increase an occupant's exposure to the outdoor environment — be it unwanted heat or cold, moisture, or air pollution. As we discuss below, these exposures can worsen respiratory, cardiovascular, and mental health, as well as affect overall comfort.

Breaking down the quality of Alberta's housing stock is also not easily done, but we know that building quality will reflect changes to building codes over time. For example, older homes built before the 1970s likely lack adequate insulation because energy-efficiency standards were introduced in the late 1970s and gradually improved over time.[2] More definitively, according to the Canada Mortgage and Housing Corporation's Housing Market Information Portal, 42% of the 598,000 Alberta homes built before 1980 need repairs and upgrades.[3]

2.1 Air quality

In Alberta, the three most common and concerning air pollutants are fine particulate matter ($PM_{2.5}$), ground-level ozone and nitrogen oxides (specifically nitrogen dioxide). The federal standards to mitigate risks to human health and the environment for these air pollutants, as well as sulphur dioxide, are set out in the Canadian Ambient Air Quality Standards (CAAQS).[4] The Government of Alberta produces an annual report assessing air quality in the province's six "air zones" against the CAAQS. The latest report, published in 2025, contains the findings on air quality for 2020–2022.[5] Although these two resources provide information on the most common air pollutants Albertans are exposed to, there are no safe levels of exposure to $PM_{2.5}$, ground-level ozone and nitrogen dioxide. According to a Health Canada report, health effects

[2] Associate Committee on the National Building Code, *Measures for Energy Conservation in New Buildings 1978* (National Research Council of Canada, 1978). https://doi.org/10.4224/40001626

[3] Canadian Mortgage and Housing Corporation, "Alberta — Housing Stock (2021)," *Housing Market Information Portal*. https://www03.cmhc-schl.gc.ca/hmip-pimh/en#Profile/48/2/Alberta

[4] Canadian Council of Ministers of the Environment, "Canada's Air." https://ccme.ca/en/air-quality-report

[5] C. Brown, R. Duruisseau-Kuntz, C. Stanley, T. Tokarek, and A. Thi, *Status of Air Quality in Alberta: Air Zones Report 2020-2022* (Government of Alberta, 2025). https://open.alberta.ca/publications/alberta-air-zones-report

are observed at very low concentrations of these air pollutants, and "any incremental increase in air pollutant concentration is associated with an increased risk of adverse health outcomes."[6]

Air pollution is one of the leading risks of illness and premature death in Canada, with almost two-thirds of premature deaths from air pollution attributed to $PM_{2.5}$, a quarter to ground-level ozone, and 8% to nitrogen dioxide.[7] In Alberta, air pollution contributes to approximately 1,400 premature deaths each year, costing the province $12.99 billion annually.[8] Canada's national average (42 premature deaths per 100,000 Canadians)[9] is higher than Alberta's (33 per 100,000).

Harmful outdoor air pollutants

$PM_{2.5}$ is a particle size (2.5 micrometres), not a specific chemical, that can only be reliably detected with monitoring devices.

Ground-level ozone is not a direct emission but is created when nitrogen oxides and volatile organic compounds interact with sunlight. It is a major component of smog but is odourless and colourless at low levels.

Nitrogen dioxide is released from the combustion of fossil fuels by vehicles and generators and is visibly reddish brown with a pungent odour.

Poor-quality buildings increase their occupants' exposure to outdoor air — and consequently to these three air pollutants — thereby threatening their health.

Health Canada research highlights the health risks posed by air pollution:[10]

- Acute exposure to nitrogen dioxide and ground-level ozone likely have a causal link with death.
- $PM_{2.5}$ and ground-level ozone have causal relationships with respiratory problems and asthma symptoms and result in emergency room visits, hospitalizations, and restricted days of activity for those affected.

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[6] Health Canada, *Health Impacts of Air Pollution in Canada: Estimates of morbidity and premature mortality outcomes – 2021 Report* (2021), 7. https://www.canada.ca/en/health-canada/services/publications/healthy-living/health-impacts-air-pollution-2021.html

[7] *Health Impacts of Air Pollution in Canada*, 4, 27.

[8] *Health Impacts of Air Pollution in Canada*, Table 4, 18.

[9] *Health Impacts of Air Pollution in Canada*, Table 4, 18.

[10] *Health Impacts of Air Pollution in Canada*, Table 1, 12.

- $PM_{2.5}$ also has a causal link to cardiac emergency room visits and hospital admissions, child acute bronchitis episodes, and death from chronic exposure.

Nitrogen dioxide, $PM_{2.5}$, and ground-level ozone are all outdoor air pollutants that can get into homes, but there are also indoor air pollutants that pose serious health risks.[11]

Harmful indoor air pollutants

In Canada, radon is responsible for over 3,000 deaths per year and is the second leading cause of lung cancer.[12] It is a radioactive gas that vents from soil and can seep into homes through cracks in the foundation, construction joints, and gaps around pipes. Outdoors, it is not a problem, but it can accumulate in enclosed, poorly ventilated spaces, such as a basement, and is undetectable without testing.

Carbon monoxide is a colourless, odourless gas produced by incomplete fossil fuel combustion. Again, without proper ventilation or detection, carbon monoxide accumulates indoors. It can come from malfunctioning appliances, such as a furnace or gas stove, or even from vehicles in an attached garage. Exposure causes dizziness and confusion at low levels, and coma or death at high levels. About 300 Canadians die from carbon monoxide poisoning each year.[12]

Mould is naturally present in the environment. Unlike radon and carbon monoxide, which are a defined chemical element and compound, respectively, mould is a fungal organism. Therefore, its sources and impacts are more diverse. Mould grows indoors in moist environments (kitchens, washrooms, basements) and often results from leaks, poor drainage, or inadequate ventilation. Mould spores can irritate the eyes, nose, and throat, making breathing difficult and worsening asthma symptoms.

Health Canada has resources to help people understand and reduce the health risks of indoor air quality from wildfire smoke, flooding, carbon monoxide, mould, and radon.[13] They have also established recommended exposure limits for indoor air pollutants.[14] Unfortunately, the latter resource is currently of limited applicability in Alberta due to a lack of granular data. As we mentioned earlier, Alberta monitors ambient air quality throughout the province. However, the

[11] Health Canada, "Indoor Air Quality," August 29, 2022. https://www.canada.ca/en/environment-climate-change/campaigns/canadian-environment-week/clean-air-day/indoor-quality.html

[12] Health Canada, "Radon – What you need to know," January 3, 2024. https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/radon-what-you-need-to-know.html

[13] "Indoor Air Quality."

[14] Health Canada, "Indoor air quality resources for professionals," November 5, 2024. https://www.canada.ca/en/health-canada/services/air-quality/residential-indoor-air-quality-guidelines.html

government does not have a monitoring program for indoor air quality, rendering it a challenge to determine the exposure to air pollutants faced by Albertans indoors. To better identify how building quality affects the health of Albertans — and thus how beneficial deep retrofits could be — we would need to know exposure levels to air pollution by building type, particularly for poor-quality and older buildings, and by location.

Concerns about retrofits also need to be addressed. One such concern is that enhancing the air tightness of a building reduces the exchange of air, thereby preventing homes from "breathing." This concern can be allayed by taking a systems approach to retrofits. For example, considering energy-efficiency improvements alongside ventilation upgrades and manually venting (i.e., running exhaust fans, opening windows) when cooking or showering. Retrofits approached in such an integrated manner can improve indoor air quality, lower respiratory and cardiovascular risks, and reduce the strain on Alberta's healthcare system.

2.2 Air temperature

2.2.1 Heat

Extreme heat is the leading weather-related cause of death in Canada, and recent heatwaves tell us that health impacts often happen inside homes. In 2021, Western Canada faced a deadly heatwave that killed nearly 700 people (619 in B.C. and 66 in Alberta). In B.C., 98% of the deaths happened at home.[15] In Alberta, calls to emergency services increased by 70%.[16] Although Alberta-specific data for the heatwave is limited, data from B.C. revealed the following costs to the healthcare system: [17]

- Hospitalizations for dehydration rose by 136%, with an average treatment cost of $4,892 per patient.
- Heatstroke admissions increased by 16,876%, costing $10,317 per patient.

[15] BC Coroners Service, *Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021* (2022). https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-and-divorce/deaths/coroners-service/death-review-panel/extreme_heat_death_review_panel_report.pdf

[16] Lisa Johnson, "Alberta saw spike in reported deaths during heatwave, causes still under investigation," *Edmonton Journal*, July 7, 2021. https://edmontonjournal.com/news/local-news/alberta-saw-spike-in-reported-deaths-during-heatwave-causes-still-under-investigation

[17] Dale Beugin et al., *The Case for adapting to extreme heat: costs of the 2021 B.C. heat wave* (Canadian Climate Institute, 2023), 33, Table 5. https://climateinstitute.ca/wp-content/uploads/2023/06/The-case-for-adapting-to-extreme-heat-costs-of-the-BC-heat-wave.pdf

There are also links between extreme heat and worsened mental health, including suicidal behaviour.[18]

As extreme weather events become more frequent and severe, we are reminded that many buildings in Alberta are not built for events such as the 2021 heat wave. At that time, only 37% of homes in the province had air conditioning, compared to 75% and 90% in Saskatchewan and Manitoba, respectively.[19] Heat-related health incidents and fatalities will continue to increase, along with healthcare costs, unless homes are retrofitted.

2.2.2 Cold

Research on energy poverty provides us with the greatest insights on how cold impacts health.[20] The research shows that people living in energy poverty are more likely to experience:

- poor physical and mental health
- cardiovascular and respiratory diseases
- hospitalizations and premature death

Energy poverty describes the financial struggle or inability of households to heat and cool their homes and to power their appliances.[21] In Canada, a common indicator is households spending over 6% of their income on energy bills.[22] By this measure, around 16% of Alberta households classify as experiencing energy poverty (about 261,750 homes), slightly below the national average of 20%.[23] Energy poverty can arise from a combination of low income, high utility bills, and energy inefficient homes.[24] This often result in homes that are too hot or too cold, leading to adverse health outcomes.

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[18] Moustaq Karin Khan Rony and Hasnat M. Alamgir, "High temperatures on mental health: Recognizing the association and the need for proactive strategies—A perspective," *Health Science Reports* 6, no. 12 (2023). https://doi.org/10.1002/hsr2.1729

[19] Statistics Canada, "Table 38-10-0019-01 Air conditioners," March 24, 2023. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810001901

[20] Mylène Riva et al., "Energy poverty: an overlooked determinant of health and climate resilience in Canada," *Canadian Journal of Public Health* 114 (2023) 426. https://doi.org/10.17269/s41997-023-00741-0

[21] Jessica McIlroy and Betsy Agar, *Affordable Home Energy for All: How Alberta can help its most vulnerable households escape energy poverty* (Pembina Institute, 2025). https://www.pembina.org/pub/affordable-home-energy-all

[22] Canadian Urban Sustainability Practitioners, "The Many Faces of Energy Poverty in Canada." https://energypoverty.ca/

[23] Efficiency Canada, "Energy Poverty in Canada." https://www.efficiencycanada.org/energy-poverty-in-canada/

[24] *Affordable Home Energy for All: How Alberta can help its most vulnerable households escape energy poverty*.

Homes that are too cold are linked to cardiovascular issues (heart attacks, strokes) and respiratory issues (particularly for those with asthma and chronic obstructive pulmonary disease), mental health strain, and greater rates of death in the winter.[25,26]

A population-level study in Ontario on the effects of temperature on non-accidental deaths found that for each 5°C change in daily temperature, there were seven excess deaths per day during cold seasons, and four during warm seasons.[27] The authors also noted that the effects of the cold on Canadians needs to be better characterized. Although this analysis focused on Ontario, it projected that excess deaths in both the summer and the winter will increase in Canada under climate change.[28]

Due to limited data, it is difficult to assess the health impacts of temperature in Alberta. The case studies in the following section show that homes retrofitted with upgraded insulation had lower mortality rates. Given Alberta's unique climate, which sees lows below −35°C and highs above 35°C,[29] there is a heightened need to investigate how building performance affects health and what benefits can be derived from retrofits.

What has been proven is that buildings that are more airtight and that have insulation with a high R-value[30] and efficient heating systems reduce temperature-related health risks and improve comfort for their occupants. Deep retrofits can achieve these outcomes, as well as reduce energy consumption, lower heating bills and enhance building resiliency.

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[25] Marmot Review Team, *The Health Impacts of Cold Homes and Fuel Poverty,* prepared for Friends of the Earth (2011). https://www.instituteofhealthequity.org/resources-reports/the-health-impacts-of-cold-homes-and-fuel-poverty/the-health-impacts-of-cold-homes-and-fuel-poverty.pdf

[26] World Health Organizations, *WHO Housing and health guidelines* (2018). https://www.who.int/publications/i/item/9789241550376

[27] Hong Chen et al., "Assessment of the effect of cold and hot temperatures on mortality in Ontario, Canada: A population-based study," *Canadian Medical Association Journal* 4, no. 1, E48–E58 (2016). https://doi.org/10.9778/cmajo.20150111

[28] Christopher Hebbern et al., "Future temperature-related excess mortality under climate change and population aging scenarios in Canada," *Canadian Journal of Public Health* 114, 726–736 (2023). https://doi.org/10.17269/s41997-023-00782-5

[29] Government of Canada, "Canadian Climate Normals 1991-2020 Data" March 20, 2025. https://climate.weather.gc.ca/climate_normals/index_e.html

[30] An R-value indicates the capacity of the insulation to resist heat flow; the greater the R-value, the better the insulation is at keeping a building cooler during the summer and warmer in the winter.

3. How buildings impact health in Alberta

As described earlier in this report, Alberta households significantly lag behind Saskatchewan and Manitoba in terms of having air conditioning, and in the 2021 heat wave, 66 Albertans died. Findings into the deaths that occurred in B.C. revealed that they were clearly linked to homes without cooling. In the absence of heatwave-related data for Alberta, it is reasonable to assume that the results would be similar in Alberta.

Despite limited data on indoor air quality and thermal performance, Alberta's aging housing stock suggests an increase in health impacts. This is because materials degrade as buildings age, leading to the following:

- moisture damage and mould in walls and roofs
- corrosion and failure of electrical systems and plumbing
- building envelopes that are less effective in keeping out drafts and moisture
- cracked foundations due to freezing and thawing cycles
- obsolescence or failure of equipment such as:
    - electrical furnaces, which last 20–30 years
    - gas furnaces, which last 15–20 years

We know that building degeneration is a problem because Canada Mortgage and Housing Corporation data reveals that 250,000 older homes in Alberta need repairs. This problem will likely get worse as more than a third of Alberta's housing stock will be at least 50 years old by 2030.[31]

Additionally, older homes, energy poverty and ill health are linked. People living in older homes are more likely to experience energy poverty, which is associated with poorer health.[32] Canadian research shows that people living in homes built before 1960 are 139% more likely to face energy poverty, which translates to about 169,000 households in Alberta.[33] And those living in homes needing significant repairs face a 147–155% higher likelihood of energy poverty.[34]

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[31] "Alberta – Housing Stock (2021)."

[32] Mylène Riva et al., "Energy poverty: an overlooked determinant of health and climate resilience in Canada," *Canadian Journal of Public Health* 114 (2023), 426. https://doi.org/10.17269/s41997-023-00741-0

[33] "Alberta – Housing Stock (2021)."

[34] Runa Das, Mari Martiskainen, and Grace Li, "Quantifying the prevalence of energy poverty across Canada: estimating domestic energy burden using an expenditures approach," *Sussex Research* (2022). https://doi.org/10.1111/cag.12750

We also know that energy poverty disproportionately impacts vulnerable groups such as low-income families, renters, single-parent households (especially single mothers), seniors, people living with disabilities, and people living in homes needing major repairs.[35] In Edmonton, Indigenous households have also been found to face higher rates of energy poverty than non-Indigenous households.[36]

[35] Mylene Riva et al., "Energy poverty in Canada: Prevalence, social and spatial distribution, and implications for future research and policy," *Energy Research & Social Science* 81 (2021). https://doi.org/10.1016/j.erss.2021.102237

[36] Canadian Urban Sustainability Practitioners Network, *Equity Implications of Energy Poverty in Canada: A preliminary analysis of energy poverty trends in racialized, recent immigrant, and Indigenous households using the Energy Poverty and Equity Explorer* (2019), 11–15. https://energypoverty.ca/Equity_Energy_Poverty_EN_Nov19.pdf

4. How retrofits can improve building quality and health

Our report *Healthy Buildings in a Changing Climate* showed that deep retrofits provide immediate health benefits by reducing exposure to wildfire smoke, extreme heat and other environmental hazards. Beyond mitigating acute impacts, buildings also affect long-term health outcomes. International research is recognizing the potential of retrofits to improve occupant health and well-being while also reducing healthcare costs, as presented in the case studies below.

4.1 New Zealand

In 2010, New Zealand's Ministry of Economic Development commissioned a cost-benefit analysis of the Warm Up New Zealand: Heat Smart Programme, a multi-year government program that provided funding for insulation and grants for clean heating.[37,38] The researchers compared retrofitted and non-retrofitted households, tracking hospitalization rates, prescription costs, and mortality using anonymized health records. They also analyzed energy savings. Results from the study were categorized either as health savings or energy savings and came from insulation upgrades or clean heating upgrades (i.e., switching to a heat pump or biomass burner).

The study found that insulation had the most benefit across both savings categories and that the biggest health savings came from reduced mortality. But even if reduced mortality were excluded from the study, the benefits from reduced hospitalizations and drug spending would result in program cost savings. The program had a net return of $1.03 billion in health and energy savings; for every dollar spent, four dollars were returned.

These findings highlight that even retrofits not explicitly designed for health benefits can yield substantial health savings, as well as illustrate a gap in understanding of the relationship

[37] Arthur Grimes, Tim Denne, Philippa Howden-Chapman, Richard Arnold, Lucy Telfar-Barnard, Nicholas Preval and Chris Young, *Cost Benefit Analysis of the Warm Up New Zealand: Heat Smart Programme*, prepared for the New Zealand Ministry of Economic Development (2012). https://www.motu.nz/our-research/urban-and-regional/housing/cost-benefit-analysis-of-the-warm-up-new-zealand-heat-smart-programme/

[38] Lucy Telfar-Barnard, Nick Preval, Philippa Howden-Chapman, Richard Arnold, Chris Young, Arthur Grimes and Tim Denne, *The impact of retrofitted insulation and new heaters on health services utilisation and costs, pharmaceutical costs and mortality: Evaluation of Warm Up New Zealand: Heat Smart*, prepared for the New Zealand Ministry of Economic Development (2011). https://www.motu.nz/our-research/urban-and-regional/housing/the-impact-of-retrofitted-insulation-and-new-heaters-on-health-services-utilisation-and-costs-pharmaceutical-costs-and-mortality-evaluation-of-warm-up-new-zealand-heat-smart/

between buildings and health. Targeted health-focused retrofits could further amplify these benefits, reducing long-term healthcare costs.

4.2 Australia

Given the success of New Zealand's Warm Up New Zealand: Heat Smart Programme, the Government of Victoria funded the Victoria Healthy Homes Program.[39] This was a collaboration between local governments, energy liaisons, healthcare institutions and researchers. The program retrofitted vulnerable households (mostly seniors) and assessed the impacts on thermal comfort, well-being, health, energy use and societal costs. The researchers measured these impacts using anonymous health records on hospital admissions, emergency department visits and pharmacy expenses, and they conducted surveys to assess self-reported health and quality of life.

The researchers concluded that relatively minor energy-efficiency and thermal-comfort retrofits reduced exposure to cold temperatures, lowered energy bills, improved quality of life and decreased use of the healthcare system. An estimated $840 per person is saved to the health system in winter medical costs and $80 in annual energy costs per household. The researchers calculated that the program yielded a net health benefit of $4,000 per household over a decade (assuming health benefits depreciate at 4% per year).[40]

The Victoria Healthy Homes Program shows that insulation retrofits (improvements in energy efficiency and thermal comfort) can create significant health and financial benefits, particularly for seniors. By reducing exposure to the cold during the winter, the retrofits lowered healthcare costs and improved quality of life.

4.3 Wales

The Welsh government ran the Warm Homes Program between 2010 and 2015 to provide environmental, social and economic benefits by retrofitting homes in low-income areas.[41] Using the health records of program participants, researchers tracked emergency hospital admissions and primary health outcomes. They also did long-term monitoring of indoor air temperature

[39] Sustainability Victoria, *The Victorian Healthy Homes Program: Research findings* (2022). https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/the-victorian-healthy-homes-program-research-findings

[40] *The Victorian Healthy Homes Program: Research findings* (2022), 50.

[41] Wouter Poortinga et al., "The health impacts of energy performance investments in low-income areas: a mixed-methods approach," *Public Health Research* 6, no. 5 (2018). https://doi.org/10.3310/phr06050

and relative humidity before and after retrofits. Program participants were also surveyed on quality of life, days with respiratory and asthma symptoms, fuel poverty and financial stress.

While the retrofits successfully raised indoor air temperatures and lowered gas use in the winter, the researchers found no evidence of changes in physical health. As a result, there were no cost savings to the healthcare system. However, retrofits involving upgrades to insulation and the installation of solar panels, solar hot water tanks, and heat pumps improved occupant thermal satisfaction and well-being. Households also reported feeling more financially stable from reduced heating bills.

Although the Welsh study did not find direct physical health improvements, the program highlights the importance of well-being and financial stability. Retrofits in Alberta could similarly enhance residents' quality of life and reduce financial stress, even if health impacts are not immediately measurable.

4.4 England

The Building Research Establishment (BRE), a government-funded, research-based organization, quantified the cost to the National Health Service (NHS) in England from people living in poor-quality housing. They paired data on health and safety hazards in the home from the 2018 English Housing Survey with NHS treatment costs.[42] The BRE estimated that poor housing conditions cost the NHS $3.0 billion annually.[43]

The housing survey identified nearly 2.6 million homes with hazards, and the BRE calculated that it would cost on average $8,100 per dwelling to mitigate the hazard, or $21 billion in total. Tackling these hazards was estimated to result in $3.0 billion in annual savings to the NHS, or net savings in seven years.

Focusing only on the 836,000 dwellings that were identified as too cold, the research organization found repairs would cost $15,300 per home, or $12.8 billion in total. However, these repairs would save the NHS $1.8 billion per year in avoided healthcare costs, with a return on investment in seven years. The repairs would also save around $32.7 billion per year in societal costs from poor housing, including those associated with poor mental health and educational achievement, achieving cost recovery in just five months.

[42] Hazards ranged from excess cold to falls to radon and carbon monoxide and more. See the following reference for more details on the hazards: Helen Garrett et al., *The cost of poor housing in England: 2021 Briefing paper* (Building Research Establishment, 2021), 6. https://bregroup.com/news/bre-report-finds-poor-housing-is-costing-nhs-1.4bn-a-year

[43] *The cost of poor housing in England: 2021 Briefing paper*, 8.

The BRE's analysis highlights the economic rationale for retrofits. Addressing poor housing can lead to substantial healthcare savings and societal benefits, making retrofits a cost-effective public health and economic strategy.

4.5 United States

Using utility data from the Home Uplift pilot initiative by the Tennessee Valley Authority in the U.S., academic researchers assessed the non-energy benefits of retrofits done by utilities in low-income households. These retrofits typically included sealing gaps and cracks and replacing windows and doors, maintaining and replacing heating and air conditioning equipment, upgrading insulation, or installing heat pumps. Household surveys were done before and after the retrofits and asked questions falling into five categories: (1) the condition of the home, (2) financial problems, (3) general health[44] and well-being, (4) life satisfaction, and (5) major health-related life events. The surveys focused on subjective experiences, asking "yes" or "no" questions about homes being too drafty, not being able to afford prescriptions, experiencing asthma and COPD symptoms, and more. The study results suggest retrofits in low-income homes can positively impact personal finances, general health, life satisfaction, and major health-related events.[45]

The Home Uplift initiative shows that retrofits can have broad non-energy benefits for low-income households.

4.6 Case study lessons

These five studies showcase how retrofits and building quality affect health. In New Zealand, researchers demonstrated remarkable health and energy savings from retrofits, primarily from insulation. In Australia, the Victorian government advanced this understanding by showing that even minor energy-efficiency and thermal-comfort retrofits reduce medical costs. In Wales and the U.S. (with the Tennessee Valley Authority), the research revealed the importance of subjective metrics of well-being such as feeling financially stable and feeling satisfied with life. In England, the BRE identified how billions could be saved annually by addressing poor-quality housing.

[44] General health is an aggregate variable tracking mental and physical health, rest and sleep, headaches, and chronic respiratory conditions such as asthma and chronic obstructive pulmonary disease.

[45] Bruce Tonn, Erin Rose and Michaela Marincic, "Cascading benefits of low-income weatherization upon health and household well-being," *Building and Environment* 242 (2023) 110470. https://www.sciencedirect.com/science/article/abs/pii/S0360132323004973?via%3Dihub

There were some differences in results, particularly those from Wales, where retrofits did not demonstrate physical improvements in health. The Welsh researchers suggested that this could have been due to the limited follow-up period — it may take more time for health improvements to materialize. Additionally, the Welsh program was area based and not demand or needs based. Regardless, the study found the retrofits increased indoor temperatures, lowered gas use, and improved subjective metrics like thermal satisfaction and well-being, which is what the program sought to do.

5. Recommended actions for Alberta

We have found that retrofits can improve occupant health and reduce healthcare costs, as shown by other jurisdictions. We have also made connections between building age, energy poverty, and occupant health in Canada, and flagged that a third of Alberta's housing stock will be at least 50 years old by 2030.

To address the effects of building quality on the health of Albertans requires a stronger foundation of evidence and targeted policy interventions. Our research has identified key data gaps on the health impacts of air pollution and thermal performance in Alberta's housing stock. The following recommendations can help in unveiling the non-energy-related financial benefits from retrofits in the form of reduced healthcare costs and advance the business case for deep retrofits beyond energy savings.

Recommendation 1: Fill gaps in health and housing data

- Affordable housing providers, non-profit housing societies, and provincial and municipal governments should work with Alberta Health Services to conduct pilot studies tracking indoor air quality, home temperatures and health outcomes. These studies would help to fill data gaps on the relationship between building conditions and health and show the monetary impact on healthcare providers and occupants.

This recommendation builds off findings that air quality and thermal comfort are the two most significant building conditions related to occupant health. Incorporating the results from the pilot studies in the cost-benefit analysis of retrofits could help advance the retrofit business case.

Recommendation 2: Include health impact assessments in retrofit programs

- Retrofit programs led by municipalities and community organizations should track health-related indicators after retrofitting either through targeted studies or simple surveys.

Retrofits are happening in Alberta, such as through Alberta Municipalities' Clean Energy Improvement Program and Kambo Energy Group's Home Upgrades Program. Typically the funding and regulations that spur retrofits are focused on improving energy efficiency. While this is a critical aspect, retrofit programs should be broadened to incorporate non-energy benefits such as better health and safety, greater building resilience and an associated decrease in insurance premiums, and improved affordability. Incorporating health considerations into retrofits programs would help generate data on the health impacts of retrofits, which could be used to calculate health savings and advance the business case for deep retrofits .

Recommendation 3: Invest in retrofits that improve health outcomes, focusing on vulnerable households

- The Government of Alberta should provide funding and other support to local governments, building owners, and industry organizations that are investing in retrofits that improve health outcomes. These supports should prioritize low-income households facing high energy burdens and poor housing conditions.

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