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Residential wood smoke: perceptions, health risks, and mitigating exposures

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Abstract: Almost one in five (19%) Canadian households rely on wood stoves or fireplaces as primary or supplemental sources of heating and cooking, and the emissions from these devices are an often overlooked source of air pollution. Residential wood burning produces the same amount of fine particulate matter ($PM_{2.5}$) as the transportation and industrial sectors combined across Canada. Exposure to wood smoke can have serious acute and chronic health effects, ranging from symptoms such as headaches, nausea, dizziness, and irritation of the eyes, nose, throat, and lungs, to an increased risk of developing chronic conditions like heart and lung diseases. Although efforts to reduce exposure by replacing old, high-emission wood stoves through education and incentives have been implemented in many jurisdictions across Canada, many of these heavily polluting devices are still regularly in use. In British Columbia alone, only 67% of fireplace inserts and 65% of wood-burning stoves are certified as low-emission. This paper examines the evidence on the disconnect between what people believe about residential wood smoke, and what is actually measured, along with the resulting health risks. We also examined current interventions, good burn practices, and jurisdictional regulations aimed at reducing indoor and outdoor wood smoke exposures. Perceptions of wood smoke were found to be inconsistent with estimated health burdens, and implementation of interventions to reduce wood smoke emissions varied greatly across jurisdictions. However, wood burning still represents the only source of energy for many Canadian households, and adaptive strategies are needed to mitigate health risks.

Key words: wood smoke, air quality, residential wood burning, emission reduction, best burning practices.

Introduction

Many Canadian households rely on wood stoves or fireplaces as primary or supplemental sources of heating, yet the smoke emitted from these appliances negatively affects both indoor and outdoor air quality. Residential wood-burning is often overlooked as a potentially harmful source of air pollution even though it produces the same amount of fine particulate matter ($PM_{2.5}$) as the transportation and industry sectors combined across Canada (Health Canada, 2023). In a 2023 Health Canada report that assessed air pollution from transportation, industry, and residential sources in Canada, 15,300 premature deaths were attributed to excess air pollution, with home firewood burning responsible for the largest percentage (15%, or 2,300 deaths). For comparison, the second and third largest categories were on-road transportation at 1,200 deaths (8%), and ore and mineral industry at 910 deaths (6%). It is important to note that this report did not include dust, fires, and agricultural sources. Nevertheless, these findings underscore a critical gap between perception and reality in Canadian air quality management.

Wood smoke is a complex mixture of particles and gases, including substantial quantities of fine particulate, $PM_{2.5}$. Wood smoke also contains gases such as carbon monoxide (CO), nitrogen oxides (NO_x), and other pollutants such as dioxins, furans, volatile organic compounds (VOCs) such as benzene and formaldehyde, and polycyclic aromatic hydrocarbons (PAHs) (Bølling et al., 2009). The concentrations of these pollutants vary depending on the makeup of the fuel source combusted and the efficiency of the appliance it is burned in. Many of these pollutants are found at higher levels in homes with wood-burning appliances and their surrounding communities. For example, several studies have demonstrated that indoor $PM_{2.5}$ levels are 20–123% higher in homes with wood-burning appliances, representing a significant health risk (Wei & Semple, 2023). This review provides an overview of the public perceptions associated with residential woodsmoke, along with current guidelines, standards, and best practices for operating wood-burning appliances.

Methodology

Grey literature and websites from public agencies in Canada and the United States for recommendations, guidelines, and best practice documents related best practices for operating wood-burning appliances and reducing smoke exposure were

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reviewed. Supplemental searches of scholarly peer-reviewed and grey literature were performed using Google, Google Scholar, and Pubmed to gain additional evidence on public perceptions of residential wood smoke and interventions. Boolean operator combinations of search terms related to residential wood smoke, indoor air, wood stoves and fireplaces were used. We identified references related to residential wood smoke and portable air cleaners (PACs) previously in a systematic rapid review (Huff et al., 2025), see review methods for more details. Forward and backward chaining of results was used to identify further relevant literature.

Health effects of wood smoke

Exposure to wood smoke pollutants can have serious acute and chronic health effects (Health Canada, 2024). $PM_{2.5}$ particles can penetrate deeply into the lungs, where they cause irritation and inflammation. Short-term exposure to wood smoke can induce headaches, nausea, dizziness, irritation of the eyes, nose, throat, and lungs (Long et al., 2024). Short-term exposure has also been associated with reduced lung function, and increased risk of severe events such as strokes and heart attacks. Long-term exposure has been associated with increased risk of developing chronic conditions such as heart and lung diseases. Pregnant people, infants, children, older adults, and those with chronic health conditions are the most susceptible to the effects of wood smoke.

Both short- and long-term exposures have been associated with worsening of respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD), including increased emergency room visits, hospitalizations, and premature deaths. Furthermore, there is no health-based limit for indoor concentrations of $PM_{2.5}$, and the current Canadian residential indoor air quality guidance recommends keeping levels as low as possible (Health Canada, 2012). Some homes have been measured to have $PM_{2.5}$ levels above the outdoor Canadian Ambient Air Quality standard of 27 $\mu g/m^2$ (24-hour average) (Canadian Ambient Air Quality Standards, n.d.).

Use of wood-burning appliances across Canada

A 2019 Statistics Canada survey on residential wood burning reported that 19% of Canadian households burn wood or wood pellets at their primary dwelling for heating or cooking (Statistics Canada, 2021). This usage equates to an estimated 3,905,861 full cords of wood and 196 million kg of pellets. By province, Newfoundland and Labrador reported the largest percentage of wood- or wood pellet-burning households at 32% and Ontario the smallest at 14% (territorial data not reported) (Figure 1). It is important to note that in 2021 an estimated 7% of rural (non-census metropolitan areas) households in Canada used wood or wood pellets for their primary source of heating compared to 1% of census metropolitan areas (Statistics Canada, 2025). The energy produced by wood burning is substantial, an estimated 69,202,747 GJ at primary residences, and is equivalent to the yearly electrical use of over 1.75 million average Canadian homes (Statistics Canada, 2024).

Many types of wood-burning appliances such as wood stoves, fireplaces, and boilers are used in Canada. In a 2024 survey of BC residents, 15% of households reported using wood burning appliances, of which wood stoves (46%), wood fireplaces (42%), and wood burning inserts (17%) were the most common (BC Lung Foundation, 2024). When BC residents were asked about the reasons for using a wood-burning appliances, 84% indicated reliability in the event of a power outage, 78% indicated the availability of wood supply, and 62% reported cost considerations. These factors are important when considering policies and practices aimed at lowering the levels of residential wood smoke in and around the home.

Perceptions

Recent surveys performed in British Columbia and the Yukon indicate that people's perception of residential wood smoke doesn't match the acute and chronic wood smoke exposure risk. For instance, residential wood burning devices release a substantial amount of air pollution into the indoor and outdoor environment, more than transportation and industry sectors combined. Yet, only 21% of residents in Whitehorse, Yukon perceived residential wood burning to be a major source of air pollution (What We Heard, 2019). Further highlighting this disconnect between measured and perceived air pollution sources, when Whitehorse residents were asked to rate the quality of neighbourhood air, 94% of respondents thought the air quality was good or very good in the summer. This number fell to 65% for winter months. These survey results align well with results from the Whitehorse Air Quality Monitoring Study, which measured higher concentrations of $PM_{2.5}$ during the winter months (Whitehorse Air Quality Monitoring Study, 2018). However, by measuring concentrations of the wood combustion marker levoglucosan in air pollution samples, wood burning was estimated to contribute between 70 and 84% of outdoor $PM_{2.5}$ levels (Environment Canada, 2011). These results indicate that residents are aware that air quality is worse during winter months, but not that wood combustion was the major source of poor air quality.

Underestimating wood burning's contribution to ambient air pollution is also prevalent in British Columbia where 79% of people surveyed in 2024 did not consider residential wood burning to be a major source of air pollution (BC Lung Foundation, 2024). In comparison, 63% and 43% of BC residents considered transportation and industry, respectively, to be important sources. Similarly, when BC residents were asked if chimney smoke was a concern to themselves or family, only 10% were concerned. This number rose to 16% when looking only at rural residents. For BC residents that were concerned, the top three responses were health-related (60%), environmental or air quality (56%), and smell (30%).

In a study of Quebec residents in 2008, Environment Canada smog warnings or living in a region that regularly experienced smog did not influence the use of residential wood heating devices (Bélanger et al., 2008). Furthermore, consultation of meteorological information in media or intense cold warnings also did not significantly influence the use of wood burning devices for heating, and the perception of a region as conducive to cold waves was significantly associated with less, not more,

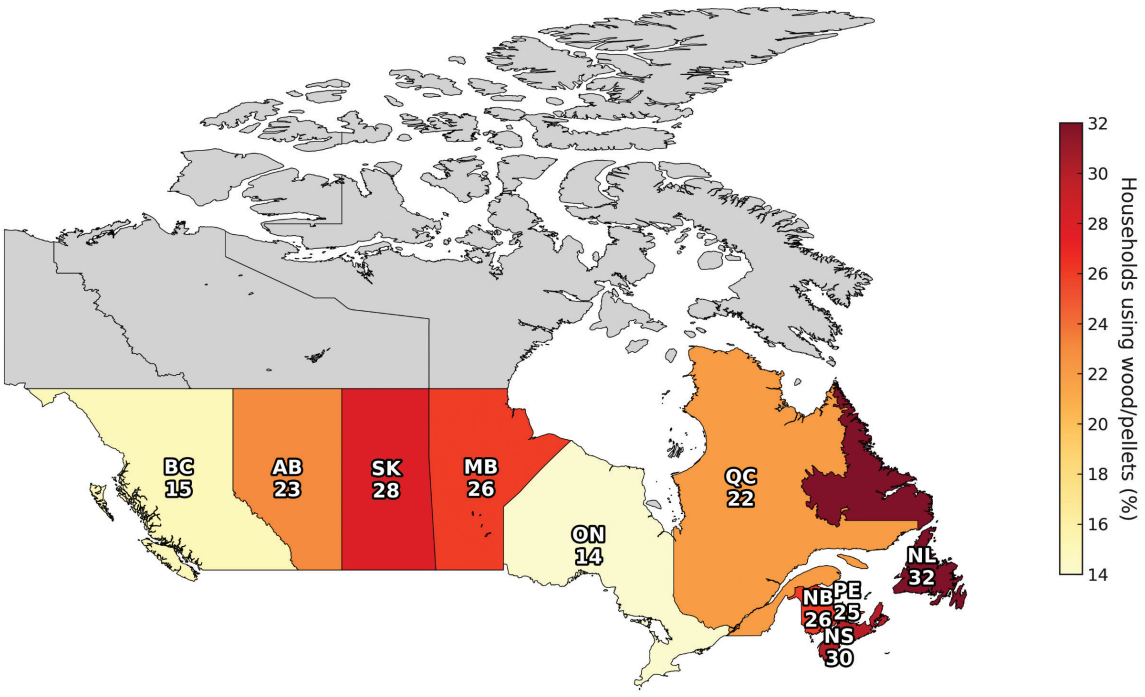

Figure 1: Percentage of households that used wood or wood pellets at their primary dwelling in Canadian provinces. Data from Statistics Canada Table 25-10-0083-01, Residential use of wood and wood pellets (Statistics Canada, 2021). Data from territories not available. The image was created by the National Collaborating Centre for Environmental Health (NCCEH) using data from boundary files from the Statistics Canada 2021 Census (Statistics Canada, 2023).

wood heating (14% vs. 23.6% of surveyed residents). Such counterintuitive results emphasize that individual or community perceptions can play a decisive role in energy behaviours, sometimes in opposition to logical climatic expectations.

In summary, Canadians underestimate the amount of air pollution residential wood burning appliances produce compared to other sources. Furthermore, there is a disconnect between perceiving wood burning as a major air pollution source even when reporting poor air quality during winter months. Lastly, concern about the impact of chimney smoke is low.

Reducing exposure to wood smoke indoors

Several best burning practices are recommended by Health Canada and the Canadian Lung Association to reduce exposure to wood smoke in the home (Canadian Lung Association, n.d.; Health Canada, 2024). These include:

Storage and drying:

- Only burn seasoned wood (split and dried for at least 6 months). Green or wet wood produces significantly more smoke.
- Dry wood outdoors. Drying wood inside adds excess humidity to the home that could lead to mould and mildew growth.

What not to burn:

- Do not burn garbage, plastics, foam containers, particle board, or painted or sealed wood because these can release toxic gases into the home and surrounding community.
- Do not burn driftwood from the ocean. Wood that has been in saltwater produces smoke with carcinogenic dioxins and furans.

Inspection and use:

- Perform regular stove/fireplace maintenance according to manufacturer's instructions, including cleaning chimneys and flues regularly to ensure proper air flow and ventilation. Have appliances professionally inspected at least once a year.
- Use dampers if available to control the ventilation, maximizing heat output and reducing the amount of wood needed for heating.
- Consider using an indoor air purifier to reduce ambient wood smoke pollutants (BC Centre for Disease Control, 2024).
- Install and maintain smoke detectors and a carbon monoxide alarm in the home.
- Consider using a low-cost $PM_{2.5}$ sensor to assess levels of exposure in the house when using appliances (United States Environmental Protection Agency, 2025).

Table 1: Effect of portable air cleaners on indoor PM2.5 in residential wood smoke impacted homes

Study	Setting	Summary of findings
Prathibha et al., 2024	11 homes, Hoopa, CA, USA	DIY and commercial PAC use significantly decreased indoor $PM_{2.5}$ by 7–10% compared to baseline
Walker et al., 2022	84 homes (n = 41 filtration, n = 43 placebo, rural households of the Navajo and Nez Perce Tribe, USA	PAC use in homes with wood stoves reduced indoor $PM_{2.5}$ mass concentrations by 51% (11.1 μg/m^3) compared to placebo
McNamara et al., 2017	48 homes (n = 25 PAC, n = 23 placebo), rural Montana, Nez Perce Indian Reservation in Idaho, and Fairbanks Alaska, USA	PACs reduced $PM_{10-2.5}$, $PM_{2.5}$, and endotoxin levels by 38, 66, and 58% (median 2.2, 16.3 μg/m^3, and 1.2 EU/m^3) compared to placebo respectively
Noonan et al., 2017	72 homes (n = 35 PAC, n = 37 placebo), Butte and western Montana, Nez Perce Indian Reservation, Idaho, and Fairbanks Alaska, USA	PACs reduced indoor $PM2_{.5}$ levels by 67% compared to homes without PACs
Ward et al., 2017	73 homes (n = 35 PAC, n = 38 placebo); Butte and western Montana; Nez Perce Indian Reservation, Idaho; and Fairbanks Alaska, USA	PACs reduced $PM_{2.5}$ by 69% (median 10.6 μg/m^3) and $PM_{2.5}$ particle count concentrations by 75% (median 25.1 particles/cm^3) post-intervention; PACs did not influence CO levels
Kajbafzadeh et al., 2015	20 homes, Vancouver, BC, Canada	PACs reduced indoor $PM_{2.5}$ by 48% (3.1 μg/m^3) and levoglucosan by 60% (17.5 ng/m^3) compared to placebo
Wheeler et al., 2014	31 homes, Annapolis Valley, Nova Scotia, Canada	PACs reduced PM, $PM_{2.5}$, and levoglucosan levels by 63, 50, and 32% (median 1.7, 1.95 μg/m^3, and 0.016 ng/m^3) compared to placebo respectively
Allen et al., 2011	25 homes (n = 13 woodburning homes, n = 12 non-woodburning homes), Smithers, BC, Canada	PACs reduced indoor $PM_{2.5}$ by 59% (6.6 μg/m^3) and levoglucosan by 74% (94 ng/m^3) compared to placebo
Hart et al., 2011	2 homes, Butte, Montana, USA	PACs reduced indoor $PM_{2.5}$ mass concentrations by 76% (10.5 μg/m^3) and particle number concentrations by 61–85% compared to when PACs were turned off
Barn et al., 2008	21 homes, Prince George, BC, Canada	PACs reduced indoor $PM_{2.5}$ by 55% (3.2 μg/m^3) compared to when PACs were turned off

Several studies over the past decade have also focused on measuring the effectiveness of air filtration or air cleaning devices, specifically PACs, in reducing concentrations of indoor air pollutants. These devices have been shown on average to reduce indoor $PM_{2.5}$ levels by 51% (range 10 to 76%, Table 1). Specifically, PACS on average reduced indoor $PM_{2.5}$ levels from 16 μg/m^3 (range 6.5 to 41.6 μg/m^3) to 8.5 μg/m^3 (range 3.3 to 30.5 μg/m^3). These results indicate that PACs can be effective tools at reducing exposure to residential wood smoke PM, however their effectiveness on reducing other smoke components such as VOCs and PAHs is unclear.

Replacing wood-burning appliances

In addition to good burning practices, changing out old stoves for heat pumps, pellet stoves, or cleaner wood stoves can reduce exposure to wood smoke pollutants. For new wood-burning appliances, the Canadian Code of Practice for Residential Wood Burning Appliances recommends using only low-emission Canadian Standards Association (CSA) or the US EPA certified units (United States Environmental Protection Agency, 2025; Canadian Council of Ministers of the Environment, 2012). These appliances burn hotter and emit less pollution both inside the home and out into the community. A recent 2025 study comparing conventional fireplaces and woodstoves to EPA certified stoves reported conventional wood stoves emitted eight times more $PM_{2.5}$ than EPA 2020 catalytic stoves (12 vs. 1.5 kg/t $PM_{2.5}$) (Environment and Climate Change Canada, 2025). Similar results were observed for CO and VOCs, with conventional wood stoves emitting 6.6 and 1.7 times more respectively.

The impact of a large scale change-out program has been evaluated in Libby, Montana, where outdoor air quality had become a persistent issue during winter months. In the lead up to the community wide wood burning device replacement program, 82% (22.8 of 27.8 μg/m^3) of outdoor $PM_{2.5}$ concentrations for 2003–2004 were attributed to residential wood burning (Ward et al., 2010). From 2005 to 2007 more than 1100 wood burning devices were replaced, leading to a 25.6% reduction in outdoor $PM_{2.5}$ (24-hour average $PM_{2.5}$: 20.1 vs. 28.2 μg/m^3). A 64% average reduction in concentrations of measured phenolics and PAHs was also reported post changeout, with the largest reduction observed for concentrations of acenaphthylene (83% reduction) (Ward et al., 2009). In terms of indoor air, pre-changeout mean $PM_{2.5}$ concentrations of 45.0 ± 33.0 μg/m^3 were reported in 21 homes and post-changeout levels were reduced to 21.0 ± 19.2 μg/m^3 (Noonan, Navidi, et al., 2012). Furthermore, the impact of the changeout program on children's health was assessed, and for a 5 μg/m^3 decrease in $PM_{2.5}$, a 26.7% reduced odds of reported wheeze was reported (Noonan, Ward, et al., 2012). Reduced odds for

Table 2: Summary of wood stove exchange programs

Location	Program	Description
BC	Community Wood Smoke Reduction Program (Government of British Columbia, 2025)	Incentivizes replacing old wood stoves, supports educational initiatives, and funds local program administration and promotion
NS	Efficiency Nova Scotia Home Heating System Rebates (Efficiency Nova Scotia, 2025)	Provides up to $500 and $1,000 in rebates for replacing wood stoves or boiler systems respectively with low emission certified models
YT	Home Heating System Rebate (Government of Yukon, 2025)	Provides up to $800, $600, and $300 in rebates for the purchase of low emission furnaces or boiler systems, pellet stoves, or cord wood stoves respectively
NT	Arctic Energy Alliance Rebate Program (Arctic Energy Alliance, n.d.)	Provides up to 50% of the purchase cost to a maximum of $2,000 in rebates for replacing wood or pellet stoves with low emission certified models
NB	New Brunswick Power Total Home Energy Savings Program (New Brunswick Power, n.d.)	Provides up to $200 and $500 in rebates for replacing wood stoves or furnace boiler systems respectively with low emission certified models
QC	RVQ 2950 Program (Quebec City, n.d.)	Grants up to 90% or up to a maximum of $1,000 of the cost of replacing wood or pellet appliances with low emission certified models

reported respiratory infections were also reported, including cold (25.4%) and influenza (52.3%).

The evaluation of stove changeout programs was also evaluated on a smaller scale for 17 homes in two communities in BC (Allen et al., 2009). Overall, median $PM_{2.5}$ levels outside changeout homes were significantly reduced by 2.7 $\mu g/m^3$ and levels of the wood combustion tracer levoglucosan were reduced by a median change of 406 ng/m^3. However, indoor levels of $PM_{2.5}$ levels were not significantly affected by the changeout program in this study. According to the authors, the substantial number of non-certified stoves still operating in the study regions likely limited the changeout program's impact on indoor air quality.

It is not known how many wood-burning appliances across Canada are low emission certified. However, in BC it is estimated that only 67% of fireplace inserts and 65% of wood-burning stoves are low emission certified (BC Lung Foundation, 2024). Many jurisdictions offer change-out programs for replacing old appliances, and support initiatives to raise awareness of good burning practices and educate the public about wood smoke and its health effects (Table 2).

Reducing wood smoke in the community

Other policies and regulations across all levels of government are also helping to reduce residential wood smoke emissions. For example, the National Building Code of Canada specifies EPA or CSA certification of solid-fuel burning space-heating equipment (Canadian Commission on Building and Fire Codes, 2022). In addition, a 2012 review by the Government of Canada identified policies and regulatory instruments related to residential wood burning across the country (Canadian Council of Ministers of the Environment, 2025). For example, the Solid Fuel Burning Domestic Appliance Regulations in BC and the Air Pollution Control Regulations in Newfoundland and Labrador ensure that only low-emission certified appliances can be sold by vendors (Government of British Columbia, 2019; Government of Newfoundland and Labrador, 2022).

At the local level, many communities now have by-laws to reduce wood smoke emissions. In Metro Vancouver, BC, for example, wood-burning appliances as of September 2025 must be registered and comply with performance standards (Metro Vancouver, n.d.). Use is prohibited (with exceptions for sole heat source residences and emergency situations) annually from May 15th to September 15th and wood-burning appliances are prohibited in new buildings. Regulations have also been introduced in Montreal, Quebec requiring declaration and the use of only low emission US EPA or CSA/B415.1-10 compliant appliances (Montreal City, 2015). Specifically, there is a 2.5 g/h PM emission limit for wood burning appliances. In addition, during smog warnings all use is prohibited in the city. The impact of the regulations was also assessed in a 2021 study, reporting that the wood combustion tracer levoglucosan dropped from 424.4 ng/m^3 during the 2009–2010 winter to 123.8 ng/m^3 during the 2018–2019 winter (Montreal City Environment Department and Emissions Control and Environmental Monitoring, 2021). Along with a reduction in wood combustion indicated by levoglucosan levels, average winter $PM_{2.5}$ levels were reduced from 10 to 8.5 $\mu g/m^3$. The number of smog days, defined as 35 $\mu g/m^3$ during at least 3 hours over more than 75% of Montreal, also dropped from 15 in 2009–2010 to 2 in 2018–2019.

Rural areas present regulatory challenges where many residences have less access to other heating sources. In these situations, different by-laws aimed at reducing wood smoke emissions may be more effective. For example, a bylaw recently passed in Gibsons, BC is designed to identify homes producing excessive smoke (Town of Gibsons, 2024). Although there is likely regional differences across Canada, a survey of 2,546 BC residents reported that there was support for regulations or programs such as providing a cash back incentive for removing old wood stoves (59%), restricting wood burning on poor air quality days (56%), and fines for producing excessive smoke (48%) (BC Lung Foundation, 2024).

For any community considering policies or regulations to reduce the air quality impacts of residential wood burning, $PM_{2.5}$ monitoring is a crucial first step in understanding wood smoke exposures. Communities can be affected by residential wood smoke in very different ways that do not necessarily correspond with the number of wood-burning households (Hong et al., 2017). For example, weather patterns and mountainous topography in some regions can trap smoke in valleys and intensify the outdoor pollution levels. Real-time outdoor air quality information including the Air Quality Health Index (AQHI) from the government of Canada is available to many communities (Environment and Natural Resources, 2025). However, for communities without $PM_{2.5}$ monitoring stations, the AQ Map, consisting of a network of low-cost sensors, may be a helpful tool in understanding current air quality (AQ Map, 2025). For indoor air pollution, low-cost $PM_{2.5}$ sensors can help assess exposure levels. Understanding the scope of the issue is vital in employing appropriate solutions to protect public health.

Summary

Residential wood burning is a significant and underestimated contributor to air pollution in Canada. Despite the ever-growing evidence of the health risks associated with wood smoke exposure, including respiratory and cardiovascular effects and premature mortality, public perception does not reflect the magnitude of this issue. Many Canadians continue to view residential wood smoke as a minor pollution source, even in communities were monitoring data clearly attribute a majority of wintertime $PM_{2.5}$ to wood combustion. This disconnect suggests that further public education and awareness initiatives are needed to align perception with evidence and bolster support for strategies that reduce the health risks associated with residential wood burning appliances.

Mitigating wood smoke exposures requires a combination of household-level interventions, community policies, and broader regulatory approaches. Good burning practices, regular maintenance, and the use of PACs can substantially reduce indoor concentrations of $PM_{2.5}$, while replacing older appliances with certified low-emission models offers long-term benefits for both indoor and outdoor air quality. Large-scale changeout programs and municipal by-laws, as demonstrated in Libby, Montana and Montreal, Quebec have shown measurable improvements in air quality and health outcomes. Continued monitoring, targeted incentives, and community engagement will be essential to reducing emissions, protecting vulnerable populations, and supporting a transition toward cleaner, healthier home heating and cooking practices across Canada.

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