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HEALTH EFFECTS FROM GAS STOVE POLLUTION

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ABOUT US

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Founded in 2013, Mothers Out Front is a growing national movement of mothers, grandmothers, and other caregivers who are working together to address the systemic causes of the climate crisis, advocate for bold climate action and environmental justice, and protect children and communities from the damaging impacts of fossil fuel extraction and use.

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Founded in 1961, Physicians for Social Responsibility is an organization of physicians and other health professionals that works to protect human life from the gravest threats to health and survival, guided by the values and expertise of medicine and public health.

ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; the San Francisco Bay Area; Washington, D.C.; and Beijing.

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EXECUTIVE SUMMARY

Over 40 years of evidence indicates that gas stoves, common in kitchens across the United States, can lead to unhealthy levels of indoor air pollution.

This report synthesizes expert findings into eight key points:

1. Indoor air is largely unregulated and is often more polluted than outdoor air.
2. Gas stoves can be a large source of toxic pollutants indoors.
3. Indoor pollution from gas stoves can reach levels that would be illegal outdoors.
4. There are well-documented risks to respiratory health from gas stove pollution.
5. Children are particularly at risk of respiratory illnesses associated with gas stove pollution.
6. Lower-income households may be at higher risk of gas stove pollution exposure.
7. Ventilation is critical but is not the sole strategy to prevent exposure.
8. Electric cooking is a cleaner household cooking option.

Air pollution is preventable. By addressing pollution at the source—in this case the gas stove—negative health impacts can be mitigated. There are practical lessons to be learned:

- Based on the latest science, Canada recently revised indoor guidelines and outdoor standards for nitrogen dioxide to be among the most stringent in the world.
- California's building electrification movement is reducing gas use in homes. Numerous cities and communities are going all-electric.
- The Massachusetts Medical Society is educating physicians and health professionals about the link between gas stoves, household air pollution, and asthma in children.
- Health research shows lower-income communities are disproportionately burdened by asthma, which is associated with gas stove use. Interventions should prioritize lower-income communities.

Taking steps to mitigate health risks can be immediate and intentional:

- **Individuals** have multiple options to control gas stove pollution: from opening the windows and using the exhaust hood during cooking and installing a low-level carbon monoxide detector, to using a plug-in induction cooktop or switching out a gas stove for an electric stove.
- **Policymakers** at the state and federal levels can start by setting science-based guidelines for indoor air quality, requiring that all new buildings protect residents from harmful levels of gas stove pollution, and providing financial incentives for transitioning to electric stoves.
- **Health professionals** can recognize the risk of gas stoves, assess risk and remediation in individual cases, and actively engage in advocacy and education.
- **Researchers** can add value by quantifying health effects of gas stoves and conducting randomized studies on the most effective interventions.

INTRODUCTION

Multiple health studies over the past forty years have investigated the health risk posed by cooking with gas stoves.[i,ii] An alarming analysis by Lawrence Berkeley National Laboratory in 2014 shows that cooking with gas is estimated to expose approximately 12 million Californians to certain pollutant levels that would exceed ambient air standards outdoors in a typical winter week.[1]

For many pollutants, the concentrations indoors are higher than outdoors, depending on activities, building materials, and products used inside the home. Little has been done to address a major source of indoor pollutants: gas stove use.[2] By looking at the last two decades of peer-reviewed studies, this report synthesizes these lines of research and summarizes eight key findings. We conclude that there is a significant and solvable health problem in plain view: gas stoves may be exposing tens of millions of people to levels of air pollution in their homes that would be illegal outdoors under national air quality standards.

Regulators have largely failed to act despite the fact that data accumulated for decades is publicly available, and is referenced by policymakers like the United States Environmental Protection Agency (US EPA).[3] For that reason, this report closes with practical and actionable recommendations for policymakers, health professionals, researchers, and individuals to better protect health from the risks of gas stove pollution.

BACKGROUND

About half of the homes in the United States use gas to meet their energy needs including heating and cooking.[4] Data from 2015 shows that nationally, 35 percent of US households—more than one-third—cook primarily with gas.[5] While home heating with gas, especially when unvented, may also contribute to indoor air pollution, this paper focuses solely on indoor air pollution caused by cooking with gas.

In analyzing the existing literature, we found a need to summarize the key findings regarding gas stove pollution, including gas stove emissions tests, air quality standards, and health impacts, in one place. The association between air pollution and poor health has been consistently documented in children as well as in adults with underlying health conditions such as asthma.[6,7] Yet anyone who spends time in a home with a gas stove can be exposed to indoor air pollution. Thus, while presenting the health impacts from previous studies, the report takes a broad view of potential gas stove pollution exposure and the toll air pollution has on health.

[i] Also called natural gas or fossil gas.

[ii] Gas stoves referred to in this report are considered stoves that use gas as their fuel source and may include or exclude a gas-powered oven. Ranges (gas stove and oven combination) are also included in many of the studies and the terms are sometimes used interchangeably.

EIGHT KEY FINDINGS

What we know about gas stove pollution and health impacts:

1. **Indoor air quality is largely unregulated.** A major study published in 2001 showed that, on average, people living in the United States spend nearly 90 percent of their time indoors.[8] And research on indoor air pollution shows that for many pollutants, it is often worse than outdoor air pollution.[9] The US EPA states that indoor levels of pollutants may be two to five, and occasionally more than 100 times higher than outdoor air pollution levels.[10] While outdoor emissions of six criteria air pollutants[iii] have decreased by 74 percent since the passage of the Clean Air Act in 1970, no federal regulations or guidelines have addressed indoor air pollution. Without federal and state regulations, pollutant reductions stop at the doorway.[11]

2. **Gas stoves emit numerous pollutants including nitrogen dioxide and carbon monoxide.** Cooking food, regardless of the type of stove used, produces certain pollutants, such as particulate matter. To separate emissions generated by the fuel or the food, a key differential is combustion (burning) of gas. Nitrogen dioxide (NO_2) and carbon monoxide (CO) are primary pollutants produced from combustion. Nitrogen dioxide levels are consistently higher in homes that cook with gas rather than electric stoves, and cook for longer periods of time. Poorly maintained stoves are more likely to emit elevated levels of carbon monoxide.[12]

   A 2014 literature review linked high NO_2 emissions with older, ill-maintained gas stoves that are poorly ventilated.[13] Older stoves likely emit higher concentrations of pollutants, and those with gas pilot lights add approximately 10 parts per billion (ppb) to indoor NO_2 levels.[14] However, a 2014 study simulating air pollution, showed that gas stoves used without exhaust hoods can produce levels of NO_2 above EPA outdoor air quality standards.[15] Their results are consistent with emissions measurements of stoves conducted in homes between 2011 and 2012.[16]

[iii] Criteria air pollutants are six common pollutants found throughout the United States and include particulate matter, photochemical oxidates (including ozone), carbon monoxide, sulfur oxides, nitrogen oxides, and lead. The EPA sets National Ambient Air Quality Standards (NAAQS) for these pollutants based on current scientific information related to health or welfare effects from pollutants.

EXHIBIT 1

Differentiating Pollutants from Cooking Food vs. Gas Fuel

Many factors contribute to which pollutants are generated from the stove and the food being cooked.

Pollutants Generated from Cooking Food (regardless of stove type)	Pollutants Associated With Gas Stoves
Particulate Matter (PM_{10}) Small particles with a diameter less than 10 micrometers. Commonly measured in cooking activities like frying or broiling with the highest emissions levels found during the oven self-cleaning cycle.[17]	**Particulate Matter ($PM_{2.5}$)** Unlike electric stoves, gas stoves emit $PM_{2.5}$ in the absence of cooking food (i.e., from the flames). Although cooking food emits $PM_{2.5}$, tests show $PM_{2.5}$ emissions from gas stoves can be two times higher than from electric stoves.[18]
Particulate Matter ($PM_{2.5}$) Small particles with a diameter less than 2.5 micrometers. $PM_{2.5}$ can penetrate deep into the lungs and even enter the bloodstream.[19] Stove tests show emissions are dependent on a number of factors such as the type of food cooked, cooking temperature, type of oil used, and type of fuel/stove used.[20]	**Nitrogen Oxides (NO_x)** When nitrogen and oxygen react to each other, especially at high temperatures, they produce several toxic gases. NO_2 and NO are the principal gases associated with combustion sources (collectively known as NO_x).[21,22] *A 2001 laboratory study showed no rise in NO_x when using an electric stove.[23] *A study published in 2016 showed that after subtracting outdoor contribution, all-electric homes had NO_x levels close to zero.[24]
Ultrafine Particles (UFP) These tiny particles are less than 100 nanometers (nm) in diameter and are hazardous to health. Cooking is the main source of UFP in homes, particularly those with gas stoves.[25] Gas stoves and electric coil resistance stoves emit high quantities of UFP, particularly smaller than 10 nm in diameter.[26]	**Nitrogen Dioxide (NO_2)** Nitric Oxide is oxidized in the air to form NO_2. More data exists on NO_2 than NO. NO_2 is regulated by the EPA and thus is the component most studied and considered by the EPA in terms of health effects.[27]
	Nitric Oxide (NO) A primary gas associated with combustion; NO is also a precursor to NO_2. *A 2001 major study found NO concentrations on electric stoves were insignificant compared to gas stoves.[28]
	Carbon Monoxide (CO) An odorless, colorless gas. A 2011–2013 study found that gas stoves can substantially increase the risk of elevated CO in the home.[29]
	Formaldehyde (CH_2O or HCHO) A known human carcinogen. Exposures at levels that occur in homes have been associated with human health impacts such as lower respiratory infections.[30,31] A new test of one gas stove shows that simmering on low heat for multiple hours can produce significant exposure levels if ventilation is not used.[32]
Other Emissions from cooking also include various volatile organic compounds (VOCs) such as benzene and acrolein as well as polycyclic aromatic hydrocarbons (PAH).[33]	

CARBON MONOXIDE IN THE HOME

Carbon monoxide (CO) is an invisible gas, undetectable by humans, produced by the incomplete combustion of fuels.[34] Indoors, CO is produced by cooking and heating appliances and can infiltrate from the outdoors. The highest levels of CO pollution are typically measured in homes with appliances that are either faulty or poorly installed, ventilated, or maintained.[35]

The United States does not have federal guidelines for indoor CO levels. Indoor and outdoor CO are chemically identical and so cause the same health effects at the same exposure levels and duration.[36] The ambient standards for CO were set by the US EPA in 1971 and have not been changed: a one-hour limit of 35 parts per million (ppm) and an eight-hour limit of 9 ppm (for each: not to be exceeded more than once per year).[37] The United States does not have a 24-hour guideline or standard, but the World Health Organization has set a guideline of 6 ppm for 24-hour exposure.[38] Not all states require carbon monoxide detectors. Twenty-seven states plus Washington, D.C., require private homes to have detectors and another 11 states require detectors either as part of a building or residential code.[39]

In homes without gas stoves, average CO levels are between 0.5 and 5 parts per million (ppm). Homes with gas stoves that are properly adjusted are often between 5 and 15 ppm whereas levels near poorly adjusted stoves can be twice as high: 30 ppm or higher.[40] A 2011–2013 study of 316 California homes that measured CO in homes found that approximately 5 percent had short-term levels that exceed California's ambient air quality standard of 20 ppm over a one-hour period or 9 ppm over an eight-hour period.[41]

The Consumer Product Safety Commission (CPSC) reports that about 170 people die every year from CO poisoning caused by non-automotive products, including stoves and ovens.[42] The CPSC helped to develop the voluntary safety standard UL 2034 for CO detectors.[43] This is the standard with which most US manufacturers comply.[44] Smoke detectors meeting UL 2034 will not sound an alarm at low CO levels. It should be noted that because of the high CO level for alarm thresholds, this standard does not wholly protect all members of the population.[45]

EXHIBIT 2
Health Effects of Carbon Monoxide by CO Level and Alarm Thresholds

CO Level	UL 2034 Alarm Thresholds[46]	Health Effects[47]
30 ppm or less	No alarm until after 30 days[48]	Most healthy people will not experience symptoms from prolonged exposure to 1–70 ppm. Some people with heart problems may experience more chest pain.
70 ppm	Alarm after 1–4 hours (but not less than 1 hour)	
		At levels above 70 ppm, symptoms become more noticeable and can include headache, fatigue, and nausea.
150 ppm	Alarm after 10–50 minutes	Sustained concentrations above 150 to 200 ppm can lead to disorientation, unconsciousness, and death.
400 ppm	Alarm after 4–15 minutes	

Standards and guidelines should protect the general population as well as sensitive populations. The most compelling health evidence for limiting CO exposure is cardiovascular morbidity. In 2010, the EPA stated that there is likely to be a causal relationship between short-term CO exposure and cardiovascular morbidity.[iv,49] People with coronary heart disease are the most vulnerable to low levels of CO exposure and are more likely to have a higher number of hospital admissions from CO exposure.[50] It is possible to install low-level CO detectors that alert occupants when levels reach as low as 5 or 6 ppm.[51] Regulators should assess requiring CO alarms, including near gas stoves, to ensure all residents are protected within an adequate margin of safety.

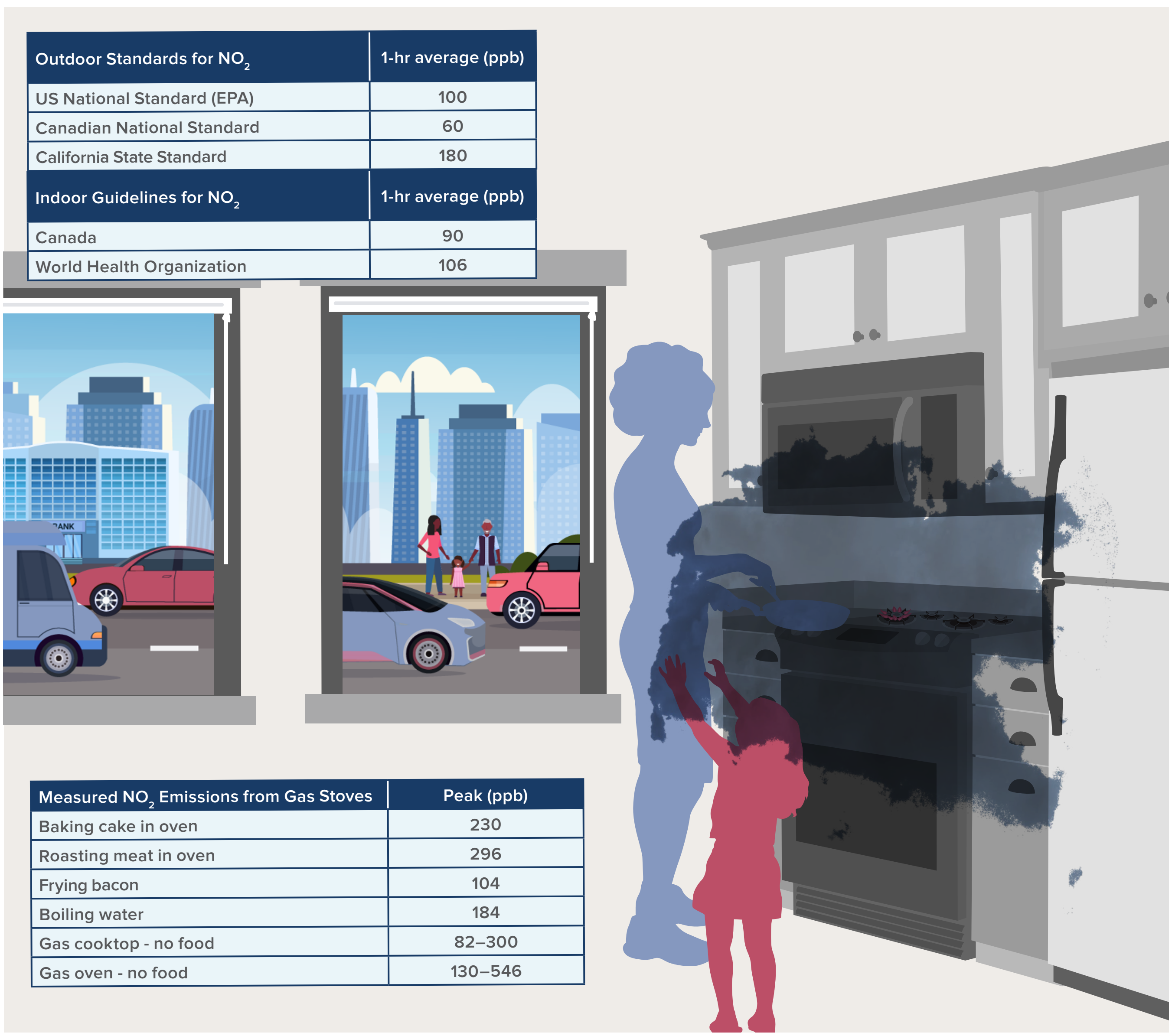
[iv] Cardiovascular morbidity may include heart attack, congestive heart failure, and ischemic heart disease.

3. **Peak indoor air pollution from gas stoves can reach levels that would be illegal outdoors.** Homes with gas stoves have approximately 50 percent to over 400 percent higher average NO_2 concentrations than homes with electric stoves.[52] In many instances, the short- and long-term NO_2 levels in homes with gas stoves are higher than outdoor EPA air quality standards, which in turn are higher and less stringent than the indoor air quality guidelines issued by the World Health Organization and Health Canada (there are no indoor guidelines issued by the US EPA).[53,54,55]

EXHIBIT 3

Gas Stoves Can Emit Elevated Indoor Nitrogen Dioxide (NO_2) Levels Often Exceeding Indoor Guidelines and Outdoor Standards[a]

Outdoor Standards for NO_2	1-hr average (ppb)
US National Standard (EPA)	100
Canadian National Standard	60
California State Standard	180
Indoor Guidelines for NO_2	**1-hr average (ppb)**
Canada	90
World Health Organization	106



Measured NO_2 Emissions from Gas Stoves	Peak (ppb)
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop - no food	82–300
Gas oven - no food	130–546

4. The risks to respiratory health from NO_2 are well-documented.

The US EPA states that strong evidence exists for a relationship between long-term exposure to NO_2 and the development of asthma in children.[56] The EPA's statement was made through review of multiple high-quality studies conducted by many different research groups. Even small increases in short-term exposure of indoor NO_2 can increase asthma risks for children.[57] For adults with asthma, NO_2 exposures not much higher than peak outdoor concentrations (1 hour) can exacerbate asthma.[58] In 2016, the EPA reported a conclusive finding that short-term exposure to NO_2 can cause respiratory illnesses.[59] This finding is largely based on short-term exposure to NO_2 triggering asthma attacks and exacerbating asthma.[60] This strengthens the EPA's prior findings in 2008.

A threshold for safe levels of NO_2 has not been determined, and studies indicate that the EPA outdoor air standards are not protective of sensitive populations. Documented health effects occur at levels well below the EPA outdoor air standard of 53 ppb for long-term exposure.[61]

A 2013 study of children with asthma in suburban and urban homes measuring month-long averages of indoor NO_2 found that as NO_2 levels increased, so did the severity of asthma.[62] For every 5-ppb increase in NO_2 above a threshold of 6 ppb, the risk of wheeze and the need for medication increased.[63] The study concluded that asthmatic children are at higher risk for more severe asthma symptoms at low levels of NO_2 and the risk rises as NO_2 rises.[64]

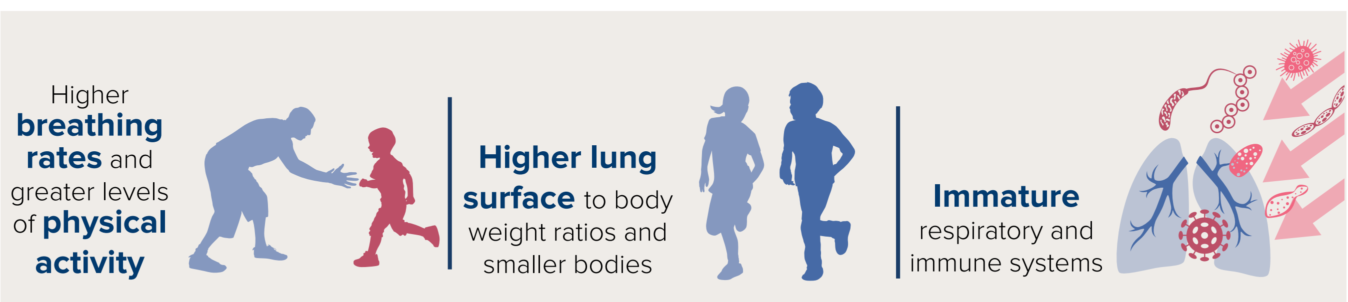
A meta-analysis published in 2013 showed children's risk of wheeze increased by 15 percent for every 15-ppb increase in NO_2.[65] Another study found that a 15-ppb increase in NO_2 corresponded to a 50 percent increase in annual risk for respiratory symptoms among children and adolescents.[66]

Besides asthma, some of the most common health effects from NO_2 exposure are those related to the respiratory tract: from symptoms like wheeze, cough, and chest tightness all the way to severe illnesses such as chronic obstructive pulmonary disease.[67,68] Research also suggests that other illnesses may be linked to elevated levels of NO_2. These include cardiovascular effects, diabetes, cancer, and reproductive effects.[69]

Finally, there is mounting evidence linking combustion-related air pollution with adverse brain development.[70] A study published in 2009 found evidence that infant through preschool-age early-life exposure (through age four) to indoor air pollution from gas appliances may be related to impaired cognitive function and may increase the risk of developing attention-deficit/hyperactivity disorder (ADHD) symptoms.[71]

EXHIBIT 4

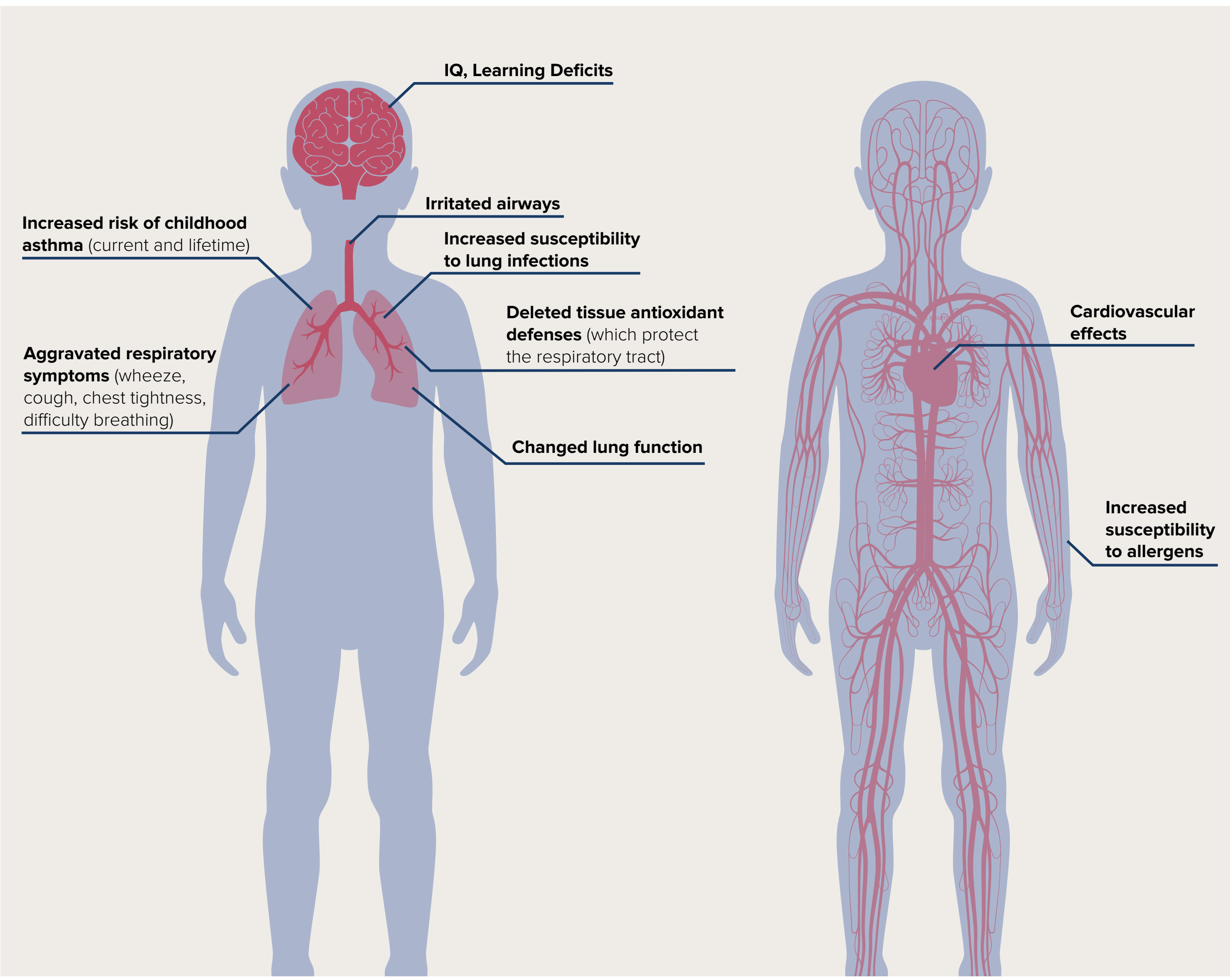
Three Main Factors Why Children Are More Susceptible to Illnesses Associated with Air Pollution than Adults[b]



5. **Children are particularly at risk from pollution associated with gas stoves.**
According to the US EPA, both unburned and burned gases release toxic chemicals into household air.[72] These chemicals include NO_2, $PM_{2.5}$, carbon monoxide, formaldehyde, and others, all of which are associated with serious human health effects.[73,74,75,76] How this mix of pollutants affects childhood respiratory illnesses is not well understood.[77] However, a meta-analysis looking at the association between gas stoves and childhood asthma found children in homes with gas stoves have a 42 percent increased risk of experiencing asthma symptoms (current asthma), a 24 percent increased risk of ever being diagnosed with asthma by a doctor (lifetime asthma), and an overall 32 percent increased risk of both current and lifetime asthma.[78] This may suggest multiple pollutants from burning gas together pose a higher risk to children than NO_2 alone.

EXHIBIT 5

Health Effects of Nitrogen Dioxide (NO_2) in Children May Include[c]



6. **Lower-income households may be at higher risk of exposure to gas stove pollution**.
   Housing is closely linked to socioeconomic status, and home size can directly influence household environmental exposure to indoor air pollution. Factors including smaller unit size, more people inside the home (occupant density), and inadequate stovetop ventilation contribute to elevated concentrations of NO_2 in lower-income, multifamily buildings.[79] Although national data for how many homes have proper stove ventilation is lacking, researchers have found that gas stoves without properly vented exhaust hoods are common in inner-city households, including in Baltimore.[80,81]

In some cases, lower-income households may have greater exposure to pollutants from gas stoves because of the practice of using gas-powered ovens as a source of heat.[82] Studies, including a nationally representative study, report that in response to malfunctioning, inefficient, or broken heating systems, some households use their ovens or gas space heaters for additional warmth.[83,84,85] This can produce elevated levels of NO_2 and other hazardous pollutants for prolonged periods of time. A study of 150 asthmatic pre-school age children in Baltimore found that 14 percent of households use the stove/oven as a source of heat, which consistently produced higher levels of NO_2 than using stoves only for cooking.[86]

INDOOR AIR POLLUTION DISPARITY: An Environmental Justice Perspective

Lower-income households are more likely to suffer health effects from outdoor air pollution.[87] The most affected are children and adults with asthma, a disease that is profoundly inequitable: 15.7 percent of African American non-Hispanic children have asthma, compared to about 7.1 percent of white non-Hispanic children.[88,89,90] While Hispanic children have a rate of 6.7 percent asthma overall, asthma prevalence in Puerto Rican children is much higher at 12.9 percent.[91] Asthma rates vary widely by county and state, with some US counties recording asthma rates in children exceeding 25 percent.[92,93]

In particular, asthmatic children from low-income families often experience greater exposure to outdoor air pollution and are more susceptible to the health effects of pollution than asthmatic children from higher-income families.[94,95] Since research shows that children with asthma are affected by indoor air pollution from gas stoves, children living in areas with high levels of outdoor air pollution and lower-income, African-American and Hispanic children with asthma are likely the most disproportionately burdened by indoor air pollution from gas stoves.[96,97]

A study of two public housing apartment buildings found significant decreases in multiple indoor exposures and improved health outcomes among participants who moved from conventional apartments to “green” housing. Nitrogen dioxide concentrations decreased by 65 percent and $PM_{2.5}$ concentrations decreased by 57 percent. The researchers stated that the change from gas to electric stoves could be a contributor to the evidenced reductions, which they note is supported by the fact that cooking times did not change.[98]

7. **Ventilation is important but cannot be relied upon as a sole strategy to prevent exposure to gas stove pollution.**

Major gas appliances found in the home are uniformly required to be vented outdoors—except for gas stoves.[99] For decades cities and states have focused on ensuring that the pollution from gas hot water heaters, gas furnaces, and gas dryers are vented outside of the home because of the known human health risk. However, there is no similar uniform venting requirement for gas stoves.

In many states, there are no venting requirements for gas stoves in new buildings. Even in states where venting gas stoves is required, there are no comprehensive standards to ensure the venting is adequate or that it automatically turns on when pollution levels are unsafe.[100]

Properly installed, maintained, and operated local ventilation (exhaust hoods over or behind stoves) can reduce NO_2 and other pollutant levels and is associated with better respiratory health.[101] However, in many places there are no building code requirements to install exhaust hoods that actually vent to the outdoors.[v] Multiple studies suggest that many exhaust hoods or hoods that recirculate air do not uniformly remove pollutants from gas stoves, particularly from the front burners.[102,103] Additionally, currently available exhaust hood technology has a wide range of performance and often very poor pollution capture rates.[104]

There are four main barriers to successfully using ventilation to reduce gas stove pollution. First, many homes do not have exhaust hoods. Second, many exhaust hoods are "ductless" or recirculating, meaning they do not vent outdoors but rather recirculate emissions through filters that do not effectively clean the air.[105]

Third, the performance and effectiveness of exhaust hoods vary widely. Tests on commercially available hoods show that they can capture anywhere from less than 15 percent of pollutants to 98 percent of pollutants depending on equipment used, air flow, and if the front or rear burners are used.[106] For units that have been tested, most fail to capture more than 75 percent of pollutants and those that do are often noisy.[107] Fourth, many people who have exhaust hoods do not use them frequently, if at all. Although no national data exists on exhaust hood use, a survey of over 350 California residents showed that 40 to 60 percent did not use an exhaust hood or open windows while cooking.[108]

In terms of why exhaust hoods are needed, some survey results show people largely do not feel that exhaust fans are needed, and for others, the fans are too noisy or people simply do not think of using them.[109] In short, we cannot rely on current exhaust ventilation practices alone to protect families from unsafe levels of gas stove pollution.

This issue may be getting worse. As homes become more energy efficient, they also risk trapping air pollution indoors. Modeling shows that from an indoor air quality standpoint to protect health, energy retrofits should, but often do not allow for increased ventilation and filtration. It is possible for energy savings (for example better insulation and tighter sealing) to make air quality worse by restricting ventilation and airflow.[110] Emerging research shows that residential

[v] Exhaust hoods (also called range or vent hoods) are devices designed to remove cooking-related contaminants. Here exhaust hoods refer to hoods over the stove, including microwave/exhaust fan combinations, exhaust fans mounted above the stove, wall, or ceiling—essentially any device designed to capture pollutants and vent to the outdoors.

ventilation is linked to lung function. A 2019 study of low-income urban homes in Colorado found that in homes with greater ventilation rates (by infiltration—or the dilution of indoor air with comparatively cleaner outdoor air) household residents (eight years of age and older) had better lung function.[111]

One study modeling weatherization found that efforts to solely tighten the envelope (to restrict or control airflow) led to a 20 percent increase in serious asthma events; however eliminating the indoor pollution sources and repairing exhaust hoods mitigated the effect.[112] Of the interventions modeled, changing the gas stove to electric resulted in one of the greatest health care savings, as reflected by reduced healthcare utilization costs such as hospitalizations and emergency department visits.[113,114]

8. **Electric cooking is the cleanest household cooking option.[115]**

Since electric stoves do not emit high levels of combustion pollutants like NO_2, they are inherently cleaner than gas stoves. In the first published intervention study to remediate indoor NO_2 concentrations from gas stoves, researchers found that replacing a gas stove with an electric stove decreased median NO_2 concentrations by 51 percent in the kitchen.[116]

The study concluded that replacing gas stoves with electric stoves produces the greatest decrease in indoor NO_2 concentrations.[117] The results show that the simple intervention of replacing a stove may not only dramatically reduce indoor NO_2 levels in the kitchen but also throughout the home.[118] Unlike relying on exhaust hoods or other pollution control options that depend on people using them, replacing a gas stove with an electric (including induction) stove can decrease pollutants at the source.

RECOMMENDATIONS

Protecting residents living in homes with gas stoves will require collaborative action by policymakers, individuals, healthcare professionals, and researchers.

POLICYMAKERS
Federal Policy

1. The Consumer Product Safety Commission (CPSC) should expeditiously:

    a. Set science-based indoor air quality guidelines for NO_2 and CO that protect the safety of sensitive populations, including children, the elderly, and those with existing respiratory ailments.

    b. Require manufacturers and installers to certify that any new gas stove installed will not expose residents to harmful levels of NO_2 and CO. This may include a requirement/provision for automatic local exhaust ventilation whenever levels in the kitchen exceed safe levels (including in commercial kitchens and restaurants to protect workers).

2. CPSC should expeditiously open a docket to develop a strategy for protecting residents who currently have gas stoves, and who may in many instances lack the financial means or, in the case of renters, the authority to fix the problem. This review should consider the full range of options at CPSC's disposal, including mandating lower-level CO detectors and requiring warnings on gas stoves, all the way to requiring replacements.

3. The Department of Housing and Urban Development (HUD) should develop and implement a strategy to ensure all residents in federally owned and supported housing do not experience unsafe levels of gas stove pollution.

4. All federal weatherization and other energy efficiency programs should be designed to ensure clean and safe air quality, and to reduce or eliminate pollution from gas appliances, including stoves.

CANADA REVISES INDOOR NO_2 AIR QUALITY GUIDELINES TO BETTER PROTECT HEALTH

Health Canada, the federal department responsible for protecting the public health of Canadians, originally identified NO_2 as an indoor health risk in 1987 and set exposure guidelines for residential air quality. In 2015, after an extensive literature review, Health Canada issued new short- and long-term indoor exposure limits to better protect human health.

For short-term exposure, 90 ppb is set as the maximum limit above which decreased lung function and increased airway responsiveness in asthmatics is possible.[119] For long term-exposure (at least 24-hour sampling) the maximum limit is 11 ppb, above which asthmatic children may experience a higher frequency of days with respiratory symptoms and/or medication use.[120] It is worth noting that Canada's revised long-term indoor NO_2 guideline of 11 ppb may be the strictest in the world; the World Health Organization is nearly twice as lenient at 20 ppb.[121,122]

Health Canada is clear that these standards do not protect against risk for the most sensitive populations which for a one-hour NO_2 concentration would be around 27 ppb.[123,vi] Its analysis considered the 2014 simulation study which suggests that less than 25 percent of homes with gas stoves and moderate ventilation would meet a one-hour standard of 27 ppb.[124] The finalized level of 90 ppb is expected to be met by nearly all gas stoves though the regulators recognize that cooking may cause spikes above these levels.[125] The proposed guideline is therefore meant to be protective of health but ultimately achievable, meaning it is not the lowest threshold identified to protect the most sensitive populations from health effects.[126]

[vi] Conversion of 50 micrograms per meter cubed to parts per billion, assuming a temperature of 25° C and standard molecular weight.

State and Local Policy

In the absence of federal leadership, state, regional, and local regulatory bodies should:

1. Adopt a health-based indoor air quality guideline that protects the most sensitive populations, including children, the elderly, and those with existing respiratory ailments.

2. Ensure building codes for new and renovated buildings have adequate ventilation and other protections to better safeguard residents from harmful levels of gas stove pollution.

3. Require manufacturers and installers to certify that any new gas stove installed will not expose residents to harmful levels of gas stove pollution. In addition to venting outdoors, this may include a building code requirement for low-level CO detectors and automatic ventilation whenever the gas stove is operated and until background levels are safe.

4. Require gas stove manufacturers to include warning labels on stoves and to send warnings to existing gas stove owners, with clear guidance on how to minimize the risk of gas stove pollution exposure.

5. Require elimination of gas stove pollution in all publicly funded buildings as soon as practical, with a focus on buildings that house children and other at-risk populations. State funds, including for schools and low-income housing, should not be used to purchase or install indoor appliances that expose occupants to harmful levels of gas stove pollution.

6. Provide financial incentives, such as tax credits or rebates, that will enable low-income homeowners to eliminate gas stove pollution, including adding plug-in induction stovetops or switching from gas to electric stoves. Prioritize homes with children and other at-risk populations.

7. Require landlords to provide notice to new and existing tenants about the risk of gas stove pollution, including options to minimize gas stove pollution such as offering induction cooktops, gas stove replacement, and stovetop ventilation to the outdoors.

IN RESPONSE TO AIR POLLUTION, CALIFORNIA LEADS NATIONAL EFFORTS TO ELECTRIFY BUILDINGS

After years of state incentives and mandates for buildings that give preference to gas, nearly two-thirds of California homes have a gas stove.[127] Lawrence Berkeley National Laboratory's 2014 simulation study of California homes with gas stoves found that a substantial number of occupants experience pollutant concentrations that exceed health-based standards, particularly when an exhaust hood is not used.[128]

The findings suggest that up to 12 million Californians could be routinely exposed to NO_2 levels and 1.7 million exposed to CO levels that exceed ambient air standards levels in a typical winter week.[129] The simulation also found that cooking on the gas stove without venting would expose 53 percent of occupants to formaldehyde levels exceeding health-based guidelines.[130] During winter, when ventilation in homes is the lowest, 55–70 percent of homes with gas stoves without ventilation may experience air quality that would be illegal outdoors.[131] The pollutant levels simulated in the study are consistent with concentrations measured in California homes.[132]

Millions of homes do not have a range hood and even among those that do, the ventilation is often not used. California communities are taking action to reduce gas consumption and emissions. As of early 2020, 30 communities either passed legislation or updated building codes for all-electric buildings. Additionally, California's state building codes require kitchen exhaust ventilation for all new homes, although this is the exception rather than the rule—most states do not.[133] California's building code currently relies on EPA standards for NO_2, and could benefit from incorporating Canada's more stringent air quality standards, which are designed to protect the most sensitive populations, including children.

INDIVIDUALS

Individuals can take direct action to reduce the risk of exposure to unsafe levels of gas stove pollution:

1. **Reduce gas stove use:** Minimize gas stove use by instead using plug-in induction cooktop and other electric appliances, such as electric kettles, toasters, microwaves, instant pots, etc.

2. **Ventilate:** If stoves have any kind of ventilation, use at all times with cooking. Ideally the stovetop exhaust hood vents to the outdoors. Cook on the back burners that are nearest to the ventilation system, if possible. Leave the ventilation system running for at least five minutes after cooking. Clean exhaust hoods periodically.

3. **Open windows:** If ventilation is not available, cook with a window open whenever possible. Even opening windows for a short period of time, such as less than five minutes, can be effective at decreasing indoor pollutant levels.

4. **Install and maintain carbon monoxide detectors:** Use devices that meet safety standards and/or sound alarms at low levels. Ideally install in kitchen and in or near bedrooms.

5. **Replace the gas stove:** Replace a gas stove with electric alternatives, such as an electric induction stove.

HEALTHCARE ORGANIZATIONS AND PROFESSIONALS

1. As part of reducing asthma triggers and other respiratory risks, health care organizations and insurance companies should assess risks posed by gas stove pollution, and where appropriate encourage and/or support families to minimize risks, including reducing gas stove use, ventilation, and gas stove replacement.

2. The Centers for Disease Control and Prevention (CDC) should provide guidance to all health professionals about the risks of gas cooking, particularly on children’s health, and provide recommendations for interventions. These interventions could include assessing the presence of gas stoves as part of the multi-trigger, multifaceted, home-based intervention for asthma recommended by the Community Preventative Services Task Force.

3. State and national medical societies and medical specialty societies should formally recognize the risk to the health of asthmatic children of cooking with gas. They should work to raise awareness among doctors and nurses by developing and distributing guidance and intervention recommendations.

MASSACHUSETTS MEDICAL SOCIETY COMMITS TO ACTION TO ADDRESS GAS STOVE POLLUTION

Founded in 1781, the Massachusetts Medical Society (MMS) is the oldest continuously operating state medical society in the United States. It is currently comprised of over 25,000 physicians and medical students. In December 2019 the MMS adopted *Informing Physicians, Health Care Providers, and the Public that Cooking with a Gas Stove Increases Household Air Pollution and the Risk of Childhood Asthma.* The two-part resolution first recognizes the association between the use of gas stoves, indoor NO_2 levels, and asthma. Secondly, the MMS commits to informing members and to the extent possible other Massachusetts organizations, health care providers, and the public that gas stove use increases household air pollution and the risk of childhood asthma and asthma severity.[134]

Indoor interventions that lower NO_2 or remove gas stove pollution could reduce the occurrence and severity of related illnesses, thus decreasing healthcare costs. In Massachusetts, the annual estimated cost of environmentally attributable asthma is between $10 and $50 million.[135]

"For kids with asthma, it is easier to replace a gas cooking stove than to move away from a busy, polluting highway."

—Dr. T. Stephen Jones, retired public health physician and coauthor and cosponsor of the resolution

Image courtesy of Dr. T. Stephen Jones

RESEARCHERS

Funders can help drive the next phase of research. Priorities include broadening the scope of health impacts studied, identifying the most successful intervention options, and quantifying the costs and benefits of action.

1. Conduct and disseminate studies on additional topics including monitoring personal peak exposures to gas stove pollution, assessing the vulnerability of different groups such as adults with underlying health conditions and the elderly, and studying the health effects of gas pollutants on other organs, including brain development.

2. Quantify economic costs associated with gas stove pollution, including health care costs. Identify who is currently paying these costs.

3. Quantify the health costs of retrofits that tightly seal the building in order to avoid unintended health costs of trapping gas pollutants, which could potentially outweigh the benefits of energy saved.

4. Conduct randomized trials to determine the impact of gas stove interventions on children with asthma to help guide interventions. The studies could evaluate the impact on childhood asthma of reducing stove use, using exhaust hoods, and replacing gas stoves with new types of electric stoves such as electric glass-top or electric induction stoves.

CONCLUSION

Pollution from gas stoves can degrade indoor air quality, and even modest use of gas stoves can expose people to levels of air pollution above outdoor air pollution standards.[vii] The body of scientific literature and analysis of the health effects from cooking with gas provides evidence of gas stoves being associated with increased risks of respiratory illnesses.

It is time to address the root cause of much of the home's indoor air pollution: the gas stove. Moving from gas to electric stoves can help protect the most vulnerable populations, including children and the elderly. There are important roles for policymakers, health professionals, researchers, and individuals to help reduce the risk of millions of people exposed to unsafe levels of gas stove pollution.

[vii] There are other examples in some states such as ventless gas heaters and gas fireplaces, but that is beyond the scope of this particular report.

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