



# The Risks and Harms of Gas-Fired Residential Appliances

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A section update of the “Compendium of Scientific, Medical, and Media Findings  
Demonstrating Risks and Harms of Fracking and Associated Gas and Oil  
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<https://concernedhealthny.org/compendium/> and  
<https://psr.org/resources/fracking-compendium-9/>

## **About Concerned Health Professionals of New York and the Science and Environmental Health Network**

Concerned Health Professionals of New York (CHPNY) is an initiative by health professionals, scientists, and medical organizations for raising science-based concerns about the impacts of fracking on public health and safety. CHPNY provides educational resources and works to ensure that careful consideration of science and health impacts are at the forefront of the fracking debate. In June 2021, the Ceres Trust granted funding for CHPNY to become a program of the Science and Environmental Health Network (SEHN). Since 1998, SEHN has been the leading proponent in the United States of the Precautionary Principle as a basis for environmental and public health policy. In service to communities and future generations, the Science and Environmental Health Network is a research institution that forges law, ethics, and science into tools for action.

## **About Physicians for Social Responsibility**

Working for more than 50 years to create a healthy, just, and peaceful world for both present and future generations, Physicians for Social Responsibility (PSR) uses medical and public health expertise to educate and advocate on urgent issues that threaten human health and survival, with the goals of reversing the trajectory towards climate change, protecting the public and the environment from toxic chemicals, and addressing the health consequences of fossil fuels. PSR was founded by physicians concerned about nuclear weapons, and the abolition of nuclear weapons remains central to its mission.

**For full background on the Compendium project, please see the introductory sections of the full report at: <https://concernedhealthny.org/compendium/> or <https://psr.org/resources/fracking-compendium-9/>**

## Introduction

### Combustion of fracked gas inside homes via gas-fired residential appliances creates health and climate harms

With natural gas burned in 60 percent of all homes, U.S. households represent the terminus of the fracking pipeline. As of 2020, an estimated 45 percent of U.S. homes used gas-fired furnaces and boilers for home heating, and 38 percent of U.S. homes used gas-fired stoves and ovens for cooking.<sup>1</sup>

Combustion of methane by residential gas appliances creates nitrogen dioxide (NO<sub>2</sub>) (a corrosive respiratory irritant linked to airway inflammation and asthma), carbon monoxide (CO) (a poisonous gas that displaces oxygen on hemoglobin in red blood cells), and carcinogens including formaldehyde and benzene. All are invisible gases that form within gas flames. Gas appliances also emit unburned methane directly into indoor air through leaks and incomplete combustion. As reported by a 2022 study in 53 homes, three-quarters of the methane emissions from gas stoves take place when the appliance is turned off and not in use. Using a 20-year timeframe for methane's global warming potential, methane emissions from all gas stoves in U.S. homes have a climate impact comparable to the annual carbon dioxide emissions of 500,000 cars. (See footnote 35.)

Whereas gas-fired furnaces, boilers, clothes dryers, and water heaters typically exhaust combustion byproducts to outside air as required by building codes, gas stoves represent a singular risk to public health because they more often release hazardous pollutants directly into indoor air within the living space of homes. Venting these emissions via range hoods is, by itself, an insufficient mitigation strategy. (See footnote 39.) Many range hoods are ductless, recirculating fumes back into indoor air space rather than venting to the outside, and do little to lower exposures. Further, significant reductions in NO<sub>2</sub> concentrations with use of ventilation hoods are limited to cooking events done on the back burners. (See footnotes 21, 40.)

The air inside homes with gas stoves has average concentrations of NO<sub>2</sub> that are 50 to 400 percent higher than the air inside homes with electric stoves.<sup>2</sup> These levels of air pollution can easily exceed health guidelines and would be considered illegal outdoors—as, for example, along a busy roadway—where concentrations are regulated by the U.S. Environmental Protection Agency (EPA). Similarly, as documented by an August 2023 study of Colorado and California homes, gas stoves release carcinogenic benzene into kitchens at levels that exceed health guidelines. These vapors quickly spread throughout homes, in some cases raising bedroom benzene concentrations above accepted health benchmarks for hours after the stove is turned off. (See footnote 23.)

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<sup>1</sup> U.S. Energy Information Administration, “2020 RECS Survey Data,” Residential Energy Consumption Survey (RECS), 2020, <https://www.eia.gov/consumption/residential/data/2020/>.

<sup>2</sup> U.S. Environmental Protection Agency, *Integrated Science Assessment (ISA) for Oxides of Nitrogen – Health Criteria*, Final Report EPA/600/R-08/071 (Washington, D.C., 2008), <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=194645>.

The link between gas stove emissions and respiratory distress in children is supported by dozens of studies dating back to 1977. By 1994, all studies of NO<sub>2</sub> exposure and respiratory illnesses in children showed positive associations.<sup>3</sup> Since then, dozens more studies have documented links between NO<sub>2</sub> exposure and asthmatic symptoms. Nitrogen dioxide exposure is also linked to chronic obstructive pulmonary disease and respiratory distress among those not suffering from asthma. The mechanism behind NO<sub>2</sub>'s ability to harm the respiratory system is well-understood. Because they are not very water-soluble, NO<sub>2</sub> molecules, when inhaled, bypass the mucus membranes in nasal and throat passages, traveling easily to the terminal bronchioles deep inside the lungs where they convert to molecules of nitric acid. Highly reactive, these molecules trigger inflammation and acute injury to pulmonary cells. They disable the immune cells that inhabit this tissue, increasing vulnerability to respiratory pathogens, such as influenza viruses, and so increasing susceptibility to infection. They also trigger bronchial spasms and wheezing.<sup>4</sup>

A 2013 systematic review and meta-analysis found that children living in homes with gas stoves have a 42 percent increased risk of having current asthma and a 24 percent increased risk of developing asthma during their lifetime. (See footnote 42.) Using these data, a 2022 study estimated that 13 percent of childhood asthma in the United States—647,700 cases—is attributable to the use of gas stoves. The study shows that, at a population level, the asthma risk to children from gas stoves is similar to children exposed to secondhand tobacco smoke. (See footnote 27.)

Nitrogen dioxide exposure from gas stove emissions is an environmental justice issue. Asthma is the leading chronic disease among U.S. children with Black children nearly three times more likely to suffer asthma than white children. Evidence suggests that communities of color and low-income communities are disproportionately harmed by gas stove emissions especially among households with smaller, older, less-ventilated living spaces, and especially if they rely on gas ovens for supplemental heat. Despite this evidence and decades of data linking gas stoves to respiratory harm, emissions from gas stoves and other gas-burning home appliances are essentially unregulated by federal or state policies.

Both the American Medical Association and the American Public Health Association have recognized the links among gas stoves, NO<sub>2</sub> pollution, and increased respiratory illnesses in children and have called for a transition away from gas stoves and toward electrification of home appliances. (See footnotes 30, 32, 33.)

In response to the mounting evidence that fossil fuel combustion inside of buildings is contributing significantly to the climate crisis, a growing movement of U.S. cities, counties, and states have passed, or are pursuing, building electrification measures. In response, the fossil fuel industry has mounted attacks on these efforts that include pre-emptive state legislation to block

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<sup>3</sup> W. Michael Alberts, "Indoor Air Pollution: NO, NO<sub>2</sub>, CO, and CO<sub>2</sub>," *Journal of Allergy and Clinical Immunology* 94, no. 2 (1994): 289–95, <https://doi.org/10.1053/ai.1994.v94.a56007>.

<sup>4</sup> Daniela Fecht et al., "Exposure to Elevated Nitrogen Dioxide Concentrations and Cardiac Remodeling in Patients With Dilated Cardiomyopathy," *Journal of Cardiac Failure* 28, no. 6 (2022): 924–34, <https://doi.org/10.1016/j.cardfail.2021.11.023>.

municipal ordinances.<sup>5</sup> Nevertheless, a September 2023 report found that that building electrification measures that require new construction to be all-electric and prohibit gas-burning appliances would have a large impact on reducing emissions from the nation’s future housing stock. The report found that passing policies that require electrification on all new residential construction, were they implemented in just 63 strategically chosen metropolitan areas, could eliminate more than half (53 percent) of methane emissions from U.S. residential building constructed between 2023 and 2030.<sup>6</sup>

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**The research summaries below include:** all those in the ninth edition fracking science Compendium, either in the section entitled “Gas-fired residential appliances” (pages 560-564) or covered as late-breaking studies in that report’s introduction; new studies appearing after March 3, 2023 and through March 22, 2025; and several studies that were missed in the ninth edition. The italicized research summary is updated from the ninth edition.

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<sup>5</sup> Influence Map, *The Global Campaign Against Building Electrification* (2025), [https://influencemap.org/report/Building\\_Electrification\\_Report](https://influencemap.org/report/Building_Electrification_Report).

<sup>6</sup> Devyani Singh et al., *A Roadmap to Fossil-Free Homes: Where Local Building Electrification Policies Would Have the Greatest Impact* (Stand.earth Research Group, Safe Cities, Lead Locally, 2023), <https://www.safecities.earth/wp-content/uploads/2023/09/SAFE-Lead-Locally-Electrification-Report-Digital.pdf>.

## **Gas-fired residential appliances: A ninth edition Compendium section update**

*Gas flames burning inside of homes and buildings represent the terminus of the fracking pipeline and are a significant contributor to poor indoor air quality. Gas-fired appliances create many pollutants including corrosive nitrogen dioxide (NO<sub>2</sub>), deadly carbon monoxide (CO), and the carcinogens formaldehyde and benzene, for which there are no safe levels of exposure. They also inevitably leak methane, carrying other pollutants with it.*

*Gas stoves, whose emissions are not routinely vented to the outside—as are furnaces, boilers and water heaters—represent a special risk. Nearly three-quarters of methane emissions from gas stoves take place while the stove is turned off and not in use. According to an Integrated Science Assessment by the U.S. EPA in 2008, the air inside homes with gas stoves has average concentrations of NO<sub>2</sub> that are 50-400 percent higher than the air inside homes with electric stoves. Recent studies have demonstrated that NO<sub>2</sub> from gas stoves moves efficiently around entire houses, as does benzene, and those living with smaller kitchens and in smaller homes suffer higher exposures. Incomplete combustion of the gas also creates particulate matter (PM) of various sizes that can penetrate deeply into the lungs and enter the bloodstream. Levels of hazardous air pollutants indoors from everyday use of gas stoves often exceed the limits of outdoor air quality standards. Indoor concentrations are often much higher than health-protective guidelines set by the World Health Organization (WHO). Opening windows or running mechanical ventilation, while critical, are frequently inadequate in reducing gas stove pollution to safe levels. Further, a 2024 shows that the addition of odorant to gas is unreliable for leak detection.*

*Nitrogen dioxide exposure is a proven cause of childhood asthma. A 2013 study found that children living in a home with a gas stove have a 42 percent increased risk of current asthma and a 24 percent increased risk of lifetime asthma. A 2022 investigation that built on this earlier research found that 13 percent of childhood asthma cases in the United States are attributable to the use of gas stoves. Subsequent analyses include a 2024 estimate indicating that gas and propane stoves contribute up to 50,000 current cases of pediatric asthma in the United States. Recognizing that cooking with a gas stove increases household air pollution and the risk of childhood asthma, the American Medical Association has called for a “transition from gas stoves to electric stoves in an equitable manner.”*

*Sophisticated assessments and simulations now demonstrate the substantial health and economic benefits of converting gas appliances to electric. With the evidence of causal associations between some of these emissions and various health outcomes—as well as that for their global warming potential—growing ever more consistent, authors of many of these recently-published studies and reports strongly recommend elimination of gas stoves. Their study discussions, as demonstrated below, contain increasingly clear and detailed recommendations for interventions including gas appliance phase-out policies, updated building codes and appliance standards, protective indoor air policies, and other public health data-driven changes to alleviate this hazard. Barriers exist, including health concerns dismissed or denied in the retail environment according to one report and consumer resistance to change*

*in another, but there is also documentation that providing education about and access to an alternative (induction stove) is successful.*

- March 22, 2025 – This study models benzene emissions from gas stove use in U.S. homes and estimated associated cancer risks under various building types, ventilation conditions, and stove-use scenarios. Researchers use the validated CONTAM simulation platform (a National Institute of Standards and Technology model to help determine airflows, contaminant concentrations, and occupant exposure in buildings) to demonstrate that benzene concentrations can significantly exceed WHO indoor air quality guidelines, particularly in smaller or poorly ventilated residences. Critically, the study links modeled exposure profiles to lifetime cancer risk estimates, including excess leukemia incidence, marking one of the first efforts to quantify the carcinogenic burden of residential gas combustion beyond respiratory endpoints. The findings emphasize that even intermittent use of gas stoves, especially in high-use and/or low-ventilation contexts, can result in persistent benzene exposure in adjacent rooms such as bedrooms, increasing the risk of cancer. These results underscore the need for both structural mitigation (e.g. effective ventilation) and systemic consideration of gas appliance phase-out to address chronic exposure to indoor air hazards.<sup>7</sup>
- March 18, 2025 – This study stands out for linking empirical measurements of nitrogen oxides (NO<sub>x</sub>) emissions from gas stoves to health-protective standards across multiple countries and scenarios. Combining experimental data with theoretical modeling in apartment settings, this study effectively translates technical findings into a policy-relevant framework by comparing measured NO<sub>x</sub> levels against current legal and health-based standards across numerous countries worldwide. By mapping real-world indoor exposure to regulatory thresholds, the study highlights the insufficiency of current ventilation practices and appliance designs in protecting human health. This alignment of scientific data with policy metrics offers a clear rationale for updating building codes, appliance standards, and exposure guidelines to address the persistent health risks posed by residential gas combustion.<sup>8</sup>
- March 14, 2025 – This study of 344 homes in 4 Canadian cities provides a data-backed rationale for phase-out strategies, appliance standards, and health interventions that are both seasonally and regionally appropriate for Canada’s built environment and public health priorities. As the first national-level indoor exposure assessment across seasons and fuel types, researchers systematically quantify the impacts of residential fossil fuel combustion, including natural gas and oil, on key indoor contaminants in Canadian homes. The research links the presence of gas stoves and dryers to significant increases in indoor NO<sub>2</sub>, up to 191 percent in winter and 114 percent in summer, while also revealing

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<sup>7</sup> Anchal Garg et al., “Exposure and Health Risks of Benzene from Combustion by Gas Stoves: A Modelling Approach in U.S. Homes,” *Journal of Hazardous Materials* 492 (July 2025): 137986, <https://doi.org/10.1016/j.jhazmat.2025.137986>.

<sup>8</sup> Alexander Shkarovskiy and Agnieszka Maliszewska, “Air Pollution Problems in Apartments Equipped with Gas Stoves,” *Energies* 18, no. 6 (2025): 1492, <https://doi.org/10.3390/en18061492>.

a significant 43-percent spike in peak hourly CO levels associated with gas stoves in winter. Similarly, oil heating demonstrated elevated NO<sub>2</sub> in winter. This study also revealed that gas heating in older and less-updated housing, more common among low-income and rural populations, is linked with higher NO<sub>2</sub> exposures (home age did not impact level of exposures in oil- and electric-heated homes in this study). This identification of disparate impacts can inform targeted retrofitting and electrification programs in Canada's energy transition. This study, with its nuanced, regionally-grounded evidence, can be useful for clinical guidance, public health interventions, and housing policy tailored to national contexts.<sup>9</sup>

- February 1, 2025 – As part of a larger clinical trial, researchers conducted “household environmental trigger audits” in the New York City apartments of 30 Black adults with uncontrolled asthma. The triggers they assessed were gas stove emission exposure, regular opening of windows facing an arterial road, and tobacco smoke exposure. Participants with daily exposure to gas stove emissions had clinically-significant worse asthma-related quality of life than those without gas stove exposures.<sup>10</sup>
- January 18, 2025 – This review synthesizes evidence on indoor air pollutants emitted by gas stoves—specifically NO<sub>2</sub>, CO, formaldehyde, benzene and particulate matter (PM)—demonstrating that kitchen concentrations frequently exceed WHO air quality guidelines. Beyond cataloging health risks, this review consolidates mitigation strategies, advocating for an integrated approach combining transitioning to electric cooking, enhanced ventilation, regulatory improvements, public awareness efforts, and financial incentives. The value of this review lies in offering both a rigorous synthesis of pollutant-specific evidence and practical policy and behavioral pathways to reduce exposure, bridging the gap between toxicological data and actionable public health interventions.<sup>11</sup>
- December 11, 2024 – As part of an intervention to reduce environmental triggers in the homes of older adults with asthma, living in low-income housing with gas stoves in Lowell, Massachusetts, this study collected data to better understand the determinants of indoor levels of NO<sub>2</sub> and inhalable particles with a diameter of 2.5 microns or less (PM<sub>2.5</sub>). Both NO<sub>2</sub> and PM<sub>2.5</sub> are emitted during gas stove use. In this study, indoor concentrations of both pollutants were significantly higher than outdoor concentrations, across all seasons, and outdoor levels did not predict indoor concentrations. Indoor NO<sub>2</sub> levels were primarily influenced by the presence of a pilot light on the gas stove; those that did had increased indoor NO<sub>2</sub> concentrations. The study used 5-7 day averages rather than real-time data collected during cooking events, which limited its ability to assess stove usage as a predictor of indoor NO<sub>2</sub> levels. The presence of a stove hood or

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<sup>9</sup> Liu Sun et al., “Associations between Residential Fossil Fuel Combustion and Indoor Concentrations of Nitrogen Dioxide, Carbon Monoxide, and Aldehydes in Canadian Homes,” *Journal of Exposure Science & Environmental Epidemiology*, ahead of print, March 14, 2025, <https://doi.org/10.1038/s41370-025-00762-6>.

<sup>10</sup> Rhea Khurana et al., “Household Environmental Triggers And Asthma Quality Of Life Among Black Adults With Uncontrolled Asthma,” *Journal of Allergy and Clinical Immunology* 155, no. 2 (2025): AB286, <https://doi.org/10.1016/j.jaci.2024.12.882>.

<sup>11</sup> Barae Jomaa et al., “Gas Stove Pollutants: Consequences on Indoor Air Quality and Health,” *Journal of the Netherlands Society of Toxicology* 2, no. 1 (2025), <https://doi.org/10.61833/JNST.2024.0004>.

mechanical ventilation in the kitchen was not associated with lower indoor concentrations of NO<sub>2</sub> and PM<sub>2.5</sub>. Nearly half of the homes in the study had a recirculating vent over the stove that did not exhaust to the outdoors.<sup>12</sup>

- December 10, 2024 – This report documents the development and application of a novel county-level modeling framework that links household electrification to quantifiable health, environmental, and economic impacts of resulting improvements in outdoor air quality. Using the National Renewable Energy Laboratory’s ResStock dataset, comprising around 550,000 simulations representative of the U.S. housing stock, authors model emissions and energy demand reductions from electrifying residential heating, water heating and clothes drying, and replacing inefficient electric appliances. Because less electricity is needed to power the inefficient models, this can lead to reduced emissions at power plants. These changes are paired with high-resolution air quality modeling via the open-source air pollution transport model, Intervention Model for Air Pollution (InMAP) and a custom “benefit per ton” metric, translating avoided emissions into estimated mortality and morbidity impacts. This approach allows for spatially granular insights, such as projecting that full electrification nationally could avoid 3,452 premature deaths, 219,000 asthma attacks, and yield \$61 billion in climate and \$39 billion in health benefits annually. This methodology allows for users to easily generate the conversion of appliance-level energy shifts into tangible health and economic benefit. Authors made these outputs publicly accessible via an interactive dashboard, empowering localized, data-driven policy and advocacy around residential electrification.<sup>13</sup>
- October 28, 2024 – This study presents the first comprehensive assessment of indoor NO<sub>2</sub> exposure from gas cooking across European Union (EU) and United Kingdom (UK) populations, mapping concentrations by cooking appliance type at the national level. It finds that over half of the countries studied exceed the 2021 WHO NO<sub>2</sub> health guidelines, with 33 percent of EU households using gas for cooking in 2022. Expanding beyond previous research focused solely on pediatric asthma, the study estimates both health and economic impacts across all age groups—including 40,000 premature deaths, 77,000 years of life lost, and 41,000 pediatric asthma cases attributable to NO<sub>2</sub> exposure, alongside 550,000 pediatric asthma cases linked to the presence of gas stoves. The total economic burden of these impacts is estimated at €180 billion (€157 billion for the EU alone), highlighting the significant potential health and financial benefits of transitioning to cleaner cooking alternatives.<sup>14</sup>
- September 5, 2024 – This 2024 study examines household readiness for electrification in New York City, focusing on adoption and attitudes toward electric stoves and rooftop

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<sup>12</sup> Khafayat Kadiri et al., “Determinants of Indoor NO<sub>2</sub> and PM<sub>2.5</sub> Concentration in Senior Housing with Gas Stoves,” *Toxics* 12, no. 901 (2024), <https://www.mdpi.com/2305-6304/12/12/901>.

<sup>13</sup> Wael Kanj et al., *Breathe Easy: Household Electrification as a Public Health Intervention to Improve Outdoor Air Quality* (Rewiring America, 2024), <https://www.rewiringamerica.org/research/home-electrification-health-benefits>.

<sup>14</sup> Dr Juana Maria Delgado-Saborit et al., *Assessment of the Health Impacts and Costs Associated with Indoor Nitrogen Dioxide Exposure Related to Gas Cooking in the European Union and the United Kingdom*, October 28, 2024, <https://repositori.uji.es/items/156fbd65-070d-4ca4-9856-9415513d505f>.

solar. Surveying nearly 2,000 adults, researchers found that only 14 percent of households use electric stoves, with 86 percent relying on gas. Further, resistance to change was highest among higher-income and White respondents, highlighting that decarbonization efforts may face cultural, not just financial, barriers. Conversely, solar energy interest was robust (77 percent), suggesting more favorable public perception of renewable energy outside the kitchen. These findings underscore the need for targeted behavioral interventions, community engagement, and tailored messaging—especially around cooking—to support effective and equitable building electrification policies.<sup>15</sup>

- July 13, 2024 – This pilot study marks the first in-home, real-world monitoring in the United States to quantify the indoor air quality impacts of transitioning from gas to induction stoves, and does so within the critical context of public housing, sites historically burdened by environmental health risks. Conducted in 20 New York City Housing Authority apartments, the study paired continuous air quality monitoring with extensive qualitative interviews to assess both pollutant exposure and lived experience. Air quality findings demonstrate a substantial 35-56 percent reduction in daily indoor NO<sub>2</sub> concentrations, with controlled cooking tests revealing spikes to 197~ppb in gas households (far above U.S. EPA thresholds for sensitive groups) versus near-background levels in induction-equipped units. CO levels also dropped significantly in induction homes. Participants unanimously praised the received induction stoves for cooking performance, ease of cleaning, safety, and reduced asthma symptoms, with none requesting a return to gas. By centering rigorous data and tenant perspectives, this study offers data- and culturally-informed evidence that electrification can improve health and quality of life, while emphasizing that effective transitions must incorporate cultural familiarity, trust-building, and user-centered design. These findings are particularly meaningful for communities historically excluded from decision-making in housing and energy systems, but who stand to benefit significantly from the energy transition.<sup>16</sup>
- June 1, 2024 – This study is the first large-scale characterization of hazard and odorant variability attributable to unburned natural gas at the point of residential delivery across North America. Analyzing 587 samples from 481 homes in 17 U.S. and Canadian cities, researchers found that 97 percent of samples contained benzene, with concentrations varying by over 50-fold across regions from 300~ppbv in Boston to 15,000~ppbv in Vancouver. Findings estimate that leakage of unburned gas from appliances and pipelines contributes roughly 25,000 lbs. of benzene annually in the United States and 4000 lbs. in Canada, emissions not captured in existing inventories. The study also reveals major inconsistencies in odorant levels, key for leak detection, demonstrating that in some regions, methane and benzene leaks may go undetected by smell, even at health-relevant levels. These findings have significant implications for indoor air quality, leak detection policy, exposure assessments, and public health. With evidence demonstrating that gas

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<sup>15</sup> Kathryn Lane et al., “Readiness for a Clean Energy Future: Prevalence, Perceptions, and Barriers to Adoption of Electric Stoves and Solar Panels in New York City,” *Energy Policy* 194 (November 2024): 114301, <https://doi.org/10.1016/j.enpol.2024.114301>.

<sup>16</sup> Misbath Daouda et al., “Out of Gas, In with Justice: Findings from a Gas-to-Induction Pilot in Low-Income Housing in NYC,” *Energy Research & Social Science* 116 (October 2024): 103662, <https://doi.org/10.1016/j.erss.2024.103662>.

composition is neither uniform nor reliably detectable, this study challenges the adequacy of current odorization and emissions standards, and provides critical data for decisionmakers to inform more protective policies for indoor environments.<sup>17</sup>

- May 3, 2024 – This study combines measured indoor NO<sub>2</sub> concentrations from over 100 U.S. homes with CONTAM-based multizone modeling (see also March 22, 2025 entry describing another study using the same program) to provide a much higher-resolution assessment of exposure from gas and propane stoves than previous studies. By modeling room-by-room pollutant dispersion and validating results against empirical data, it shows how NO<sub>2</sub> accumulates throughout entire homes, not just kitchens, and that short-term exposures frequently exceed EPA and WHO health benchmarks, especially in smaller or poorly ventilated spaces. Results demonstrate that short-term NO<sub>2</sub> levels exceeded WHO health-based benchmarks in 76 percent of homes and that residents in smaller homes (<800ft<sup>2</sup>) experience roughly four times higher long-term exposures compared to those in larger homes (>3000ft<sup>2</sup>). The study helps clarify the environmental justice dimensions of gas and propane stove use, finding that American Indian and Alaska Native households experience 60 percent more, and Black and Hispanic/Latino households 20 percent more, NO<sub>2</sub> exposure than the national average. In addition, researchers estimate that gas and propane stoves contribute up to 19,000 adult deaths annually in the United States, as well as 50,000 current cases of pediatric asthma.<sup>18</sup>
- February 29, 2024 – This advocacy report offers insights into the critical information gap in consumer-facing retail environments: even after rising media attention and regulatory scrutiny, most major appliance retailers (including Lowe’s, Home Depot, and Best Buy) continue to fail in informing customers about the health risks of gas stoves. A “secret-shopper” survey at 62 locations across 11 states found that 76 percent of sales associates either dismissed or denied any health concerns associated with gas stoves, while only 24 percent offered accurate information about indoor air pollution risks. Furthermore, 16 percent still recommended gas stoves even when shoppers expressed concerns about health and 80 percent did not indicate that external ventilation is necessary for safety. Induction cooktops were found to be absent from display in 37 percent of stores, limiting consumer exposure to healthier alternatives. By exposing the disconnect between growing scientific consensus on the well-documented links between gas stove emissions and respiratory health and what consumers experience at the point-of-sale, this report identifies a critical barrier in informed decision-making. These findings demonstrate the retail environment as a pivotal venue for public health communication and highlights the need for mandatory staff training, clearer educational material, and visible promotion of electric cooking options. This report offers concrete, actionable levers for consumer

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<sup>17</sup> Sebastian T Rowland et al., “Downstream Natural Gas Composition across U.S. and Canada: Implications for Indoor Methane Leaks and Hazardous Air Pollutant Exposures,” *Environmental Research Letters* 19, no. 6 (2024): 064064, <https://doi.org/10.1088/1748-9326/ad416c>.

<sup>18</sup> Yannai Kashtan et al., “Nitrogen Dioxide Exposure, Health Outcomes, and Associated Demographic Disparities Due to Gas and Propane Combustion by U.S. Stoves,” *Science Advances* 10, no. 18 (2024): eadm8680, <https://doi.org/10.1126/sciadv.adm8680>.

protection agencies, state and federal policymakers, and retailers aiming to align business practices with public health evidence.<sup>19</sup>

- February 1, 2024 – This systematic review and meta-analysis examines data from over 100 studies from around the world to compare health outcomes associated with household use of gaseous fuels (e.g. natural gas, liquified petroleum gas, and biogas) against both traditional polluting fuels (e.g. wood, charcoal, and kerosene), and clean alternatives (e.g. electricity). Studies included were of widely varying design and quality, and studies addressing health outcomes that were exacerbations of existing underlying conditions were excluded. This review’s unique contribution lies in offering a comprehensive synthesis of the health effects of gaseous fuels for household cooking and heating on a global scale, where previous reviews have looked at single health outcomes or focused on specific energy uses (e.g. only gas cooking), and not considered both traditional polluting (solid fuels and kerosene) and clean (electricity) reference options. The study demonstrates a lower risk for key health outcomes when switching from solid fuels and kerosene to use of gaseous fuels for cooking or heating. However, when compared to electricity, gas use is associated with modest increases in risks for pneumonia and chronic obstructive pulmonary disease, and a small, but not statistically-significant rise in childhood asthma. This study contributes global, policy-relevant evidence that contextualizes gaseous fuels as a transitional solution, particularly for low- and middle-income countries, while reinforcing that electrification remains the optimal long-term goal for protecting respiratory and perinatal health.<sup>20</sup>
- February 1, 2024 – This study examines an understudied class of atmospheric particles known as nanocluster aerosol (NCA: particles in the size range of 1-3 nm), as they are emitted during realistic propane gas cooking experiments. Researchers from Purdue University evaluated these emissions using state-of-the-art air quality instrumentation. NCAs in this context are critically important to understand, as they efficiently deposit in the human respiratory system and can translocate to vital organs. The study finds that NCA emission factors as high as  $\sim 10^{16}$  particles per kilogram of fuel burned, levels that can rival or exceed those from gasoline and diesel engines, meaning people may be receiving a larger dose of NCA indoors with gas cooking than outdoors near car exhaust. Children were estimated to have higher dose rates than adults per pound body weight and these rates were greater than that for adults by about 2.3-fold for the head airways, 2.2-fold for the tracheobronchial region, and 3.0-fold for the pulmonary region. Results also indicate that these ultrafine particles cannot be inferred from standard indoor air quality indicators like PM<sub>2.5</sub> or NO<sub>x</sub> concentrations. By highlighting the scale of these emissions and the limitations of current monitoring frameworks, the study underscores the need for direct, size-specific measurement approaches and supports stronger ventilation (though

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<sup>19</sup> Abraham Scarr, *Gas Stove Omissions: Retailers Are Failing to Warn Consumers about the Health Risks of Cooking with Gas* (US PIRG Education Fund, 2024), <https://pirg.org/edfund/resources/gas-stove-omissions/>.

<sup>20</sup> Elisa Puzzolo et al., “Estimated Health Effects from Domestic Use of Gaseous Fuels for Cooking and Heating in High-Income, Middle-Income, and Low-Income Countries: A Systematic Review and Meta-Analyses,” *The Lancet Respiratory Medicine* 12, no. 4 (2024): 281–93, [https://doi.org/10.1016/S2213-2600\(23\)00427-7](https://doi.org/10.1016/S2213-2600(23)00427-7).

not directly tested in this study), electrification, and exposure mitigation strategies in homes.<sup>21</sup>

- December 1, 2023 – A team of medical pulmonary specialists published a “Viewpoint” in the *Annals of the American Thoracic Society* on the lack of practical progress following decades of data generated on gas stoves and respiratory health. Authors show that “[r]emoving the predominant source completely and replacing a gas stove with an electric stove... is generally the most effective intervention in real-world settings.” They outline the shortcomings of ventilation interventions, including the decrease of NO<sub>2</sub> concentrations up to 95 percent only occurring when cooking was limited to the back cooktop burners in one study, but other studies showing no decrease with ventilation. The team concludes that “[a]n increasingly common and rational policy approach is to prohibit the installation of new gas stoves” and that assistance in replacing gas stoves for those for whom cost is a barrier is important.<sup>22</sup>
- August 15, 2023 – This empirical evaluation analyzes a real-world electrification initiative in Ecuador where 750,000 households transitioned from gas to induction cookstoves between 2015 and 2021. Leveraging national health and energy data, the authors report that residential electricity consumption rose by a modest 5 percent, while the predominantly hydroelectric energy grid enabled a net reduction in greenhouse gas emissions. Crucially, this transition coincided with declines in all-cause and respiratory-related hospitalizations nationwide, demonstrating tangible public health gains. The study stands out for offering large-scale, policy-relevant evidence from a developing-country context, where grid decarbonization and clean cooking converge to generate meaningful climate and health co-benefits. The modest increase in national electricity demand demonstrates that millions of households can electrify cooking without destabilizing the grid, especially when paired with hydro or other clean generation, making this study especially significant when planning for residential electrification and scaling induction cooking programs within existing infrastructure.<sup>23</sup>
- June 15, 2023 – The first study to quantify the formation of benzene indoors from gas combustion by residential cooking stoves used data collected in 87 homes in California and Colorado. Benzene is a known carcinogen and also has non-cancer health effects. Researchers found that stoves fired by natural gas or propane, with burners set either to “high” or ovens set to 350°F, emitted levels of benzene 10 to 25 times higher than emissions from electric alternatives. They also studied the migration of benzene throughout the home, including tests of bedrooms furthest from kitchens. In all cases, gas burner or oven use led to peak bedroom benzene concentrations between 5 and 70 times above baseline levels, and in some cases beyond the California Office of Environmental

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<sup>21</sup> Satya S Patra et al., “Dynamics of Nanocluster Aerosol in the Indoor Atmosphere during Gas Cooking,” *PNAS Nexus* 3, no. 2 (2024): pgae044, <https://doi.org/10.1093/pnasnexus/pgae044>.

<sup>22</sup> Laura M. Paulin et al., “Gas Stoves and Respiratory Health: Decades of Data, but Not Enough Progress,” *Annals of the American Thoracic Society* 20, no. 12 (2023): 1697–99, <https://doi.org/10.1513/AnnalsATS.202306-533VP>.

<sup>23</sup> Carlos F. Gould et al., “Climate and Health Benefits of a Transition from Gas to Electric Cooking,” *Proceedings of the National Academy of Sciences* 120, no. 34 (2023): e2301061120, <https://doi.org/10.1073/pnas.2301061120>.

Health Hazard Assessment acute and chronic reference exposure levels. These levels often persisted for hours after stoves were turned off.<sup>24</sup>

- March 3, 2023 – A group of public health researchers reviewed the evidence on the link between gas stoves and adverse health effects and advised that households inhabited by individuals with asthma, chronic obstructive pulmonary disease, or other respiratory diseases should, if feasible, make the transition to electric stoves, “and all other households could consider it.” The group also noted that there also exists a strong climate rationale to electrify home appliances and ban natural gas hookups in new residential construction.<sup>25</sup>
- January 21, 2023 – Using the annual Munich Oktoberfest as a case study, an international research team documented significant methane leaks from gas-fired cooking and heating appliances and showed that electricity for cooking and heating has been a more climate-friendly energy source at the festival since 2005 due to the increasing use of renewable electricity. The team’s air monitoring results showed that Oktoberfest could reduce total carbon emissions from energy consumption by 87 percent if all gas-fired appliances were replaced with electric ones. Methane emissions from gas-fired heaters and grills originate both from leaks and from incomplete combustion. Extending the study to 25 major natural gas-consuming nations, the team determined that natural gas still generates lower carbon emissions for residential appliances than electricity in 18 of 25 countries studied due to high numbers of coal-burning power plants. However, “as the share of renewable energy in the electricity mix steadily increases...the carbon footprint of electricity will be lower than that of natural gas in these countries in the near future.” In other words, the climate friendliness of electric residential appliances over gas-fired appliance will increase over time.<sup>26</sup>
- January 19, 2023 – An assessment of the barriers that prevent a rapid transition to induction and electric stoves identified the need of many residents living in low-income, substandard housing to rely on gas stoves for space heating as an obstacle to electrification. Public efforts toward building electrification “must center equity and improving housing conditions for disadvantaged groups, especially those who disproportionately rely on stoves as a supplemental heating source.”<sup>27</sup>
- December 21, 2022 – An international team of researchers found that gas stoves are responsible for almost 13 percent of childhood asthma in the United States. Using data

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<sup>24</sup> Yannai S. Kashtan et al., “Gas and Propane Combustion from Stoves Emits Benzene and Increases Indoor Air Pollution,” *Environmental Science & Technology*, June 15, 2023, [acs.est.2c09289](https://doi.org/10.1021/acs.est.2c09289), <https://doi.org/10.1021/acs.est.2c09289>.

<sup>25</sup> John R. Balmes et al., “Cooking with Natural Gas: Just the Facts, Please,” *American Journal of Respiratory and Critical Care Medicine* 207, no. 8 (2023): 996–97, <https://doi.org/10.1164/rccm.202302-0278VP>.

<sup>26</sup> Florian Dietrich et al., “Climate Impact Comparison of Electric and Gas-Powered End-User Appliances,” *Earth’s Future* 11, no. 2 (2023), <https://doi.org/10.1029/2022EF002877>.

<sup>27</sup> Misbath Daouda et al., “Correspondence on ‘Home Is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User,’” *Environmental Science & Technology* 57, no. 4 (2023): 1848–49, <https://doi.org/10.1021/acs.est.2c09423>.

from the American Housing Survey on gas stove use in U.S. homes, the team estimated the population attributable fraction for gas stove use and current childhood asthma. This epidemiological tool describes the fraction of a disease that could theoretically be prevented if exposure to a given risk factor were eliminated. Specifically, team found that 12.7 percent of current childhood asthma in the United States could be prevented if gas stoves were not present. The population attributable factor varied greatly by state. For Illinois, 21.1 percent of childhood asthma cases were attributable to gas stoves. In California, 20.1 percent. In New York, 18.8 percent. In Massachusetts, 15.4 percent. In Pennsylvania, 13.5 percent. Florida experienced the lowest burden at 3 percent. Differences between states, the authors point out, are entirely due to different state-level proportions of households that cook with gas. In Illinois, for example, nearly 80 percent of households with children cook with gas, whereas only 9 percent of households in Florida do.<sup>28</sup>

- December 1, 2022 – Aiming at equipping Australian general practitioners with their responses to the health risks of cooking and heating with gas, this article, published in a medical journal, primarily discusses the residential gas-use related respiratory effects of NO<sub>2</sub> and the toxicity of acute or chronic exposure to CO. Authors note that gas stove use is estimated to contribute to 12 percent of childhood asthma in Australia, and emphasize NO<sub>2</sub>'s role as a respiratory irritant linked to both asthma development and exacerbations in children and adults. The piece provides readers with guidelines for recognizing health impacts of indoor exposure to combustion products like NO<sub>2</sub>, such as its link to asthma, and for diagnosing CO poisoning. The article recommends that clinicians routinely inquire about indoor gas exposure in patients—especially those with asthma or vague winter symptoms—and that “advocacy by their doctors may help patients in poorly maintained rental properties have their home environment improved.”<sup>29</sup>
- November 15, 2022 – Researchers used “trace gas analyses” on unburned samples from residential gas stoves in 16 counties across California. They found 12 hazardous air pollutants, known to cause short-term and chronic adverse health impacts, including benzene. They determined that gas leakage from stoves and ovens while not in use can result in indoor benzene concentrations that exceed California’s “8-h Reference Exposure Level,” which are levels similar to second hand tobacco smoke. Researchers warn that their estimates of indoor benzene are likely low, as they do not include leakage from gas stoves from combustion or incomplete combustion, other gas appliances, and other sources. In addition, the study found wide differences in pollutant levels between gas company of origin, and regions. They found “exceptionally high” levels in samples

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<sup>28</sup> Talor Gruenwald et al., “Population Attributable Fraction of Gas Stoves and Childhood Asthma in the United States,” *International Journal of Environmental Research and Public Health* 20, no. 1 (2022): 75, <https://doi.org/10.3390/ijerph20010075>.

<sup>29</sup> Ben Ewald et al., “Health Risks from Indoor Gas Appliances,” *Australian Journal of General Practice* 51, no. 12 (2022): 935–38, <https://doi.org/10.31128/AJGP-08-22-6535>.

collected in the North San Fernando and Santa Clarita Valleys, which are near the Aliso Canyon underground gas storage facility.<sup>30</sup>

- November 8, 2022 – In a review of the data linking NO<sub>2</sub> from gas stoves to health harms, the American Public Health Association (APHA) called, in a policy statement, for the U.S. EPA, the U.S. Department of Housing and Urban Development, and the U.S. Centers for Disease Control to formerly recognize “the links among gas stove emissions, NO<sub>2</sub> pollution, and increased risk of illness in children, older adults, people with underlying conditions, and environmental justice communities. Furthermore, the public and health care practitioners should be educated on the health harms of gas stove emissions and promotion of mitigation solutions should be expedited.” The APHA further called upon the EPA to set health-protective indoor air quality guidelines, called upon the U.S. Consumer Product Safety Commission to set performance standards for gas stoves and range hoods, and called upon local and state legislative and regulatory bodies “to adopt residential building codes with preferences for installing electric appliances and to require electric appliances for building projects receiving municipal or state funding.”<sup>31</sup>
- June 28, 2022 – A research team led by the Harvard T.H. Chan School of Public Health investigated hazardous air pollutants present in natural gas combusted inside of Massachusetts homes. The team identified 21 different toxic air pollutants, including benzene and toluene, within consumer-grade natural gas entering homes. Undetected leaks were common, and concentrations of hazardous air pollutants in indoor natural gas emissions were highly variable, with the highest concentrations taking place during the winter months. The team noted that hazardous air pollutants from indoor natural gas leaks are not routinely monitored or accounted for in any state or federal inventory. This study is the first to provide a detailed analysis of the hazardous air pollutants present in natural gas used in residential buildings.<sup>32</sup>
- May 18, 2022 – In a resolution intended to inform physicians and health care providers about the health dangers of gas stoves, the American Medical Association (AMA) recognized the association between the use of gas stoves, indoor NO<sub>2</sub> levels, and childhood asthma. The resolution also urged advocacy for innovative programs to assist with the cost of transitioning from gas to electric stoves. This resolution passed into

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<sup>30</sup> Eric D. Lebel et al., “Composition, Emissions, and Air Quality Impacts of Hazardous Air Pollutants in Unburned Natural Gas from Residential Stoves in California,” *Environmental Science & Technology*, October 20, 2022, acs.est.2c02581, <https://doi.org/10.1021/acs.est.2c02581>.

<sup>31</sup> American Public Health Association, *Gas Stove Emissions Are a Public Health Concern: Exposure to Indoor Nitrogen Dioxide Increases Risk of Illness in Children, Older Adults, and People with Underlying Health Conditions*, Policy Statement no. 20225 (2022), <https://www.apha.org/Policies-and-Advocacy/Public-Health-Policy-Statements/Policy-Database/2023/01/18/Gas-Stove-Emissions>.

<sup>32</sup> Drew R. Michanowicz et al., “Home Is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User,” *Environmental Science & Technology*, June 28, 2022, acs.est.1c08298, <https://doi.org/10.1021/acs.est.1c08298>.

AMA policy, thereby committing the professional organization to carrying out such education and advocacy.<sup>33, 34</sup>

- April 13, 2022 – A study by the National Center for Healthy Housing of 152 affordable homes with gas stoves in New York and Chicago sought to determine whether mechanical ventilation was effective in reducing levels NO<sub>2</sub>, PM<sub>2.5</sub>, CO<sub>2</sub>, CO, and formaldehyde. The study used air sampling, interviews, and visual assessments of conditions. There was no significant difference in NO<sub>2</sub> levels between the study group that had continuous mechanical ventilation, and the comparison group that did not have continuous mechanical ventilation. Levels of the other four contaminants were reduced by continuous mechanical ventilation, with the largest improvement (44 percent) for formaldehyde and the smallest for NO<sub>x</sub> (13 percent). All homes had been rehabilitated using green building practices, but a study home met the criteria for continuous mechanical ventilation if it complied with ASHRAE Standard 62.2, the industry standard for ventilation and indoor air quality in residential buildings.<sup>35</sup>
- January 27, 2022 – A Stanford University study quantified methane leaks from gas-fired stoves and ovens in 53 homes. The results showed that methane was released during all phases of stove use: when it was turned off, when it was in use, and during ignition and extinguishment. The team estimated that between 0.8 and 1.3 percent of the gas used by kitchen stoves is released as unburned methane, with more than three-quarters of emissions taking place when the stove was turned off. “Using a 20-year timeframe for methane, annual methane emissions from all gas stoves in U.S. homes have a climate impact comparable to the annual carbon dioxide emissions of 500,000 cars.” In addition, the team found that NO<sub>2</sub> emissions, assessed in 32 of the 53 homes, were linearly related to the amount of gas burned. “Our data suggest that families who don’t use their range hoods or who have poor ventilation can surpass the 1-hour national standard of NO<sub>2</sub> (100 ppb) within a few minutes of stove usage, particularly in smaller kitchens.”<sup>36</sup>
- May 5, 2020 – A report on the health effects of gas stoves released by a consortium of environmental advocacy groups led by the Rocky Mountain Institute includes a comprehensive compendium of the many dozens of peer-review studies documenting the health harms from gas stove pollution and dating back more than 40 years. All together, these studies show that “gas stoves may be exposing tens of millions of people to levels

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<sup>33</sup> American Medical Association House of Delegates, “Draft Resolution: Informing Physicians, Health Care Providers, and the Public That Cooking with a Gas Stove Increases Household Air Pollution and the Risk of Childhood Asthma,” May 18, 2022, <https://www.ama-assn.org/system/files/a22-439.pdf>.

<sup>34</sup> American Medical Association, “Informing Physicians, Health Care Providers, and the Public That Cooking with a Gas Stove Increases Household Air Pollution and the Risk of Childhood Asthma D-135.964,” 2022, <https://policysearch.ama-assn.org/policyfinder/detail/gas%20stove?uri=%2FAMADoc%2Fdirectives.xml-D-135.964.xml>.

<sup>35</sup> National Center for Healthy Housing, *Studying the Optimal Ventilation for Environmental Indoor Air Quality* (Enterprise Community Partners, 2022), [https://nchh.org/resource-library/report\\_studying-the-optimal-ventilation-for-environmental-indoor-air-quality.pdf](https://nchh.org/resource-library/report_studying-the-optimal-ventilation-for-environmental-indoor-air-quality.pdf).

<sup>36</sup> Eric D. Lebel et al., “Methane and NO<sub>x</sub> Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes,” *Environmental Science & Technology* 56, no. 4 (2022): 2529–39, <https://doi.org/10.1021/acs.est.1c04707>.

of air pollution in their homes that would be illegal outdoors under national air quality standards.”<sup>37</sup>

- March 27, 2020 – A research team measured methane emissions from gas-fired appliances at the 2018 Oktoberfest folk festival in Munich, Germany where natural gas is used to heat tents and power grills and other cooking appliances. Taking into account wind speed and direction, the team found enhancements of up to 100 parts per billion, compared to background levels and measurements after Oktoberfest, showing that large festivals can be significant methane emitters due to both incomplete combustion and methane leakage from gas appliances.<sup>38</sup>
- February 4, 2015 – An Oregon State University team used data from the National Health and Nutrition Examination Survey to identify young children living in homes with a gas stove and whose parents provided information on their stove habits and data on pneumonia and cough. After adjusting for other factors that could influence the association, they found three times higher odds of parent-reported pneumonia and two times higher odds of cough among children living in homes with gas stoves used for home heating without ventilation.<sup>39</sup>
- September 2, 2014 – A cross-sectional study that examined the association between gas stoves and chronic respiratory illness in U.S. children found that ventilation is associated with reduction, but not elimination of, childhood asthma risk. The research team found that lung function was higher among children whose parents reported using range hoods when operating gas stoves.<sup>40</sup>
- June 1, 2014 – This “News” piece in *Environmental Health Perspectives* covers the research to date on cooking-related pollutants, finding that gas stoves “emit a cocktail of potentially hazardous chemicals and compounds,” that are less diluted when found in the outdoors. The author finds that only a few states have adopted ventilation codes that adequately address issues of minimum airflow and exhaustion to the outdoors. Even when proper ventilation is in place, survey data cited by the author indicates it is often not turned on, due to noise, and experiments showing that capture efficiencies are lower for front burners. The author says that, even with research challenges assessing the health effects of cooking pollutants, some, such as NO<sub>2</sub>, are relatively well understood.<sup>41</sup>

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<sup>37</sup> Brady Anne Seals and Andee Krasner, *Health Effects from Gas Stove Pollution* (Rocky Mountain Institute, Physicians for Social Responsibility, Mothers Out Front, and Sierra Club, 2020), <https://rmi.org/insight/gas-stoves-pollution-health>.

<sup>38</sup> Jia Chen et al., “Methane Emissions from the Munich Oktoberfest,” *Atmospheric Chemistry and Physics* 20, no. 6 (2020): 3683–96, <https://doi.org/10.5194/acp-20-3683-2020>.

<sup>39</sup> Eric S Coker et al., “A Cross Sectional Analysis of Behaviors Related to Operating Gas Stoves and Pneumonia in U.S. Children under the Age of 5,” *BMC Public Health* 15, no. 1 (2015): 77, <https://doi.org/10.1186/s12889-015-1425-y>.

<sup>40</sup> Molly L Kile et al., “A Cross-Sectional Study of the Association between Ventilation of Gas Stoves and Chronic Respiratory Illness in U.S. Children Enrolled in NHANESIII,” *Environmental Health* 13, no. 1 (2014): 71, <https://doi.org/10.1186/1476-069X-13-71>.

<sup>41</sup> Nate Seltenrich, “Take Care in the Kitchen: Avoiding Cooking-Related Pollutants,” *Environmental Health Perspectives* 122, no. 6 (2014), <https://doi.org/10.1289/ehp.122-A154>.

- January 1, 2014 – A study of indoor air pollution from gas stoves in California homes used a mass-balance model to estimate time-dependent pollutant concentrations and exposures experienced by individual inhabitants. The researchers found that gas stoves are a significant contributor to poor indoor quality and were associated with elevated levels of NO<sub>2</sub>, CO, and formaldehyde. The simulation model estimated that—in homes using gas stove without coincident use of venting range hoods—62 percent, 9 percent, and 53 percent of occupants were routinely exposed to levels of NO<sub>2</sub>, CO, and formaldehyde that exceeded acute health-based standards and guidelines.<sup>42</sup>
- August 20, 2013 – A meta-analysis of 41 studies on the link between indoor nitrogen oxides from exposure to gas cooking and asthma in children provided “quantitative evidence that, in children, gas cooking increases the risk of asthma and indoor NO<sub>2</sub> increases the risk of current wheeze.” The findings showed that children living in homes with gas stoves have a 42 percent increased risk of having current asthma and a 24 percent increased risk of developing asthma during their lifetime.<sup>43</sup>

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<sup>42</sup> Jennifer M. Logue et al., “Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California,” *Environmental Health Perspectives* 122, no. 1 (2014): 43–50, <https://doi.org/10.1289/ehp.1306673>.

<sup>43</sup> Weiwei Lin et al., “Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children,” *International Journal of Epidemiology* 42, no. 6 (2013): 1724–37, <https://doi.org/10.1093/ije/dyt150>.