
ANALYSIS:

Multnomah County Gas
Stove Report Based on Flimsy
Arguments, Flawed Research
& Lack of Transparency



A project of the INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA



Executive Summary

The Multnomah County, Ore., Health Department released a report¹ in November 2022 claiming that gas stoves are a “health hazard.” Despite conducting no new research and only analyzing a handful of questionable studies, the department recommended residents replace the popular cooking appliances with electric stoves.

This report is the first from a government agency to use health claims to justify restricting natural gas stoves, a staple of millions of American homes and an appliance that a recent *Morning Consult* poll² found is still the favored choice when compared with electric.

The county indicates its report “summarizes some of the most recent health evidence on gas stoves and their impact on health, reviews case studies of policy action, and offers public health recommendations.” But the report relies on questionable studies – several of which EID has reviewed previously – while ignoring a myriad of other factors that determine indoor air quality, such as road vehicle emissions, air rate exchange, climate, weather conditions, and occupant behavior while neglecting to examine proper ventilation, a key component in examining indoor air quality. As a result, the conclusions of the report raise questions as to the transparency and reliability of Multnomah County’s data.

As Energy in Depth noted³ last month, this report, which is essentially a literature review, is part of a broader national strategy driven by “Keep It In the Ground” groups that has resulted in cities and counties across Oregon aiming to ban consumer access to natural gas with seemingly little efforts to educate the public. It is also unclear how much support these extreme measures have among Oregon residents. Further, it appears the report was conducted without consultation from local businesses or industry, including county residents experienced in installing residential and industrial ventilation.

This analysis shows that the factual basis of the report is flimsy, lacking, and is not nearly as robust as would be expected for a governmental mandate that will severely restrict consumer choices for nearly one million Oregon residents.

Key Findings

1. The report relies heavily on flawed studies with improper methodologies that have been questioned publicly.
 - For example, a key study used in the report sealed their test kitchen in plastic tarps, therefore creating an unrealistic environment. As Dr. Daniel Tormey, president of Catalyst Environmental Solutions said⁴: “the study results are useless for evaluating health-based exposures because no kitchen is set up like that. In other words, they weren’t simulating a real-life cooking experience.”
2. Literature review does not provide information on exposure and concentrations, meaning it’s not possible to determine if there is a health threat.
 - As Dr. Julie Goodman⁵, a fellow of the American College of Epidemiology and Academy of Toxicological Sciences, explained in her testimony to the Multnomah County Commissioners

¹ https://multco-web7-psh-files-usw2.s3-us-west-2.amazonaws.com/s3fs-public/gas-stoves-health-risk-report-2022_0.pdf

² <https://morningconsult.com/2021/02/12/energy-efficiency-series-natural-gas-electric-alternatives-polling/>

³ <https://www.energyindepth.org/oregon-municipalities-push-anti-natural-gas-agenda-based-on-flawed-research/?154>

⁴ <https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/>

⁵ <https://gradientcorp.com/goodman-sac/>

on the report: “The presentation lists many health effects associated with pollutants, generally. But there is no discussion of the concentrations at which any of these effects could occur. Chemicals do not cause harmful effects unless they are at a dose high enough to overwhelm the body’s normal biological processes. And so, what this means is that the mere presence of an air pollutant doesn’t indicate an increased health risk. And without a consideration of concentration or dose, it’s not possible to determine whether exposures could be harmful.”

3. Data show that most pollutant emissions come from cooking food, regardless of the type of cooking appliance.
 - The county report largely glosses over a key component of indoor air quality endorsed by academics, the EPA, and the Sierra Club: proper ventilation. As the California Air Resources Board’s website on indoor air pollution and cooking⁶ explains: “Cooking can also generate unhealthy air pollutants from heating oil, fat and other food ingredients, especially at high temperatures... Studies show that air can be unhealthy to breathe when people cook in kitchens with poor ventilation. The best way to ventilate your kitchen is to use a properly-installed, high efficiency range hood over your stove.”
 - This was acknowledged during the county health department’s presentation on the report when one commissioner questioned why her VOC monitor would go off while cooking despite her having no gas appliances in her home.
4. The report claims to be a literature review but curiously omits the most complete analysis to date on the subject.
 - In contrast to Multnomah County’s claim, the International Study of Asthma and Allergies in Childhood⁷ – the largest and most complete analysis to date examining any potential link between gas appliances and childhood asthma – found “no evidence of an association between the use of gas as a cooking fuel and either asthma symptoms or asthma diagnosis.” The Multnomah County report neither cited nor referenced this study.
5. A predominant study used to buoy the report was funded by environmental activists with a history of “advocacy” research.
 - PSEHE’s Executive Director wrote a memo on how to use headline-generating health research while its co-founder has bragged that his research is “a form of advocacy.”
 - Among PSEHE’s funders is the Park Foundation, which supports a “Keep It In The Ground” agenda and “resisting all new gas and oil drilling.”
6. The report analyzes a limited number of sources on indoor air quality and even fewer that look at potential impacts from gas stoves.
 - Of the 43 research citations (39 unique sources) used by the county health department, only 9 of the resources focused on general indoor air quality in the United States, while 22 focused on broader topics such as outdoor air quality or environmental justice. Worse, fewer than one-third of the citations relate to indoor air quality, and among those the report utilized only eight unique sources directly relevant to indoor air quality and gas stoves.

⁶ <https://ww2.arb.ca.gov/resources/documents/indoor-air-pollution-cooking>

⁷ <https://pubmed.ncbi.nlm.nih.gov/24429203/>

Citation	Category	Citation	Category	Citation	Category
1	General IAQ	16	IAQ + Gas Stoves	31	Other – PM
2, 28	General IAQ	17	Other – Natural Gas Consumption	32	General IAQ
3	IAQ + Gas Stoves	18, 38	Other – OAQ	33	General IAQ
4, 41	IAQ + Gas Stoves	19	Other – Air Quality	34	General IAQ
5	Other – Industrial Emissions	20	Other – Covid	36	IAQ + Gas Stoves
6	General IAQ	21	Other – Covid	37	Other – Climate Change
7	General IAQ	22	Other – PM, Covid	39	Other – Natural Gas Production & Consumption
9	Other – OAQ, EJ	23	IAQ + Gas Stoves	40	Other – Climate Change
10	Other – OAQ	24	IAQ + Gas Stoves	42	Other – Climate Change
11	Other – EJ	25	IAQ + Gas Stoves	43	General IAQ
12	Other – EJ	26	IAQ + Gas Stoves		
13	Other – OAQ	27, 35	General IAQ		
14	Other – EJ	29	Other – PM		
15	Other – EJ	30	Other – PM		

*Note: Indoor Air Quality (IAQ); Outdoor Air Quality (OAQ); Environmental Justice (EJ); Particulate Matter

**Sources cited twice are shown as such in the chart.

Questions Go Unanswered

At the briefing⁸ on the report last month, outgoing Multnomah Board of County Commissions Chair Deborah Kafoury, who initially requested the report, announced it was a “first step” and that the board will use it to “figure out if they want to take the next steps and move forward” with actions to ban natural gas in buildings in the county. However, several of the Commissioners raised important questions.

Acknowledging that Dr. Goodman’s testimony⁹ raised valid questions for consideration, Commissioner Sharon Meieran asked:

“As we think about how to best allocate our resources to impact air quality...and the impact on human health, as well as climate change...question about whether it’s stoves themselves. If we’re investing in, say, ventilation and education versus maybe a smaller impact to replace stoves in households, it wasn’t clear to me that it’s gas stoves themselves if used in certain ways – back burner, ventilation, etc. – with no smoking in the households or other

⁸ <https://www.multco.us/multnomah-county/news/board-commissioners-briefed-public-health-review-health-risks-posed-gas-stoves>

⁹ https://www.youtube.com/watch?v=6Fkm_BeqihA&t=139s

factors...that those themselves are the biggest problem. Are they independently shown, proven to be themselves [gas stoves] the contributor?"

It's a good question that deserves a response – and one that the department was unable to answer during the presentation of the report in November. There's been no indication by the commissioners if they have reached out to Dr. Goodman to get a response to these questions.

In addition, Commissioner Jessica Vega Pederson discussed her experience with her VOCs (volatile organic compounds) monitor going off frequently while cooking, despite not having any gas appliances in the house. To this, the department also seemingly agreed, negating much of the supposed research in the report:

"Yea, I have to say I have a similar experience cooking in my house...Particle pollution will happen from cooking, regardless of the fuel type."

Flawed Research Methodology

The report draws on numerous citations, many non-specific to indoor air quality, to make the overall claim that "gas appliances contribute to indoor air pollution and are a health hazard." However, in addition to focusing on too broad of studies, a comprehensive literature review of the documents cited does not provide information on exposure and concentrations, meaning it's not possible to determine if there is a health threat from using natural gas stoves alone.

As Dr. Julie Goodman¹⁰, a fellow of the American College of Epidemiology and Academy of Toxicological Sciences, explained in her testimony to the Multnomah County Commissioners on the report:

"The presentation lists many health effects associated with pollutants, generally. But there is no discussion of the concentrations at which any of these effects could occur. Chemicals do not cause harmful effects unless they are at a dose high enough to overwhelm the body's normal biological processes. And so, what this means is that the mere presence of an air pollutant doesn't indicate an increased health risk. And without a consideration of concentration or dose, it's not possible to determine whether exposures could be harmful." (emphasis added)

Furthermore, the report ignores the effects of using a range hood or ensuring proper ventilation of pollutants. According¹¹ to Brett Singer¹² of Berkeley Lab, cooking food on any type of stove, even induction, produces fine particles and some organic chemicals, so he advises:

"The first tip is to ventilate when you cook, and to ventilate more the more you cook. Range hoods are the most effective way to do this, if your range hood actually moves air out of the kitchen. ... pollutants can be easily addressed with good kitchen ventilation." (emphasis added)

¹⁰ <https://gradientcorp.com/goodman-sac/>

¹¹ <https://scopeblog.stanford.edu/2018/03/06/use-your-range-hood-for-a-healthier-home-advises-indoor-air-quality-researcher/>

¹² <https://indoor.lbl.gov/people/brett-singer>

The U.S. Environmental Protection Agency and others also stress proper ventilation regardless of the appliance used to cook foods. The EPA’s page on indoor air quality¹³ features no endorsement of electric stoves but does endorse proper ventilation practices to protect residents. And in the EPA’s November update¹⁴ of sources of indoor particulate matter, the agency states:

“Many cooking appliances and the process of cooking itself can increase levels of indoor PM...Improving ventilation and filtration during cooking can reduce exposure to indoor PM,” before listing the benefits of a range hood and proper ventilation on indoor air quality. (emphasis added)

Even a recent UCLA study¹⁵ commissioned by the Sierra Club acknowledged that moving to an electric stove doesn’t make a difference for pollutants from food:

“Some PM emissions are associated with cooking oils and foods, and there are no mitigation methods for this, other than the use of ventilation devices such as range hoods. We do not claim that the transition to electric appliances would make a substantial difference in terms of emissions from cooking oils and food.” (emphasis added)

Multnomah County’s report also claims that “Gas cooking activities cause pollutants, including nitrogen dioxide (NO₂), carbon monoxide (CO) and particulate matter (PM), which can reach levels that affect human health.” However, in contrast, most pollutants don’t actually come from the stove, but rather the food. As Dr. Daniel Tormey, president of Catalyst Environmental Solutions, writes¹⁶:

“What is being cooked is often the predominant source of emissions, rather than how you cook it. That’s an important fact because the authors of this latest study explicitly called for replacing your gas stoves with electric ones because of health impacts. Since a major source of emissions in your kitchen is the food you cook, replacing your gas stove with electric will do very little to address indoor air quality or health.” (emphasis added)

Similarly, Multnomah County claimed that “the EPA’s Integrated Science Assessment for Oxides of Nitrogen found NO₂ is present in homes with gas stoves at concentrations that are 50 percent to over 400 percent higher than those in homes with electric stoves.”

However, that’s a misrepresentation of the EPA’s findings. The EPA study¹⁷ found that NO₂ concentrations are highly spatially and temporally variable in urban areas. And the cited studies¹⁸ on gas stoves within the EPA report on Oxides of Nitrogen focused on inner city children and multifamily households, who are disproportionately BIPOCs, and, unfortunately, whose communities have higher exposure to asthma reinforcing environmental pollutants.

¹³ <https://www.epa.gov/indoor-air-quality-iaq/sources-combustion-products>

¹⁴ https://www.epa.gov/indoor-air-quality-iaq/sources-indoor-particulate-matter-pm?utm_content=&utm_medium=email&utm_name=&utm_source=govdelivery&utm_term=#how

¹⁵ <https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/>

¹⁶ <https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/>

¹⁷ <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=194645>

¹⁸ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4254510/>

Underpinning many of the claims from Multnomah County, the report cites a study¹⁹ published in Feb. 2022 from a Stanford University graduate student²⁰ and Physicians, Scientists and Engineers for Healthy Energy (PSEHE). This study has significant challenges with its findings and potential bias.

In addition to explaining that the food itself, not the appliance it's cooked on is the "predominant source of emissions," Dr. Tormey, identified²¹ several major flaws in the study including:

"It compares two minutes of nitrogen oxides (NOx) released to a one-hour federal NOx standard for outdoor air. This is very much apples and oranges because the one-hour standard is meant to provide an exposure that may occur for one hour, not two minutes. Moreover, the actual wording in the study does not conclude that their findings would violate the NOx standard. The researchers merely made the comparison, not really using it as a significance criterion."

"The researchers sealed their test kitchens in plastic tarps to concentrate the emissions so they would be easier to measure. While this is a novel and interesting method, the study results are useless for evaluating health-based exposures because no kitchen is set up like that. In other words, they weren't simulating a real-life cooking experience." (emphasis added)

Finally, Multnomah County claims that "Gas appliances contribute to indoor air pollution and are a health hazard, increasing the risk of childhood asthma and asthma severity." In reality, in the most robust global study²² conducted on this topic, the International Study of Asthma and Allergies in Childhood (ISAAC), researchers evaluated more than half a million children from 47 countries, including the United States, over five years, and found:

"We detected no evidence of an association between the use of gas as a cooking fuel and either asthma symptoms or asthma diagnosis."

Similarly, a PREPARE study tracked²³ Black and Hispanic or Latino adults' asthma severity and symptoms from 2018 through the pandemic and found that despite increased time spent indoors at home, asthmatics experienced a 40 percent decrease in their symptoms. The study didn't separate residents by cooking appliance, but the findings suggest that the home environment was a safe space, and it is factors outside of the house that have the outsized impact on asthma symptoms.

Dive in Deeper – Energy In Depth's Citation by Citation Debunk

Citations that directly state natural gas is a key pollutant in homes and contributes to negative health impacts were predominately authored by activist organizations with strong commitments to "keep it in the ground" policies. Other more reputable studies and governmental resources found that the connection was more

¹⁹ <https://pubs.acs.org/doi/10.1021/acs.est.1c04707>

²⁰ <https://news.stanford.edu/2022/01/27/rethinking-cooking-gas/#:~:text=Stanford%20researchers%20found%20that%20gas,oxides%2C%20a%20toxic%20air%20pollutant.>

²¹ <https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/>

²² <https://pubmed.ncbi.nlm.nih.gov/24429203/>

²³ [https://www.jaci-inpractice.org/article/S2213-2198\(21\)00500-6/fulltext](https://www.jaci-inpractice.org/article/S2213-2198(21)00500-6/fulltext)

tenuous than Multnomah County reported, even directly stating that residents can greatly reduce exposure by “using a stove hood with a fan vented to the outdoors” or “buying a gas stove with pilotless ignition.”

Citations Directly Related to Gas Stoves

Citation 3	California Air Resources Board. Combustion pollutants and indoor air quality. https://ww2.arb.ca.gov/resources/documents/combustion-pollutants-indoor-air-quality
How it was used in the report	Citation for “ <i>Pollutants of Concern from Gas Stoves</i> ” subsection of the <i>Background</i>
Fact	CARB’s website on indoor air pollution and cooking ²⁴ includes natural gas stoves as a potential source of pollution if it is leaking but explains: “Cooking can also generate unhealthy air pollutants from heating oil, fat and other food ingredients, especially at high temperatures... Studies show that air can be unhealthy to breathe when people cook in kitchens with poor ventilation. The best way to ventilate your kitchen is to use a properly-installed, high efficiency range hood over your stove. A high efficiency range hood has a high cubic feet per minute (cfm) rating and a low sones (noise) rating. If you have a gas stove, a qualified technician should inspect it every year for gas leaks and carbon monoxide.”
Citation 4, 41	Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes. ²⁵ Eric D. Lebel, Colin J. Finnegan, Zutao Ouyang, and Robert B. Jackson. Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes Environmental Science & Technology 2022 56 (4), 2529-2539 DOI: 10.1021/acs.est.1c04707 ²⁶
How it was used in the report	<p>“A newer but small study from Stanford University earlier this year concluded that 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.”</p> <p>“Gas stoves are a source of combustion (burning) pollution inside the home, occurring during ignition, extinguishment, and even when the appliance is off.”</p>
Fact	<p>Here are a few things²⁷ to keep in mind about the study –</p> <ul style="list-style-type: none"> • The authors’ health claims are unsupported by their findings and methods, with five stoves accounting for half of their measured emissions, a methodology that excluded ventilation by sealing off the kitchen, and using a 1-h national outdoor standard for their assessment. • The researchers create an unrealistic kitchen environment to achieve their results by sealing their test kitchen in plastic tarps. As Dr. Daniel Tormey, president of Catalyst Environmental Solutions said²⁸: “the study results are useless for evaluating health-based exposures because no kitchen is set up like that. In other words, they weren’t simulating a real-life cooking experience.”

²⁴ <https://ww2.arb.ca.gov/resources/documents/indoor-air-pollution-cooking>

²⁵ <https://pubs.acs.org/doi/10.1021/acs.est.1c04707>

²⁶ <https://pubs.acs.org/doi/10.1021/acs.est.1c04707?ref=PDF>

²⁷ <https://www.energyindepth.org/five-facts-on-psehes-new-questionable-indoor-air-quality-study/?154>

²⁸ <https://www.washingtontimes.com/news/2022/feb/16/gas-stoves-and-mythical-health-risks/>

	<ul style="list-style-type: none"> PSEHE, the group that conducted research being relied on in the report, is an extremely biased group with a clear anti-natural gas agenda.²⁹ In fact, PSEHE’s Executive Director Seth Shonkoff wrote a 2012 memo³⁰ laying out a playbook for using headline generating health research, regardless of the quality of the studies, to influence public perception and policies, while the group’s co-founder³¹, Cornell University professor Anthony Ingraffea,³² has bragged³³ that his research is “a form of advocacy” with “advocacy-laced words and phrases in our papers.” Additionally, among PSEHE’s funders³⁴ is the Park Foundation, which supports³⁵ a “Keep It In The Ground” agenda and “resisting all new gas and oil drilling.”
Citation 16	A cross sectional analysis of behaviors related to operating gas stoves and pneumonia in U.S. children under the age of 5. ³⁶ Coker ES, Smit E, Harding AK, Molitor J, Kile ML. BMC Public Health. 2015 Feb 4;15:77. doi: 10.1186/s12889-015-1425-y. PMID: 25648867; PMCID: PMC4321321.
How it was used in the report	<i>“Across Multnomah County, 50% of households rely on gas heat appliances (primarily using gas to heat their homes, including gas furnaces, boilers, wall units and stoves). Many but not all of these households use gas stoves; the proportion is unknown.”</i>
Fact	Authors were unable to compare the effects of stove operating behaviors on respiratory illnesses in homes that used electric stoves since only respondents with a gas stove were asked about ventilation practices and using their stove for heat. Further, authors found that gas stoves for heat without ventilation was associated with higher odds of pneumonia and cough among U.S. children less than five years old who live in homes with a gas stove, but ventilation reduced the odds ratio.
Citation 23	Integrated Science Assessment for Oxides of Nitrogen. U.S. Environmental Protection Agency. Health Criteria 2-38 (2008).
How it was used in the report	<i>“The EPA’s Integrated Science Assessment for Oxides of Nitrogen found NO2 is present in homes with gas stoves at concentrations that are 50% to over 400% higher than those in homes with electric stoves.”</i>
Fact	This study found that the observed strength of the association between personal exposures and ambient concentrations are not only affected by the variation in physical parameters (e.g., penetration coefficient, mass transfer coefficient, air exchange rate, and indoor sources) but also affected by data quality and study design. Key findings related to assessing NO2 exposure also emphasized that No2 concentrations are highly spatially and temporally variable in urban areas.
Citation 24	Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children. ³⁷ Weiwei Lin, Bert Brunekreef, Ulrike Gehring. International Journal

²⁹ <https://www.psehealthyenergy.org/our-work/programs/environmental-health/>

³⁰ <https://eidhealth.org/anti-fracking-donor-memo-strategy-questionable-health-claims/>

³¹ <https://www.psehealthyenergy.org/news/news-from-pse/pse-a-birth-story/>

³² <https://www.psehealthyenergy.org/about/staff/tonyingf/>

³³ https://www.youtube.com/watch?v=naLjGOP1-_s

³⁴ <https://parkfoundation.org/wp-content/uploads/2021/07/2nd-quarter-2021.pdf>

³⁵ <https://parkfoundation.org/program-interests/>

³⁶ <https://pubmed.ncbi.nlm.nih.gov/25648867/>

³⁷ <https://academic.oup.com/ije/article/42/6/1724/737113>

	of Epidemiology, Volume 42, Issue 6, December 2013, Pages 1724–1737, https://doi.org/10.1093/ije/dyt150
How it was used in the report	<i>“A meta-analysis of 26 years of research provides evidence that children living in homes with gas stoves have an increased risk of asthma, and that indoor NO₂ increases the risk of current wheeze in children.”</i>
Fact	<ul style="list-style-type: none"> • Authors admit that the effects of gas cooking and indoor NO₂ on asthma and wheeze were found to be relatively small with odds ratios less than 1.5 and isn’t clear to the authors to what extent the observed associations with gas cooking are attributable to NO₂ alone. This unknown is seen in their dataset, which saw increased odd ratios when all confounders were adjusted and studies without confounder adjustment were excluded. • Confounders in the meta-analysis included numerous items: mold, mildew, water leaks, maintenance medication use, passive smoking, region, metropolitan area, pets, heating fuel, dampness, etc. Essentially, authors had to control for the whole suite of household environmental factors to show natural gas was as impactful as the county claims it to be. Multnomah County report fails to address all the confounding issues surrounding poor indoor air quality. • One study in the meta-analysis³⁸ even notes “no single exposure is likely to hold the key to childhood asthma, and new hypotheses about environmental exposures will evolve over the course of a cohort study.” • The study was also international, with the association of asthma with gas cooking being lower in North America, and the higher associations in Europe and Asia-Pacific skewing the data higher.
Citation 25	Integrated Science Assessment for Oxides of Nitrogen (2016). ³⁹ U.S. Environmental Protection Agency.
How it was used in the report	<i>“EPA’s Integrated Science Assessment has identified a causal relationship between short-term exposure to NO₂ concentrations within the range generated by gas stoves and adverse respiratory effects, including asthma exacerbation.”</i>
Fact	<p>The EPA’s Integrated Science Assessment did find a causal relationship between short-term exposure of NO₂ concentrations and adverse respiratory effects, but they did not connect gas stoves emission ranges to asthma. The language in the report is thus deceptive: the authors appeared to insert “within the range generated by gas stoves” to make it appear as if the EPA’s assessment was examining those appliances. The EPA report states that recent studies show associations between indoor combustion and indoor NO₂, but those studies’ ranges of gas stove emissions varied heavily by the study, including:</p> <ul style="list-style-type: none"> • Both Brauer et. al (1990) studies had unvented combustion conditions in a year where most homes had steady on pilot lights, not the modern gas ranges. • Brauer (1991) had an 11-group sample size, all homes used unvented gas ranged for cooking, and they did not control for confounding factors like smokers in the home or pets. • Two of the studies used 24 h measurements when NO₂ National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS) are only available⁴⁰ for 1-hour and annual arithmetic mean averaging times.

³⁸ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3094407/>

³⁹ <https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879>

⁴⁰ https://www.calrest.org/sites/main/files/file-attachments/ucla_study_-_natural_gas_stoves_-_tormey_critical_review.pdf

Citation 26	Human Health Risk Assessment for Ambient Nitrogen Dioxide (2016). Health Canada. https://perma.cc/G2CN-D4F2
How it was used in the report	<i>“A causal link between short- and long-term exposure to NO2 and a variety of other health harms, such as heart rate variability, systemic inflammation of other organs, adverse birth outcomes, cancer, and death has also been cited by EPA and Health Canada in their Human Health Risk Assessment for Ambient Nitrogen Dioxide.”</i>
Fact	Health Canada’s figure comes from <i>unvented</i> gas cooking and heating appliances and the risk assessment report continues that gas stoves with pilot lights emit more NO ₂ than those from gas stoves with more modern electric ignition systems, and that mean/median concentrations of NO ₂ indoors were relatively low in a study of Canadian homes with vented gas furnaces. The United States mandated the removal of pilot lights from most stoves in 1990, and extended the regulation to all gas stoves in 2009. ⁴¹
Citation 36	Natural gas used in homes contains hazardous air pollutants: Policymakers and individuals can act to mitigate potential health risks from natural gas. ⁴² Harvard T.H. Chan School of Public Health. ScienceDaily. ScienceDaily, 28 June 2022.
How it was used in the report	<i>“The degree to which VOCs are present indoors from gas stoves is not well researched. However, a recent and widely cited study from Harvard found that natural gas used in homes throughout the Greater Boston area contained varying levels of volatile organic chemicals even when the stove was off.”</i>
Fact	Here are a few items ⁴³ to keep in mind about the study – <ul style="list-style-type: none"> • Researchers acknowledge low levels of VOCs and admit that the VOCs in natural gas “are likely lower compared to other source types.” • The study is not a health risk assessment and, in the webinar⁴⁴ discussing it, authors clarified that the presence of VOCs is in such small concentrations that there is no cause for immediate concern. • The New York Times⁴⁵ reported that study author Dr. Michanowicz said: “The concentrations of benzene that the researchers found in the natural gas samples were ‘much lower compared to the amount in gasoline,’ a common source of the chemical along with plastics, resins and nylon fibers, types of rubbers, dyes, vehicle exhaust, and tobacco smoke.”

Citations Related to General Indoor Air Quality, Not Gas Stoves

Citation 1	The total exposure assessment methodology (TEAM) study: Summary and analysis. U.S. Environmental Protection Agency. 1987. EPA/600/6-87/002a. Washington, DC.
How it was used in the report	<i>“Indoor air pollution levels are often two to five times, and occasionally more than 100 times, higher than outdoor levels.”</i>
Fact	This 1987 study discusses indoor air quality but does not provide evidence that gas stoves negatively impact indoor air quality.

⁴¹ <https://appliance-standards.org/product/cooking-products>
⁴² <http://www.sciencedaily.com/releases/2022/06/220628083239.htm>
⁴³ <https://www.energyindepth.org/new-gas-stove-study-finds-low-voc-levels-doesnt-assess-health-risks/>
⁴⁴ <https://www.youtube.com/watch?v=OA9mYTdEe88>
⁴⁵ <https://www.nytimes.com/2022/06/28/climate/natural-gas-home-toxic-chemicals.html>

Citation 2, 28	Why Indoor Chemistry Matters. Washington, DC: The National Academies Press. National Academies of Sciences, Engineering, and Medicine 2022. ⁴⁶
How it was used in the report	<p><i>“The National Academy of Sciences published a 2022 report which emphasized that environmental conditions and indoor chemistry can vary between buildings.”</i></p> <p><i>“The National Academy of Sciences reports that particulate matter emissions from gas stoves can vary depending on the type of cooking (i.e., frying vs. simmering), foods cooked, temperature, and other factors.”</i></p>
Fact	This study discusses indoor air quality but does not provide evidence that gas stoves negatively impact indoor air quality. The National Academy of Sciences reports that “cooking generates gases and particles, both from the heat source (e.g., combustion or electric coils) and the food preparation itself, which can differ based on the cooking style (e.g., frying or boiling) and ingredients (e.g., sauces, oils, spices, protein, and vegetables).”
Citation 6	Indoor Air Quality: Effects on Human Health. U.S. Environmental Protection Agency. ⁴⁷
How it was used in the report	<i>“Indoor air pollution can cause and worsen respiratory illness, including asthma, alongside other non-respiratory health issues such as heart disease, cancer and premature death.”</i>
Fact	The website is the EPA’s 101 page on indoor air quality but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 7	The inside story: a guide to indoor air quality. Washington, DC: U.S. Environmental Protection Agency and the U.S. Consumer Product Safety Commission, Office of Radiation and Indoor Air; 1995. Document #402-K-93-007. ⁴⁸
How it was used in the report	Supporting source for “Sensitive Groups” subsection of <i>Background</i>
Fact	This website is an EPA explainer on indoor air quality. While natural gas stoves are mentioned in the list of combustion products, along with a host of other products, the EPA qualifies its list by stating “the relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted.” EPA also lists ventilation as an approach to lowering the concentrations of indoor air pollutants in the home.
Citation 27, 35	Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review. Vardoulakis et al. Int. J. Environ. Res. Public Health 2020, 17(23), 8972
How it was used in the report	<p><i>“A 2020 systematic review on indoor exposure to air pollutants in the home environment notes that the most important predictors of indoor NO2 concentrations were gas stove use, followed by ventilation and outdoor NO2 levels.”</i></p> <p><i>“Volatile organic compounds (VOCs) can be emitted through leaks in gas lines and gas stoves inside the home. The VOCs in gas can include formaldehyde and benzene. Many VOCs are ozone precursors, are possible carcinogens and have been reported to be</i></p>

⁴⁶ <https://doi.org/10.17226/26228>

⁴⁷ <https://www.epa.gov/report-environment/indoor-air-quality#:~:text=Effects%20on%20Human%20Health,-Health%20effects%20associated&text=Irritation%20of%20the%20eyes%2C%20nose,%2C%20heart%20disease%2C%20and%20cancer.>

⁴⁸ <https://www.epa.gov/indoor-air-quality-iaq/inside-story-guide-indoor-air-quality>

	<i>significant risk factors for asthma. A 2020 systematic review found that indoor VOC concentrations were negatively correlated with ventilation.”</i>
Fact	The full conclusions of the study were: “Household characteristics and occupant activities play a large role in indoor exposure, particularly cigarette smoking for PM _{2.5} , gas appliances for NO ₂ , and household products for VOCs and PAHs. Home location near high-traffic-density roads, redecoration, and small house size contribute to high indoor air pollution.” The study also explains “major sources of NO ₂ indoors are <i>unvented</i> gas heaters and cooker,” and indoor air quality was exacerbated by “ventilation, season, and outdoor NO ₂ levels.” Authors found that “in most studies, air exchange rates are negatively associated with indoor air pollution,” confirming that ventilation remains vital to improving indoor air quality.
Citation 32	A decade of the U.S. energy mix transitioning away from coal: historical reconstruction of the reductions in the public health burden of energy. J Buonocore (Harvard T.H. Chan School of Public Health) et al. 2021 Environ. Res. Lett. 16 054030, https://doi.org/10.1088/1748-9326/abe74c . (Table 2 & Figure 16)
How it was used in the report	<i>“One high-profile modeling study suggests that among fuels used in residential buildings, gas is second only to biomass in attributable mortality in Oregon. The same study, using 2017 modeled results for the United States, reported that burning gas for any purpose in buildings (residential and commercial) was responsible for an estimated 3,860 to 5,800 deaths annually nationwide (860 to 1,600 for commercial buildings and 3,000 to 4,200 residential).</i>
Fact	The study acknowledges that authors did not evaluate the public health impacts of combustion of gas and coal, nor is the study a comprehensive life cycle assessment or health impact assessment. Furthermore, it does not include health impacts of indoor exposures, including unvented gas combustion from cooking, indoor gas leaks, or indoor exposure to wood smoke.
Citation 33	U.S. Environmental Protection Agency. ⁴⁹
How it was used in the report	<i>“Carbon monoxide (CO) is colorless, odorless and is produced by the incomplete combustion of gas and other fuels. Breathing in CO reduces the amount of oxygen that can be transported in the bloodstream to organs like the heart and brain. It can cause dizziness, confusion, fatigue, unconsciousness, heart problems and death.”</i>
Fact	According to the EPA, a variety of sources release carbon monoxide, but its effect varies at different concentration levels. The EPA does not advocate for removing gas stoves or gas appliances, but purchasing vented space heaters or using an exhaust fan vented to the outdoors.
Citation 34	WHO Guidelines for Indoor Air Quality: Selected Pollutants. World Health Organization, 2010. https://www.ncbi.nlm.nih.gov/books/NBK138710/ ; CO ISA, EPA, 2010
How it was used in the report	<i>“Carbon monoxide poisoning can be fatal in just minutes if concentrations are high enough indoors. WHO, in its review of the scientific evidence, notes exposure to carbon monoxide can also reduce maximum exercise ability in healthy young individuals, while the EPA concludes a causal relationship is likely to exist between short term exposures to CO and cardiovascular morbidity.”</i>

⁴⁹ <https://www.epa.gov/indoor-air-quality-iaq/carbon-monoxides-impact-indoor-air-quality#Overview>

Fact	This study discusses potential health impacts from CO exposure but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 43	“Housing Interventions and Health: A Review of the Evidence,” National Center for Healthy Housing. David E. Jacobs and Andrea Baeder. January 2009 ⁵⁰
How it was used in the report	<i>“Motivated by the information presented above, findings that removing indoor fossil fuel combustion reduces exposure to harmful pollution, and the lack of federal oversight over gas stove emissions, some states and local authorities have developed their own standards or policies to protect their constituents.”</i>
Fact	This study mentions gas stoves twice, and never links them directly to health impacts or recommend them to be removed from the household. The neighborhood-level interventions highlighted in the report notes that there are improvements to be made, but “the majority of interventions considered in [the] paper was not intended to improve health,” and warns that “as important as it is, the link between housing conditions and health effects constitutes only half of the knowledge needed.” Authors understand that there is compelling evidence that inadequate ventilation adversely affects health and is an area of further research.

Other Citations

Citation 8	PM2.5 pollutants disproportionately and systemically affect people of color in the United States. Tessum, C.W., Paoella, D.A., Chambliss, S.E., Apte, J. S., Hill, J. D., & Marshall, J. D. (2021). <i>Science Advances</i> , 7(18), eabf4491.
How it was used in the report	<i>“Racism and classism shape the choices people have about where to live and work, and thus their exposure to air pollution. Home environments are an important determinant of health. Although there is a knowledge gap on inequities with indoor air pollution, research shows that low-income and BIPOC populations are disproportionately burdened by most types of pollution.”</i>
Fact	This study discusses environmental justice but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 9	2014 Report Card on Racial and Ethnic Disparities. ⁵¹ Multnomah County Health Department.
How it was used in the report	<i>“Data show outdoor air pollution is not spread evenly across our communities and demographic groups.”</i>
Fact	This study discusses environmental justice but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 10	Analysis from the National Air Toxics Release Inventory, 2014. ⁵² Multnomah County Environmental Health Services.
How it was used in the report	<i>“There are documented disproportionate impacts [of outdoor air pollution].”</i>
Fact	This study discusses the important issue of <i>outdoor</i> air quality but does not specifically answer the question as to the effect of gas stoves on air pollutants.

⁵⁰ <http://ncharchive.org/LinkClick.aspx?fileticket=2lvaEDNBldU%3D&tabid=229>

⁵¹ <https://multco-web7-psh-files-usw2.s3-us-west-2.amazonaws.com/s3fs-public/2014%20Report%20Card%20on%20Racial%20and%20Ethnic%20Disparities%20-%20Full%20Report%20-%20v121214.pdf>

⁵² <https://multco.maps.arcgis.com/apps/MapJournal/index.html?appid=886de8737ec84c3d99382a69d4f93853>

Citation 11	Socioeconomic Disparities and Air Pollution Exposure: a Global Review. ⁵³ Hajat, A., Hsia, C. & O’Neill, M.S. Curr Envir Health Rpt 2, 440–450 (2015).
How it was used in the report	<i>“Historically, low-income people and people of color have experienced disproportionate exposure to ambient air pollution.”</i>
Fact	This study discusses environmental justice but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 12	Disparities in Air Pollution Exposure in the United States by Race-Ethnicity and Income, 1990–2010. ⁵⁴ J. Liu, L. P. Clark, M. Bechle, A. Hajat, S.-Y. Kim, A. Robinson, L. Sheppard, A. A. Szpiro, J. D. Marshall. ChemRxiv. Preprint.
How it was used in the report	<i>“Historically, low-income people and people of color have experienced disproportionate exposure to ambient air pollution.”</i>
Fact	This study discusses environmental justice but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 13	American Lung Association. State of the Air Report, 2022. ⁵⁵ 26434/chemrxiv.13814711.v1; P. Mohai, D. Pellow, J. T. Roberts, Environmental justice. Annu. Rev. Env. Resour. 34, 405–430 (2009)
How it was used in the report	<i>“People of color are 1.5 times more likely to live in an area with poor air quality compared to white people.”</i>
Fact	This report discusses general air quality but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 14	Analysis by the American Lung Association Epidemiology and Statistics Unit. ⁵⁶ CDC. NHIS 2018.
How it was used in the report	<i>“The CDC reports asthma rates to be much higher among Black children.”</i>
Fact	This analysis discusses environmental justice but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 15	Institute of Medicine. Toward Environmental Justice: Research, Education, and Health Policy Needs. ⁵⁷ Washington, DC: National Academy Press, 1999
How it was used in the report	<i>“Lower-income households have an increased risk of illness from air pollution because they are more likely to be in areas with higher concentrations of outdoor pollutants.”</i>
Fact	This study discusses environmental justice but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 17	Oregon Department of Energy’s 2020 Biennial Energy Report. ⁵⁸
How it was used in the report	<i>“Across Multnomah County, 50% of households rely on gas heat appliances (primarily using gas to heat their homes, including gas furnaces, boilers, wall units and stoves).”</i>
Fact	This discusses natural gas consumption but does not provide evidence that gas stoves negatively impact indoor air quality. It also underscores the stakes: half of the county’s homes rely on natural gas appliances, meaning any policy impacting those appliances should be based on robust and credible data.

⁵³ <https://doi.org/10.1007/s40572-015-0069-5>

⁵⁴ <https://ehp.niehs.nih.gov/doi/10.1289/EHP8584>

⁵⁵ <https://www.annualreviews.org/doi/abs/10.1146/annurev-environ-082508-094348>

⁵⁶ <https://www.lung.org/research/trends-in-lung-disease/asthma-trends-brief/current-demographics>

⁵⁷ <https://pubmed.ncbi.nlm.nih.gov/23035313/>

⁵⁸ <https://www.oregon.gov/energy/Dataand-Reports/Documents/2020-BER-County-Profiles-Supplement.pdf>

Citation 18, 38	Global mortality from outdoor fine pollution generated by fossil fuel combustion: Results from GEOS-Chem. Env Research. ⁵⁹ K. Vohra, A. Vodonos, J. Schwartz, E.A. Marais, M.P. Sulprizo, L.J. Mickley. 2021;195; AQLI. 2022. https://aqli.epic.uchicago.edu/reports/
How it was used in the report	<i>“When looking at the burden of disease, indoor and outdoor air pollution are important risk factors. Researchers estimate 350,000 premature deaths from air pollution in the United States annually and an average of two years off the global average life expectancy.”</i> <i>“Combustion of fossil fuels contributes to climate change and harms health.”</i>
Fact	This study discusses outdoor air quality but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 19	Air Quality Life Index 2022 Update. ⁶⁰ Michael Greenstone, Christa Hasenkopf and Ken Lee. Air Quality Life Index.
How it was used in the report	<i>“The Energy Policy Institute states that breathing polluted air is more dangerous than smoking cigarettes or drinking alcohol.”</i>
Fact	This analysis discusses air quality generally but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 20	Exposure to air pollution and COVID-19 mortality in the United States. ⁶¹ Wu, X., Nethery, R. C., Sabath, B. M., Braun, D., & Dominici, F. (2020). medRxiv.
How it was used in the report	<i>“Emerging evidence shows there are multiple pathways by which air pollution may interact with COVID-19. First is long-term exposure to pollution, which increases the likelihood of diseases such as asthma, chronic obstructive pulmonary disease (COPD), heart disease and diabetes – all conditions that make cases of COVID-19 more likely to be severe.”</i>
Fact	This study discusses COVID-19 but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 21	Association between short-term exposure to air pollution and COVID-19 infection: evidence from China Sci. Y. Zhu, J. Xie, F. Huang, L. Cao. Total Environ., 727 (2020), p. 138704, 10.1016/j.scitotenv.2020.138704
How it was used in the report	<i>“Second is short-term exposure to air pollution, which is thought to injure and inflame lungs, contributing to a greater susceptibility to infection.”</i>
Fact	This study discusses COVID-19 and particulate matter but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 22	Air Pollution and COVID-19: The Role of Particulate Matter in the Spread and Increase of COVID-19’s Morbidity and Mortality. ⁶² S. Comunian, D. Dongo, C. Milani, P. Palestini.

⁵⁹ <https://www.sciencedirect.com/science/article/abs/pii/S0013935121000487>

⁶⁰ <https://epic.uchicago.edu/news/air-pollution-worse-for-global-lifespan-than-cigarettes-or-alcohol/#:~:text=That's%20according%20to%20the%20latest,alcohol%2C%20or%20conflict%20and%20terrorism.>

⁶¹ <https://www.medrxiv.org/content/10.1101/2020.04.05.20054502v2>

⁶² <https://pubmed.ncbi.nlm.nih.gov/32580440/>

	(2020). Int J Environ Res Public Health. 22;17(12):4487. doi: 10.3390/ijerph17124487. PMID: 32580440; PMCID: PMC7345938
How it was used in the report	<i>“There are differences in COVID-19 infection rates by race and ethnicity. Additionally, some scientists think air pollution affects the transmission of COVID-19 infection and its ability to move and survive in the air.”</i>
Fact	This study discusses COVID-19 but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 29	Integrated Science Assessment for Particulate Matter. ⁶³ U.S. Environmental Protection Agency. 2019; WHO. September 2021.
How it was used in the report	<i>“The health effects of breathing in PM_{2.5} are well documented by authoritative sources, with mounting scientific evidence showing that there is no known risk-free level of PM_{2.5} exposure.”</i>
Fact	This study discusses particulate matter but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 30	Health and Environmental Effects of Particulate Matter (PM). U.S. Environmental Protection Agency. ⁶⁴
How it was used in the report	<i>“PM poses serious health risks, such as premature death, heart attacks, aggravated asthma, decreased lung function, and increased respiratory symptoms such as irritation of the airways, coughing or difficulty breathing.”</i>
Fact	This analysis discusses particulate matter but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 31	Health Effects of particulate matter: Policy implications for countries in eastern Europe, Caucasus and central Asia. 2013. ⁶⁵ World Health Organization.
How it was used in the report	<i>“WHO has stated that there is a close relationship between exposure to high concentrations of small particulates (PM₁₀ and PM_{2.5}) and increased mortality or morbidity, both daily and over time. All-cause daily mortality is estimated to increase by 0.2–0.6% per 10 µg/m³ of PM₁₀ while long-term exposure to PM_{2.5} is associated with an increase in the longterm risk of cardiopulmonary mortality by 6–13% per 10 µg/m³ of PM_{2.5}.”</i>
Fact	This analysis discusses particulate matter but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 37	Climate and Health in Oregon 2020. ⁶⁶ Oregon Health Authority (OHA). December 2020.
How it was used in the report	<i>“The specific role of gas stoves as a contributor to climate change is not well-researched to date, but we felt it important to discuss, given that climate change is a threat</i>

⁶³ [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

⁶⁴ <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>

⁶⁵ https://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf

⁶⁶ <https://www.oregon.gov/oha/ph/healthyenvironments/climatechange/pages/profile-report.aspx#:~:text=Climate%20and%20Health%20in%20Oregon%202020&text=it%20documents%20cross%2Dcutting%20health,importance%20of%20building%20social%20resilience.>

	<i>multiplier for public health. Climate change has various serious health impacts in Oregon and Multnomah County.”</i>
Fact	This analysis discusses the important issue of climate change but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 39	Identifying and Regulating the Environmental Risks in the Development and Utilization of Natural Gas as a Low-Carbon Energy Source. ⁶⁷ Jiaxin Fu, Yingqi Liu, FeiHong Sun. (2021). Front. Energy Res., 9.
How it was used in the report	<i>“Leaked methane or carbon dioxide and carbon monoxide from gas extraction and combustion can cause climate-related health harms.”</i>
Fact	This study discusses natural gas production and consumption but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 40	United Nations Economic Commission for Europe. ⁶⁸
How it was used in the report	<i>“Localized health impacts from hazardous air pollution emissions from fuel extraction processes have been noted by governmental bodies and researchers. The United Nations found methane to be over 80 times more powerful than carbon dioxide as a warming gas over a 20-year timeframe in addition to being an ozone precursor.”</i>
Fact	This analysis discusses the important issue of climate change but does not provide evidence that gas stoves negatively impact indoor air quality.
Citation 42	Integrated Science Assessment for CO ₂ . U.S. Environmental Protection Agency. ⁶⁹
How it was used in the report	<i>“Additionally, evidence reviewed by the EPA concludes that a causal relationship exists between current atmospheric concentrations of CO (not CO₂) and effects on climate.”</i>
Fact	This assessment discusses CO but does not provide evidence that gas stoves negatively impact indoor air quality. Residential CO emissions in the United States have declined 37% percent from 1990-2020 according to the EPA’s GHG Inventory ⁷⁰ and are only 7.5% of total nationwide CO emissions.

⁶⁷ <https://www.frontiersin.org/articles/10.3389/fenrg.2021.638105/full>

⁶⁸ <https://unece.org/challenge>. August 10,2022

⁶⁹ <https://www.epa.gov/isa/integrated-science-assessment-isa-carbon-monoxide>

⁷⁰ <https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-2022-main-text.pdf>