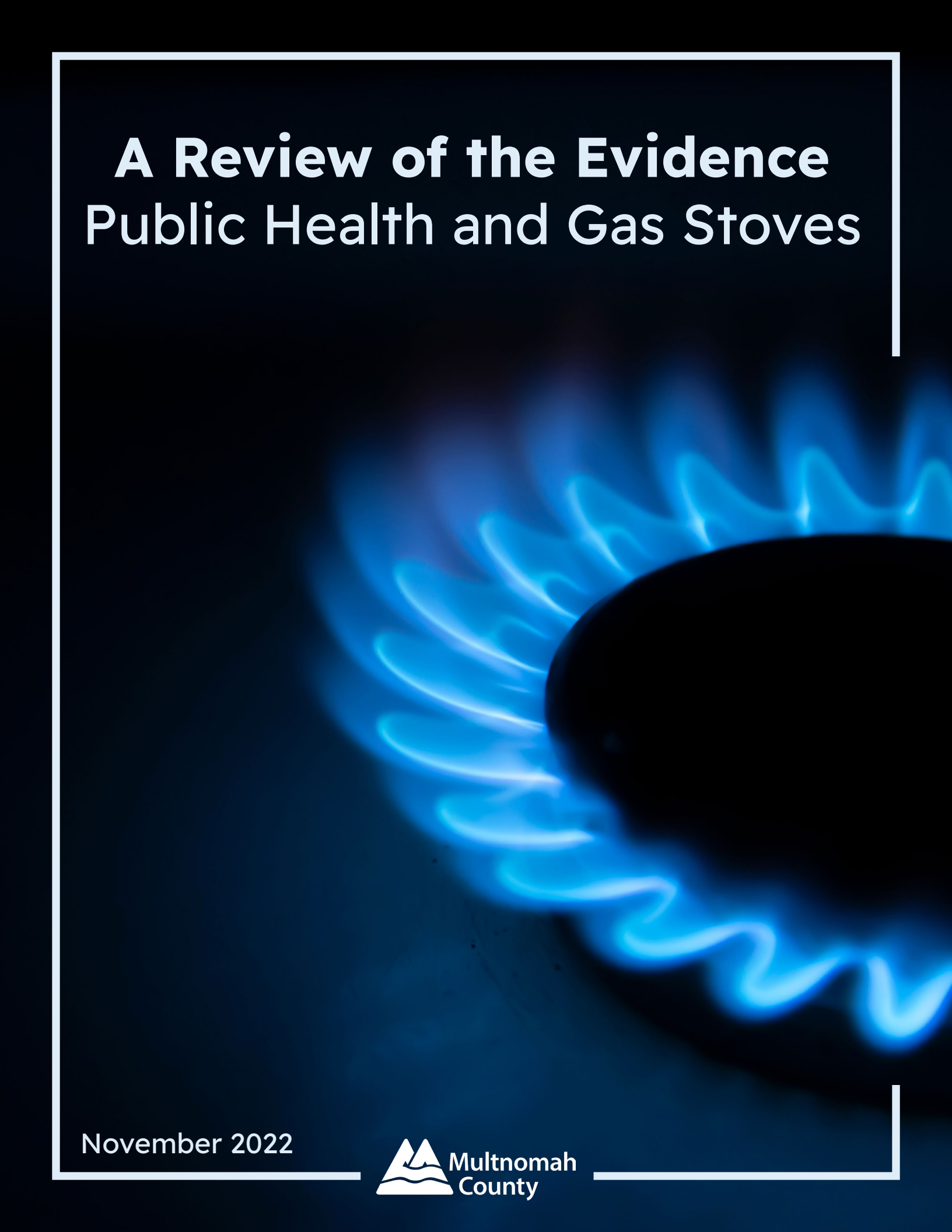
A Review of the Evidence
Public Health and Gas Stoves



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Multnomah County

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Introduction

Awareness that outdoor air pollution can impact health is prevalent, but less well known is that indoor air pollution can also have significant and harmful health effects. While air indoors can be safer during times of high outdoor pollution events (like wildfire), indoor air pollution has consistently been ranked among the top five environmental risks to public health from comparative risk studies performed by EPA's Science Advisory Board (SAB). In recent years, news media have broadened awareness of decades of research demonstrating that gas appliances, especially for cooking, are a health risk. Research described in this report shows that gas appliances contribute to both indoor air pollution and climate change. While outdoor air pollution and some of its most common pollutants have been regulated for decades through various means in the United States, no federal standards or guidelines govern indoor air pollution. This 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.

Executive Summary

- Gas appliances contribute to indoor air pollution and are a health hazard, increasing the risk of childhood asthma and asthma severity.
- BIPOC and low-income families experience disproportionate exposure to ambient air pollution and as a result suffer a higher burden from indoor air pollution.
- Gas appliances use methane gas, almost always a fossil fuel, that can contribute to outdoor air pollution levels and climate change.
- Gas cooking activities cause pollutants, including nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter (PM), which can reach levels that affect human health.
- Multnomah County Public Health recommends against indoor combustion appliances, including gas and wood-burning appliances.
- When a non-combustion appliance is available, health officials recommend prioritizing their use.
- When combustion appliances reach the end of their service life, health officials recommend replacing them with a non-combustion appliance.

Background

Indoor air pollution levels are often two to five times, and occasionally more than 100 times, higher than outdoor levels.[1] With our outdoor environments undergoing changes due to climate change (wildfires/urbanization), indoor spaces where people spend the majority of their time are further impacted in ways that scientists are still trying to understand. The National Academy of Sciences published a 2022 report which emphasized that environmental conditions and indoor chemistry can vary between buildings.[2] They highlighted that researchers know very little about how humans are exposed to indoor chemicals across different pathways and exposure routes. This is also true of cumulative and long-term exposures on human health. This 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. Gas stoves are of concern because they are a proximate source of indoor air pollution, and ventilation practices vary widely.

1 U.S. Environmental Protection Agency. 1987. The total exposure assessment methodology (TEAM) study: Summary and analysis. EPA/600/6-87/002a. Washington, DC.

2 National Academies of Sciences, Engineering, and Medicine 2022. Why Indoor Chemistry Matters. Washington, DC: The National Academies Press. https://doi.org/10.17226/26228

Pollutants of Concern from Gas Stoves[3]

Gas stoves are a source of combustion (burning) pollution inside the home, occurring during ignition, extinguishment, and even when the appliance is off.[4] Gas used in homes produces pollutants through leaks and combustion. Gas is made up primarily of methane (CH_4). It also releases carbon dioxide (CO_2), carbon monoxide (CO) and volatile organic chemicals (VOCs, e.g. formaldehyde). VOCs can also form secondary pollutants, such as particulate matter (PM) and ozone (O_3).[5] When lit, gas-burning appliances also produce nitric oxides such as nitrogen dioxide (NO_2) as a by-product.

Health Impacts

Most gas stove owners are already aware of the burn risks of open flames, the fire hazard of gas leaks, and perhaps even carbon monoxide poisoning. However, many are likely less familiar with the health risks associated with other pollutants emitted from gas stoves and combustion that affect indoor air pollution. Homes and buildings can trap pollutants that are emitted from indoor sources, exposing occupants to pollutants for longer durations. In addition, personal activities (like cooking) happen close to sources, increasing inhalation of pollutants. 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.[6]

Sensitive Groups[7]

Some populations are more susceptible to the risks of indoor air and gas stove pollution. The risk to children is heightened due to their increased breathing rate, higher lung-to-body ratios, and smaller bodies. Aging adults are at increased risk because of the likelihood of pre-existing conditions. People with respiratory and heart conditions are more likely to be affected by air pollution.

Environmental Justice

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.[8]

3 California Air Resources Board. Combustion pollutants and indoor air quality. https://ww2.arb.ca.gov/resources/documents/combustion-pollutants-indoor-air-quality.

4 Lebel ED, Finnegan CJ, Ouyang Z, Jackson RB. Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes. Environ Sci Technol. 2022 Feb 15;56(4):2529-2539. doi: 10.1021/acs.est.1c04707. Epub 2022 Jan 27. Erratum in: Environ Sci Technol. 2022 May 17;56(10):6791. PMID: 35081712.

5 U.S. Environmental Protection Agency. Controlling Air Pollution from the Oil and Natural Gas Industry. https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/basic-information-about-oil-and-natural-gas

6 U.S. Environmental Protection Agency. Indoor Air Quality: Effects on Human Health. https://www.epa.gov/report-environment/indoor-air-quality#:~:text=Health%20effects%20associated%20with%20indoor,%2C%20heart%20disease%2C%20and%20cancer.

7 U.S. Environmental Protection Agency and the U.S. Consumer Product Safety Commission. 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. Available from URL: http://www.epa.gov/iaq/pubs/insidest.html

8 Tessum, C.W., Paolella, D.A., Chambliss, S.E., Apte, J. S., Hill, J. D., & Marshall, J. D. (2021). PM2. 5 polluters disproportionately and systemically affect people of color in the United States. Science Advances, 7(18), eabf4491.

Data show outdoor air pollution is not spread evenly across our communities and demographic groups.[9] There are documented disproportionate impacts.[10] Historically, low-income people[11] and people of color[12] have experienced disproportionate exposure to ambient air pollution. People of color are 1.5 times more likely to live in an area with poor air quality compared to white people.[13] The CDC reports asthma rates to be much higher among Black children.[14]

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.[15] They also are more likely to use gas stoves as supplemental heat.[16] Cumulative effects from combined exposure to outdoor and indoor pollution can lead to poor health outcomes. Environmental injustices worsen the adverse health impacts of gas stove emissions.

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).[17] Many but not all of these households use gas stoves; the proportion is unknown.

9 Multnomah County Health Department. 2014 Report Card on Racial and Ethnic Disparities. 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

10 Multnomah County Environmental Health Services. Analysis from the National Air Toxics Release Inventory, 2014. Retrieved from: https://multco.maps.arcgis.com/apps/MapJournal/index.html?appid=886de8737ec84c3d99382a69d4f93853

11 Hajat, A., Hsia, C. & O'Neill, M.S. Socioeconomic Disparities and Air Pollution Exposure: a Global Review. Curr Envir Health Rpt 2, 440–450 (2015). https://doi.org/10.1007/s40572-015-0069-5

12 J. Liu, L. P. Clark, M. Bechle, A. Hajat, S.-Y. Kim, A. Robinson, L. Sheppard, A. A. Szpiro, J. D. Marshall, Disparities in Air Pollution Exposure in the United States by Race-Ethnicity and Income, 1990–2010. ChemRxiv. Preprint. 10.26434/chemrxiv.13814711.v1; P. Mohai, D. Pellow, J. T. Roberts, Environmental justice. Annu. Rev. Env. Resour. 34, 405–430 (2009)

13 American Lung Association. State of the Air Report, 2020.

14 CDC. NHIS 2018. Analysis by the American Lung Association Epidemiology and Statistics Unit. Retrieved from: https://www.lung.org/research/trends-in-lung-disease/asthma-trends-brief/current-demographics

15 Institute of Medicine. Toward Environmental Justice: Research, Education, and Health Policy Needs. Washington, DC: National Academy Press, 1999

16 Coker ES, Smit E, Harding AK, Molitor J, Kile ML. 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. 2015 Feb 4;15:77. doi: 10.1186/s12889-015-1425-y. PMID: 25648867; PMCID: PMC4321321.

17 Oregon Department of Energy's 2020 Biennial Energy Report. Accessed from: https://www.oregon.gov/energy/Data-and-Reports/Documents/2020-BER-County-Profiles-Supplement.pdf

Health Impacts

Health Outcomes Related to Air Quality in Multnomah County

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.[18] The Energy Policy Institute states that breathing polluted air is more dangerous than smoking cigarettes or drinking alcohol.[19] Exposure to air pollution affects health across the lifecourse, from low birth weight to premature death. In Multnomah County, life expectancy ranges neighborhood by neighborhood from 72 to 90 years of age. Air pollution is just one environmental exposure contributing to life expectancy variations. Major health effects include asthma, heart attacks and stroke, Alzheimer's disease, and increased cancer risk. Air pollution causes or contributes to many of the leading causes of death in Multnomah County, including cancer, heart disease, stroke, chronic lower respiratory disease, and diabetes (Table 2).

Multnomah County prevalence of conditions related to air quality are shown in Table 1, tabulated by poverty status. Asthma is among the most prevalent chronic diseases, with one in 10 Multnomah County adults reporting a diagnosis. Socioeconomic disparities are apparent for heart attacks, low birthweight, preterm birth, diabetes and asthma. Adults living at or below the federal poverty level have a higher prevalence of these conditions compared to those not living in poverty.

Table 1. Illness related to air quality by poverty status in Multnomah County, 2016-2019

	Age-adjusted prevalence (95% Confidence Interval)		
Illness type	**Total Population**	**At or below poverty***	**Above poverty***
Adults who have had a stroke	2.6% (2.2-3.1%)	6.1% (3.7-9.6%)	2.1% (1.7-2.6%)
Adults who have had a heart attack	3.2% (2.7-3.7%)	6.1% (3.9-9.3%)	2.5% (2.1-3.1%)
Low birthweight (<2,500 grams)	6.9% (6.6-7.2%)	8.1% (7.6-8.5%)	6.1% (5.8-6.4%)
Adults who have had cancer	7.3% (6.7-8.0%)	8.5% (6.1-11.7%)	7.3% (6.6-8.1%)
Preterm birth (< 37 weeks)	8.2% (7.9-8.5%)	9.7% (9.3-10.3%)	7.3% (6.9-7.6%)
Adults with diabetes	7.6% (6.9-8.4%)	14.2% (10.7-18.5%)	6.8% (6.0-7.6%)
Adults with asthma	9.7% (8.9-10.6%)	14.7% (11.2-17.7%)	9.3% (8.3-10.3%)

Sources: BRFSS 2016-2019, Oregon Birth Certificates 2016-2019. "Confidence interval" means that there is a 95% chance that the true value is within the range.

*For birth outcomes, at or below poverty reflects births paid by Medicaid/OHP; above poverty reflects births paid by private insurance.

18 K. Vohra, A. Vodonos, J. Schwartz, E.A. Marais, M.P. Sulprizo, L.J. Mickley. Global mortality from outdoor fine pollution generated by fossil fuel combustion: Results from GEOS-Chem. Env Research. 2021;195; AQLI. 2022. https://aqli.epic.uchicago.edu/reports/

19 AQLI. 2022. https://aqli.epic.uchicago.edu/reports/

Table 2: Death rates from health conditions associated with air pollution in Multnomah County, 2016-2020	
Cause of death	**Rate per 100,000 population (95% CI)**
Major cardiovascular diseases (including stroke)	195.6 (191.3 - 199.9)
Chronic lower respiratory disease	33.7 (31.9 - 35.5)
Lung cancer (including cancers of the trachea and bronchus)	33.6 (31.8 - 35.4)
Alzheimer's disease	33.2 (31.5 - 35.0)
Diabetes	24.7 (23.2 - 26.2)

All conditions are leading causes of death in Multnomah County, 2016-2020
Source: CDC WONDER

Air Pollution and COVID-19

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.[20] Second is short-term exposure to air pollution, which is thought to injure and inflame lungs, contributing to a greater susceptibility to infection.[21] 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.[22]

20 Wu, X., Nethery, R. C., Sabath, B. M., Braun, D., & Dominici, F. (2020). Exposure to air pollution and COVID-19 mortality in the United States. medRxiv.

21 Y. Zhu, J. Xie, F. Huang, L. Cao. Association between short-term exposure to air pollution and COVID-19 infection: evidence from China Sci. Total Environ., 727 (2020), p. 138704, 10.1016/j.scitotenv.2020.138704

22 S. Comunian, D. Dongo, C. Milani, P. Palestini. (2020). Air Pollution and COVID-19: The Role of Particulate Matter in the Spread and Increase of COVID-19's Morbidity and Mortality. Int J Environ Res Public Health. 22;17(12):4487. doi: 10.3390/ijerph17124487. PMID: 32580440; PMCID: PMC7345938.

Review of Health Impacts by Gas Stove Pollutants

Gas stoves release a number of pollutants (like VOCs) through leaks, while also generating nitrogen oxides (most notable NO_2), carbon dioxide, carbon monoxide and particulate matter when in use. To date, the majority of research concerning gas stove emissions has focused on their effect on indoor air quality. The findings of gas stoves' impact on outdoor environments is limited.

Methods

We searched PubMed, Google Scholar and documents from authoritative sources (EPA, CDC, WHO, ALA, etc.) for systematic reviews or meta-analyses. Systematic reviews are defined as peer-reviewed journal articles that summarize findings of a body of literature on a specific topic, applying inclusion criteria for search terms, date of publication and study design. Meta-analyses are peer-reviewed journal articles that gather data from multiple studies and re-analyze them to determine the strength of findings and relationships across multiple studies.

Study design guides our assessment of the strength of scientific evidence. We view systematic reviews and meta-analyses as a strong study design. For this report, we consider a single high-quality systematic review or meta-analysis, or a report from an authoritative source to be sufficient for drawing conclusions about associations between risk factors and health outcomes. This is especially true if it summarizes many studies, finding consistent results and a large effect size. We emphasize recent reviews on the assumption that they encompass older ones and are most likely to represent the current state of scientific understanding. When no systematic review is available, we rely on review articles that are non-systematic reviews and employ less robust search strategies but nevertheless synthesize a body of literature rather than a small number of studies. As a guiding principle, we avoid making claims based on a single study, case studies, or gray literature. Individual well-known studies with larger sample size are mentioned to provide additional evidence, if they were not part of a review article, but are not considered sufficient on their own for drawing conclusions about associations and are viewed as low to moderate in strength of evidence. For more details on the rating of the evidence and review of the studies used, see Appendix.

Nitrogen Dioxide (NO_2)

EHS found strong evidence from systematic reviews and authoritative sources that Nitrogen dioxide (NO_2) from gas stoves adversely impacts health. NO_2 is a reactive gas released from the combustion of methane gas. NO_2 is the component of greatest concern and is used as the indicator for the larger group of NOx. NO_2 irritates eyes, nose and throat, and causes shortness of breath.

The EPA's Integrated Science Assessment for Oxides of Nitrogen found NO_2 is present in homes with gas stoves at concentrations that are 50% to over 400% higher than those in homes with electric stoves.[23] Cooking with gas can produce levels that exceed outdoor EPA health standards and World Health Organization (WHO) guidelines. 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 NO_2 increases the risk of current wheeze in children.[24] The analysis found that, compared to homes without gas stoves, children in homes with gas stoves are 42% more likely to experience symptoms associated with asthma, and 24% more likely to be diagnosed with lifetime asthma due to NO_2 emissions in the home.

23 U.S. Environmental Protection Agency. Integrated Science Assessment for Oxides of Nitrogen—Health Criteria 2-38 (2008) https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=194645.

24 Weiwei Lin, Bert Brunekreef, Ulrike Gehring.Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children. International Journal of Epidemiology, Volume 42, Issue 6, December 2013, Pages 1724–1737, https://doi.org/10.1093/ije/dyt150

EPA's Integrated Science Assessment has identified a causal relationship between short-term exposure to NO_2 concentrations within the range generated by gas stoves and adverse respiratory effects, including asthma exacerbation.[25] A causal link between short- and long-term exposure to NO_2 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.[26] A 2020 systematic review on indoor exposure to air pollutants in the home environment notes that the most important predictors of indoor NO_2 concentrations were gas stove use, followed by ventilation and outdoor NO_2 levels.[27]

Particulate Matter (PM)

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.[28] The report identified this exposure as a health risk, though it pointed to other research on specific health outcomes as examples, not as a comprehensive or systematic review of health impacts. Particulate matter emissions occur indoors when cooking, no matter the fuel type used. However, the open flame of a gas stove does produce particulate matter (PM) even when there is no cooking happening on the stove.

Particulate matter consists of a complex mixture of organic and inorganic substances, with a diameter of less than 10μm suspended in the air. These particles can be so small that they bypass a body's natural defense mechanisms. Lungs are not always able to filter the smallest of these particles (diameter of less than 2.5 μm), landing the health-damaging particles in our bloodstream and multiple organs. 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.[29]

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.[30] WHO has stated that there is a close relationship between exposure to high concentrations of small particulates (PM_{10} 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 $\mu g/m^3$ of PM_{10} while long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary mortality by 6–13% per 10 $\mu g/m^3$ of $PM_{2.5}$.[31]

Research is less developed on outdoor combustion of natural gas, contributing to a lack of certainty in outdoor impacts from gas. 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

25 U.S. Environmental Protection Agency. Integrated Science Assessment for Oxides of Nitrogen (2016). https://www.epa.gov/isa/integrated-science-assessment-isa-nitrogen-dioxide-health-criteria.

26 Health Canada, Human Health Risk Assessment for Ambient Nitrogen Dioxide (2016), https://perma.cc/G2CN-D4F2

27 Vardoulakis et al. Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review. Int. J. Environ. Res. Public Health 2020, 17(23), 8972

28 National Academies of Sciences, Engineering, and Medicine 2022. Why Indoor Chemistry Matters. Washington, DC: The National Academies Press. https://doi.org/10.17226/26228

29 U.S. Environmental Protection Agency. Integrated Science Assessment for Particulate Matter. 2019; WHO. September 2021. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

30 U.S. Environmental Protection Agency. Health and Environmental Effects of Particulate Matter (PM). Retrieved from: https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm

31 World Health Organization. Health Effects of particulate matter: Policy implications for countries in eastern Europe, Caucasus and central Asia. 2013. Retrieved from: //efaidnbmnnnibpcajpcglclefindmkaj/https://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf

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).[32] This is a conservative estimate because it includes only health impacts from outdoor $PM_{2.5}$ and precursor pollution; it also does not include pollution from upstream extraction. A single modeling study is not sufficient for strong conclusions but suggests the extent of impacts.

Carbon Monoxide (CO)

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.[33] 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.[34] Gas stoves can be a source of low level carbon monoxide emissions. Patterns of use and appliance maintenance can affect emission levels and impacts. While this exposure pathway is a possibility, evidence is lacking on typical levels of exposure from gas stove emissions.

Volatile Organic Compounds (VOCs)

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 significant risk factors for asthma. A 2020 systematic review found that indoor VOC concentrations were negatively correlated with ventilation.[35] 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.[36] When leaked, these VOCs are known to be toxic and linked to cancer. They also can form secondary health-damaging pollutants such as particulate matter and ozone. While this exposure pathway is a possibility, evidence is lacking on typical levels of exposure from gas stove emissions.

32 These values are based on additional analysis from Jonathan Buonocore, Sc.D, the study's lead author; RMI used median estimates from the results of 3 reduced complexity models used in: J Buonocore (Harvard T.H. Chan School of Public Health) et al, "A decade of the U.S. energy mix transitioning away from coal: historical reconstruction of the reductions in the public health burden of energy," 2021 Environ. Res. Lett. 16 054030, https://doi.org/10.1088/1748-9326/abe74c. (Table 2 & Figure 16)

33 U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/indoor-air-quality-iaq/carbon-monoxides-impact-indoor-air-quality

34 World Health Organization, 2010. https://www.ncbi.nlm.nih.gov/books/NBK138710/; CO ISA, EPA, 2010

35 Sotiris et al. Indoor Exposure to Selected Air Pollutants in the Home Environment: A Systematic Review. Int. J. Environ. Res. Public Health 2020, 17(23), 8972; https://doi.org/10.3390/ijerph17238972

36 Harvard T.H. Chan School of Public Health. "Natural gas used in homes contains hazardous air pollutants: Policymakers and individuals can act to mitigate potential health risks from natural gas." ScienceDaily. ScienceDaily, 28 June 2022. www.sciencedaily.com/releases/2022/06/220628083239.htm

Climate Impacts

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 multiplier for public health. Climate change has various serious health impacts in Oregon and Multnomah County.[37] Impacts include respiratory illness from deteriorating air quality, heat-related illness and death from warmer summer temperatures, changing patterns of vector-borne disease, threats to food and water quality, and accompanying economic and social stressors. For these reasons, mitigating climate change would contribute to protecting Multnomah County residents from these health hazards.

Combustion of fossil fuels contributes to climate change and harms health.[38] Leaked methane or carbon dioxide and carbon monoxide from gas extraction and combustion can cause climate-related health harms.[39] In the past, gas has been seen as a "cleaner" energy source when compared to other dirtier fossil fuels such as coal, but gas is a large contributor to greenhouse gas emissions. The residential sector plays a critical role in emission reduction, as a source of greenhouse gas (GHG) emissions.

There are upstream outdoor emissions associated with gas extraction and distribution. Methane is a potent greenhouse gas that is released at all stages of the gas system, from drilling and production to pipeline distribution and eventually in homes with gas lines. 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.[40] 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.[41] While meta-analyses on the impacts of gas stoves to outdoor environmental impacts are lacking, this individual study suggests the extent of impacts. Additionally, evidence reviewed by the EPA concludes that a causal relationship exists between current atmospheric concentrations of CO (not CO_2) and effects on climate.[42]

37 Oregon Health Authority (OHA). Climate and Health in Oregon 2020. December 2020.

38 K. Vohra, A. Vodonos, J. Schwartz, E.A. Marais, M.P. Sulprizo, L.J. Mickley. Global mortality from outdoor fine pollution generated by fossil fuel combustion: Results from GEOS-Chem. Env Research. 2021;195

39 Jiaxin Fu, Yingqi Liu, FeiHong Sun. (2021)Identifying and Regulating the Environmental Risks in the Development and Utilization of Natural Gas as a Low-Carbon Energy Source. Front. Energy Res., 9.

40 United Nations Economic Commission for Europe. Retrieved from https://unece.org/challenge August 10,2022

41 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

42 CO ISA, EPA

Health Based Regulation & Policy

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.[43] They include:

Resolutions

- California Air Resources Board (CARB): In November 2021, CARB adopted a resolution in support of updating building codes to improve ventilation standards and move toward electrification of appliances—making California the first state to issue official guidance to address the health impacts of gas stoves and other appliances.
- American Medical Association (AMA): This national group representing physicians has recognized the association between use of gas stoves, indoor nitrogen dioxide levels, and asthma health risk through the introduction of Resolution 439 (A-22), informing physician, health-care providers and the public that cooking with a gas stove increases household air pollution and the risk of childhood asthma.

Indoor Air Quality Guidelines

- Canada: Continues to update outdoor and indoor guidelines to better protect health. Canada has a maximum NO_2 residential exposure limit of 90 parts per billion (ppb) over a one-hour exposure and 11 ppb over the long-term (>24 h), which is lower than the EPA's outdoor standards of 100 ppb for 1hr exposure and 53 ppb annual.
- CARB Recommendations: Indoor air quality guidelines for pollutants including nitrogen dioxide (NO_2), formaldehyde, carbon monoxide (CO), particulate matter (PM_{10}, $PM_{2.5}$), polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons.

Other Policy Actions

- Financial Incentives: Sacramento Municipal Utility District (SMUD) provides financial incentives to switch from gas to electric.
- Gas Bans: At least 77 cities in 10 U.S. states have been working to phase out gas. Berkeley, CA first banned gas hookups in new multi-family construction, setting the stage for other big cities to follow, including New York City, San Francisco and Seattle which allow no gas in new buildings. San Diego and Denver are also taking action. In Oregon, Eugene most recently voted to direct city staff to draft ordinance language that would prohibit natural gas hookups for new residential buildings, which if passed would make Eugene the first city in Oregon to ban gas.

43 "David E. Jacobs and Andrea Baeder, "Housing Interventions and Health: A Review of the Evidence," National Center for Healthy Housing, January 2009, http://nchharchive.org/LinkClick. aspx?fileticket=2lvaEDNBIdU%3D&tabid=229"

Recommendations

Public Health recommends against combustion appliances, including gas stove appliances, to protect public health, improve indoor and outdoor air, reduce emissions and mitigate climate change.

When a non-combustion appliance is available, health officials recommend prioritizing their use to benefit occupants' respiratory health and reduce asthma morbidity in children.

If a non-combustion appliance is not available, adequate ventilation to the outdoors must be required and in working order. Ventilation should be used whenever the appliance is in use.

When replacing combustion devices, health officials recommend replacing them with non-combustion appliances.

Appendix

Evidence ratings generally follow guidelines used by CDC.

Evidence review ratings adapted from What Works for Health.

Rating	Amount of evidence	Quality of evidence
Strong evidence	1 or more systematic reviews, multiple experimental studies; Authoritative sources (e.g. government and international bodies, non-governmental institutions)	Strong designs, statistically significant positive findings consistent across studies, large effect size
Moderate evidence	1 or more systematic reviews, 2 experimental studies, 3 studies with unmatched comparisons or pre-post measures	Less rigorous designs, some statistically significant positive findings but inconsistency across studies
Insufficient evidence	No more than 1 experimental study, 2 or fewer studies with unmatched comparisons or pre-post measures	Study quality varies/often low, inconclusive findings

Evidence reviewed: exposure to pollutants
Gas stove use, combustion

Pollutant	Quality	Description	Count	Reference List
NO_2 There is strong evidence that indoor NO_2 concentrations from gas stove combustion harm health.	High	Systematic review & authoritative sources	5	WeiWei et al. 2013; Vardoulakis et al. 2020; EPA 2008; EPA 2016; HealthCanada 2016
PM There is strong evidence that exposure to particulate matter harms health. Excluding cooking, the evidence suggests that PM levels from gas stove combustion may harm health, but the evidence is undeveloped and considered insufficient.	High	Authoritative sources	2	EPA 2019; WHO 2021
	Low	Modeling study	1	Buonocore et al. 2021

Evidence reviewed: exposure to pollutants (continued) Gas stove use, combustion				
Pollutant	**Quality**	**Description**	**Count**	**Reference List**
CO Evidence is lacking on typical levels of exposure from gas stove emissions and associated health impacts.	Medium	Authoritative source	1	EPA 2010

Note: There are several other pollutants related to gas combustion. This review focuses on criteria pollutants, which are known to have health effects and have been most publicly studied.

Evidence reviewed: exposure to pollutants Gas stove use, fugitive emissions				
Pollutant	**Quality**	**Description**	**Count**	**Reference List**
VOCs The evidence is lacking on typical levels of VOCs emitted from gas stoves and their direct health impacts.	Medium	Systematic review	1	Sotiris et al. 2020
	Low	Observational study	1	Harvard 2022
CH4 Gas stoves as contributors to climate change are not well-researched to date. However, the climate-related harms from leaked methane from production and transport are.	High	Authoritative source	1	UNECE 2022
	Low	Modeling study	1	Lebel et al. 2022