American Gas Association Evaluation of Report
Health Effects from Gas Stove Pollution

Rev 7.14.2020

The Rocky Mountain Institute (RMI), in collaboration with Mothers Out Front, Physicians for Social Responsibility, and Sierra Club, released a report titled *Health Effects from Gas Stove Pollution*, here referred to as "RMI" or the "RMI report."[1]

The RMI report is one of several reports, slide decks, and blogs that RMI has crafted to support policies to limit or remove the option of natural gas from homes and incentivize or mandate electric appliances in homes and businesses.[2]

AGA has conducted a review of *Health Effects from Gas Stove Pollution.* The following paper evaluates and responds to the eight specific claims stated in the Executive Summary of the RMI report. Note that, in some cases, the claims differ from similarly enumerated statements made in the body of the report. Those discrepancies are addressed.

Some of the findings in the *Health Effects from Gas Stove Pollution* are not justified based on the report's supporting statements and citations. Furthermore, the report's conclusions and recommendations are not sufficiently substantiated for making policy or consumer decisions about energy choices.

Claim 1. Indoor air is largely unregulated and is often more polluted than outdoor air.

The US Environmental Protection Agency (EPA)-led Federal Interagency Committee on Indoor Air Quality (CIAQ) has responsibility across several federal agencies for indoor air quality (IAQ) issues, including residential IAQ and asthma. The Interagency Committee includes the departments of Commerce, Defense, Energy, Health and

[1] *Health Effects from Gas Stove Pollution* https://rmi.org/insight/gas-stoves-pollution-health/

[2] Rocky Mountain Institute:
"The Impact of Fossil Fuels in Buildings." January 2020. https://rmi.org/insight/the-impact-of-fossil-fuels-in-buildings/
"Fossil Gas Has No Future in Low-Carbon Buildings." January 2020. https://rmi.org/fossil-gas-has-no-future-in-low-carbon-buildings/
"A New Approach to America's Rapidly Aging Gas Infrastructure." January 2020. https://rmi.org/a-new-approach-to-americas-rapidly-aging-gas-infrastructure/
"The Economics of Electrifying Buildings." 2018. https://rmi.org/insight/the-economics-of-electrifying-buildings/

Human Services, Housing and Urban Development, Interior, Justice, Labor, State, Transportation, and the Treasury, as well as Consumer Product Safety Commission, the EPA, and other federal authorities. The work of the Interagency Committee routinely addresses IAQ issues of public importance. The Interagency Committee has not identified gas cooking emissions as an important issue concerning asthma or respiratory illness.

The Consumer Product Safety Commission is the lead federal authority on reviewing consumer health and safety associated with natural gas appliances. At present, the CPSC has expressed no concerns over gas cooking appliances as a risk to consumers.

RMI cites the EPA web page, "Why Indoor Air Quality is Important to Schools." On the page, EPA writes that "There is substantial evidence that indoor environmental exposure to allergens, such as dust mites, pests and molds, plays a role in triggering asthma symptoms. These allergens are common in schools. There is also evidence that exposure to diesel exhaust from school buses and other vehicles exacerbates asthma and allergies." EPA does not identify gas equipment or gas cooking appliances in this context.[3]

Claim 2. Gas stoves can be a large source of toxic pollutants indoors.

RMI writes that "[c]ooking food, regardless of the type of stove used [emphasis added], produces certain pollutants, such as particulate matter." Indeed, studies have consistently found that emissions from the cooking process—not from the burner or heat source operation—represent the chief source of concern concerning indoor air quality.[4]

With respect to gas cooking equipment, combustion emissions from gas ranges, ovens, and cooktops can contribute to some degree to emissions of NO_2 and other recognized pollutants. However, federal health and safety agencies have not identified specific health or safety issues or studies supporting policies for regulating unvented combustion appliances or their use since changes to the safety standard for unvented heaters were made in the North American standards for safety in the 1980s and testing and labeling for NO_2 emissions were implemented in the 1990s.

An extensive AGA review of relevant literature from the US Environmental Protection Agency (EPA), US Consumer Product Safety Commission (CPSC), US Department of Housing and Urban Development, and other federal agencies has not identified specific needs for limiting combustion emissions beyond the current safety standards limit for NO_2 emissions from unvented space heaters.

[3] https://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools

[4] Abdullahi, L., Delgado S., Juana M., Harrison, R., "Emissions and Indoor Concentrations of Particulate Matter and Its Specific Chemical Components from Cooking: A Review," Atmospheric Environment, vol. 41, pp. 260-294, June 2013.

All certified gas appliances must meet emission limits set by the Z21/83 standards committee using its American National Standards Institute (ANSI)-approved standards procedures. Concerning safety standards for CO emissions, studies show that gas ranges produce considerably less than the allowable maximum in the standard. An analysis by Battelle Memorial Institute under sponsorship by GRI has shown that the CO limit is conservative in protecting public safety and health in terms of exposure levels that can result from oven use.[5] The CO emission limit in the Z21.1 standard is based on exposure due to misuse of the oven as a space heater.

It is essential that an installed gas range, oven, or cooktop has been design certified to the ANS Z21.1 standard, which includes requirements for proper operation and limits on emissions. Natural gas kitchen appliances should be installed in accordance with manufacturer installation instructions and local installation codes such as the International Fuel Gas Code or the National Fuel Gas Code. And a gas range should be maintained in good working order and periodically inspected by a qualified technician.

Claim 3. Indoor pollution from gas stoves can reach levels that would be illegal outdoors.

The claim of a relationship of gas cooking emissions and exceeding outdoor standards for health-related pollutants is not justified by the literature cited in the report. Two principal studies are referenced in support, and neither study measured emission exposures in households. Additionally, RMI incorrectly compares a "peak" emissions event of NO_2 to a time-averaged standard based on long-term exposure.

The first study cited is Logue et al. (2014) published in *Environmental Health Perspectives*.[6] The Logue et al. study presented the results of a simulation model. While that fact alone does not invalidate the analysis, the study's applicability to the broad statement about indoor pollution as claimed is limited.

The study simulation relied upon modeling assumptions concerning emission source rates, the mass balance approach used, occupancy patterns, cooking appliance operation pattern, and occupant response to both cooking effluent and combustion productions. Behavior-related variables associated with residential cooking appear to be lacking from the model, which is a significant omission since the association of combustion product accumulation from cooking appliances and kitchen temperature rise has long been the basis for limiting combustion emissions. Finally, the emission factors assumed for cooking appliances, the initial inputs to modeling pollutant exposures, appear to come from an LBNL study of natural gas combustion emissions associated

[5] U. S. Environmental Protection Agency, "Review of the National Ambient Air Quality Standards for Carbon Monoxide, Assessment of Scientific and Technical Information: OAQPS Staff Paper," EPA-452/R-92-004, Aug. 1992. (

[6] Jennifer M Logue et al., Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California, 122 ENVIRONMENTAL HEALTH PERSPECTIVES 43 (2014), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3888569/

with imported LNG, which would produce different emission characteristics. Also, it is unclear from documentation of both the modeling study or the previous LBNL study whether the emission factors used are based upon peak concentrations of pollutants, time-averaged concentrations, and a hybrid of peak and time-averaged measurements.

The second article cited Singer et al. (2017), a study performed to examine residential cooking appliance exhaust hood design and use beginning with its publication in 2013 and updated in 2017, but which included authors' inferences about cooking appliance combustion emissions absent of cooking processes.[7] AGA's review found the study results inadequate to justify the researcher's conclusions regarding combustion emissions and exposures. The following abbreviated criticisms emerged from AGA's review:

- The studies made far-reaching conclusions concerning natural gas-fired cooking products based on an unvalidated set of coupled, dissimilar modeling methods. No actual emissions exposures were measured.

- Key intermediate calculations and initial estimates were not reported in association with exposure calculations and, therefore, could not be reviewed to assess their validity.

- The emission factors used for cooking appliances, the initial inputs to modeling pollutant exposures, appeared to come from an LBNL study of natural gas combustion emissions associated with imported LNG, which would produce different emission characteristics.

- Time scales between pollutant generation events and "acute" concentration thresholds did not align, and the lags were not explained.

- Occupancy factors in determining exposure appeared to come from different, likely incompatible literature sources.

- Modeling results placed major importance on very short-term exposures (less than one hour), creating additional uncertainties over modeling validity.

Finally, RMI compares indoor "peak" emissions of NO_2 with time-averaged concentrations based on emission exposure levels. However, it is not correct to compare a "peak" emissions event to a standard based on "long-term exposure." Long-term exposures would, at a minimum and with respect to health standards, be associated with a continuous 24-hour and annual average exposure. Gas cooking NO_2

[7] Brett C. Singer et al, Pollutant Concentrations and Emission Rates from Scripted Natural Gas Cooking Burner Use in Nine Northern Californian Homes, Lawrence Berkeley National Laboratory, 2016, p. 5, https://escholarship.org/uc/item/859882pw

generation events last a period of minutes to, perhaps once or twice annually for 4 to 6 hours under normal usage patterns. Beyond NO_2 generation cycles, NO_2 decays in household environments, so that exposures from a static generation event are not prolonged and accumulative.

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The CSA Group recently conducted testing to develop independent data on NO_2 emissions from gas ranges. Four residential natural gas ranges, including integrated cooktops and ovens from different manufacturers, were tested using the standard test protocol for these products documented in the consensus national standard. Combustion products were sampled for nitrogen dioxide (NO_2) using the current regulatory protocol effective in the State of California.

Steady-state emissions rates for NO2 were measured for cooktops and ovens and used to calculate “air-free” NO2 emissions factors for comparison purposes. “Air-free” emission rates are rates in parts per million (ppm) in undiluted combustion products. Results demonstrated that natural gas range emissions of NO_2 during normal operation of cooktop burners and ovens were consistent with limits imposed by standards for safety for unvented heating appliances. The limit for air-free NO_2 emission rate for unvented space heaters is set at 20 ppm. No NO_2 limits are in effect for natural gas ranges under current standards. Because natural gas ranges during normal cooking operations are operated more intermittently and for shorter periods than unvented gas space heaters, and typically have lower natural gas input rates, the contribution of NO_2 to the indoor environment is even less than would be expected than for unvented space heaters.

Comparison of the CSA Group results to other notable studies requires conversion of the results from ppm measurements to mass flux emission rates, which is currently underway. Once data conversions are completed, the CSA Group results provide, for the first time, transparent data on source emission rates for NO2 for indoor air quality modeling and exposure estimates and for comparison to other studies of residential natural gas ranges.

Claim 4. There are well-documented risks to respiratory health from gas stove pollution.

<u>This claim, which appears in the RMI report executive summary, is not repeated, detailed, or supported by the information in the RMI report or the cited literature.</u>
The claim differs significantly from the similarly numbered statement in the report’s body, which reads, “The risks to respiratory health from NO_2 are well-documented.” The risks to respiratory health from NO_2 *are* well-documented. The RMI report cites several studies as evidence of the association of NO_2 exposure and specific health

risks.[8] However, the relevance of the studies cited needs to be assessed when compared with the consensus public health literature and US Environmental Protection Agency 1,148-page *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria* which considers all health and technical literature in consideration of changes to the NAAQS thresholds (which is cited). The ”criteria” document provides the US EPA’s evaluation and synthesis of the most policy-relevant science related to the health effects of gaseous oxides of nitrogen, including a detailed treatment covering asthma and specific consideration of natural gas combustion products such as NO_2.[9]

The EPA “criteria” document is developed for setting outdoor standards and presents the most detailed and systematic analysis of all health-related literature associated with airborne-emissions. The document is reviewed through the Clean Air Scientific Advisory Committee (CASAC) process supporting the National Ambient Air Quality Standards (NAAQS). The five-year revision cycle to the NAAQS requires a comprehensive EPA review of health studies and data. This review is the most exhaustive and complete public agency review of health information conducted in the US. All published health literature is reviewed and screened in accordance with a consensus on the merits of the research in justifying support of or reconsideration of outdoor air quality standards for the criteria pollutants. Since human health outcomes depend upon both outdoor and indoor exposures to criteria pollutants, indoor exposures are equally relevant to the CASAC process.

Concerning RMI’s statement that “There are well-documented risks to respiratory health from gas stove pollution,” this claim is unfounded in the consensus public health literature.

[8] Kathleen Belanger et al, “Household levels of nitrogen dioxide and pediatric asthma severity”, Epidemiology 24(2), March 2013, p. 320–330, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3686297/

Weiwei Lin, Bert Brunekreef, and 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): 1724–1737, https://doi.org/10.1093/ije/dyt150.

Ruifeng Li et al., Association of indoor nitrogen dioxide with respiratory symptoms in children: Application of measurement error correction techniques to utilize data from multiple surrogates, Journal of Exposure Science & Environmental Epidemiology 16, 2006, https://doi.org/10.1038/ sj.jes.7500468.

Devon C. Payne-Sturges et al., “Healthy Air, Healthy Brains: Advancing Air Pollution Policy to Protect Children’s Health,” American Journal of Public Health 109, 2019, https://doi.org/10.2105/ AJPH.2018.304902.

Eva Morales et al., “Association of Early-life Exposure to Household Gas Appliances and Indoor Nitrogen Dioxide with Cognition and Attention Behavior in Preschoolers,” American Journal of Epidemiology Vol. 169, No. 11, June 2009, https://doi.org/10.1093/aje/kwp067.

[9] U. S. Environmental Protection Agency, “Integrated Science Assessment for Oxides of Nitrogen – Health Criteria,” EPA/600/R-
15/068, January 2016.

While NO_2 at high concentrations is associated with "exacerbation" of asthma in asthmatic children and adults (i.e., asthma attacks), this association is only relevant for relatively high concentrations that underpin the National Ambient Air Quality Standards (NAAQS) for NO_2.

Concerning the *development* of asthma, according to the Institute of Medicine, *Clearing the Air: Asthma and Indoor Air Exposures*, natural gas combustion emissions, including those listed in the claims and others, are listed as IAQ agents for which "Inadequate or Insufficient Evidence to Determine Whether or Not an Association Exists" in causing the development of asthma.[10] The classification of asthma agents (dealing with both development or "exacerbation" of asthma, the latter pertaining to asthma attacks among individuals with pre-existing diagnosed asthma) are as follows:

1) "Sufficient Evidence of a Causal Relationship,"
2) "Sufficient Evidence of an Association,"
3) "Limited or Suggestive Evidence of an Association,"
4) "Inadequate or Insufficient Evidence to Determine Whether or Not an Association Exists,"
5) "Limited or Suggestive Evidence of No Association."

TABLE 3 Summary of Findings Regarding the Association Between Indoor Biologic and Chemical Exposures and the *Development* of Asthma

Biologic Agents	Chemical Agents
Sufficient Evidence of a Causal Relationship	
House dust mite	(no agents met this definition)
Sufficient Evidence of an Association	
(no agents met this definition)	ETS (in preschool-aged children)
Limited or Suggestive Evidence of an Association	
Cockroach (in preschool-aged children)	(no agents met this definition)
Respiratory Syncytial Virus (RSV)	
Inadequate or Insufficient Evidence to Determine Whether or Not an Association Exists	
Cat	NO_2, NO_x
Cow and horse	Pesticides
Dog	Plasticizers
Domestic birds	VOCs
Rodents	Formaldehyde
Cockroaches (except for preschool-aged children)	Fragrances
Endotoxins	ETS (in school-aged and older children, and in adults)
Fungi or molds	
Chlamydia pneumoniae	
Chlamydia trachomatis	
Mycoplasma pneumoniae	
Houseplants	
Pollen	
Limited or Suggestive Evidence of No Association	
Rhinovirus (adults)	(no agents met this definition)

Source: National Institute of Medicine, Clearing the Air: Asthma and Indoor Air Exposures (Permission for Reproduction Pending)

[10] National Institute of Medicine, Clearing the Air: Asthma and Indoor Air Exposures, Washington, DC: National Academy Press, 2000, pp. 8-11.

In the case of NO_2 from combustion sources, AGA reviewed the most recent Criteria Document, the *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria*, for any updated findings concerning an association with natural gas appliance emissions of NO_2 and health effects since the publication of "Clearing the Air." That review concludes that, while an evaluation of asthma development and exacerbation is covered in-depth and with a wealth of new studies, the *Clearing the Air* findings from 2000 are not contradicted on the basis of NO_2 emissions. While it has been nineteen years since the publication of "Clearing the Air," no new contradicting conclusions regarding the development of asthma and exposure combustion products have been adopted by the responsible public health community and through its various consensus processes. The National Institute of Medicine (now the National Academy of Medicine) has not supplemented or updated its findings over this period. Likewise, a review of health and guidance literature from the responsible public health agencies, ranging from simple agency guidance to detailed technical analysis of specific combustion product exposures and health effects, found none that contradicted the 2000 National Institute of Medicine's findings.

Claim 5. Children are particularly at risk of respiratory illnesses associated with gas stove pollution.

<u>The claim of relationship to childhood risk of asthma, the percentage risk increases cited, and the contribution of gas cooking is not justified by the cited technical literature.</u> The actual contribution of natural gas cooking emissions to IAQ was not examined in the studies considered. The claimed asthma frequencies as they relate to natural gas cooking appliances are, as a consequence, unjustified. "Exposure to a gas stove" is not exposure to emission products from combustion.

The quantitative statements of childhood asthma risk are based upon "meta-analysis" of 1,064 articles conducted by Weiwei Lin et al. (2013).[11] This work expands upon a 1992 meta-analysis covering 58 sources by Hasselblad, et al. (1992).[12]

Note that the meta-analysis study is not included in the NO_2 Criteria Document because it communicates meta-analysis results only and does not present reviewable fundamental scientific knowledge that could be used in deliberations on appropriate air quality standards or their reconsideration on new evidence. However, several of the references included in the meta-analysis are included in the EPA HERO database and thus have been included in the literature review of the NO_2 Criteria Document as reviewed through the Clean Air Scientific Advisory Committee (CASAC) process.

[11] Hasselblad, V. I., D. M. Eddy, D. J. Kotchmar, "Synthesis of Environmental Evidence: Nitrogen Dioxide Epidemiology Studies," <u>Journal of Air and Waste Management,</u> 42(5), May 1992, pp. 662-71.

[12] Weiwei Lin et al., Meta-Analysis of the Effects of Indoor Nitrogen Dioxide and Gas Cooking on Asthma and Wheeze in Children, 42 INTERNATIONAL JOURNAL OF EPIDEMIOLOGY 1724 (2013), available at https://doi.org/10.1093/ije/dyt150.

Following a review of the literature included in the Hasselblad meta-analysis, it was found that none of the citations presented sufficient causative associations that would link the use of these appliances to asthma or other respiratory illnesses. Natural gas cooking appliance emissions of NO_2 were not measured. The citations fail this test for one or more of the following reasons:

- Incremental contribution of natural gas cooking appliance emissions was not controlled relative to other sources of NO_2, chiefly involving outdoor air concentrations.

- Other known asthma or respiratory illness agents were not measured or controlled for.

- Cooking activity patterns were not included in emissions associations and concentration data, typically relating to 24-hour exposure durations and longer.

- Potential exposures of subjects, specifically kitchen exposures during cooking events, were not accounted for.

- Comparisons to electric cooking did not account for covariant factors affecting either airborne contaminants or health effects, which would have required controlling for socio-economic status, location background air quality, and other factors, including other known agents of asthma development and respiratory illness, as discussed above.

- Cooking process emissions, most notably the concentrations of fine and ultra-fine particulates known for causing respiratory distress, were not measured or otherwise included in the studies.

- Underlying health conditions (absent of the influence of cooking activities) and symptoms were not diagnosed by qualified professionals but were self-reported.

A commentary on the Lin et. al. paper, cited by RMI, notes further limitations of the meta-analysis's causative associations: "The risk estimates studies included in the meta-analysis by Lin et al. were those adjusted for asthma risk factors, but it is not described which these were, apart from smoking in the household. In any case, it is hard to disentangle the effects of strongly associated indoor factors and housing quality through traditional confounder adjustment."[13]

[13] Martine Vrijheid, "Commentary: Gas cooking and child respiratory health—time to identify the culprits?," International Journal of Epidemiology, Volume 42, Issue 6, December 2013, https://doi. org/10.1093/ije/dyt189

Claim 6. Lower-income households may be at higher risk of gas stove pollution exposure.

Socio-economic disparities can lead to disparate outcomes for energy poverty, health, and other factors. However, the cited materials do not support the claim that "lower-income households may be at higher risk of gas stove pollution exposure." The association of socio-economic factors to asthma and other respiratory illnesses and gas cooking is often missing from the cited sources. Where covered, sources lack control of science-based causes of asthma in these populations and make an error of using the "presence" of gas cooking appliances or general ambient air quality sources of contaminants as a proxy for exposure to combustion products from indoor sources. One study using a survey approach found that the use of unventilated gas cooking equipment (the "stove") as a heat source—a practice that the CPSC and other organizations specifically identify to be avoided—is associated with the increased the odds of respiratory illness. One study indicated that the presence of a gas stove and the use of a space heater or oven/stove for heat were independently associated with higher NO_2 concentrations; however, the authors note that the effects of indoor NO_2 concentrations on asthma symptoms may be misestimated because personal monitoring of exposure was not included in the study. One study set out to develop an analytical basis for understanding the role of combustion emission from gas cooking appliances; the study is too opaque to develop firm conclusions. Details on the relevant studies follow:

- The Adamkiewicz, et. al., study refers to gas stove cooking among a number of indoor and outdoor sources contributing to low-income population "exposures" to $PM_{2.5}$ and NO_2. The authors write that "indoor concentrations of airborne pollutants may be driven by the design or condition of the home's physical structure; resident behaviors; product use profiles; characteristics of household furnishings; presence, condition, and use of mechanical ventilation; air infiltration pathways (especially in multi-family settings); and outdoor pollutant concentrations." The study provides no descriptions of specific respiratory system impacts. The study uses "literature" values for source rates of pollutants to model steady-state exposure concentrations using a simplistic box model for single-family occupancies and the National Institute of Standards and Technology (NIST) CONTAM model for multi-family structures. None of the modeling or initial conditions are provided. Gas cooking appliance and smoking results are conflated in observations of particulate matter concentrations from indoor sources, while the use of gas cooking appliances for supplemental space heating—a practice that the CPSC and other organizations specifically identify should be avoided—is identified as a source of elevated NO_2 levels. Much of the study identifies additional analytical and research needs, the study itself being highly opaque in developing qualitative statements. A more detailed review of the methods used and quantitative

results is warranted before policies regarding gas cooking can be extrapolated.[14]

- The Hansel, et. al. study uses an interviewer-administered questionnaire to assess housing characteristics and potential sources of indoor NO_2 concentrations. A self-reported time-activity diary to track household activities correlated with NO_2 concentrations. Indoor-air sampling for NO_2 and $PM_{2.5}$ was conducted during a 72-hour study period. The authors note that the link between indoor NO_2 concentrations and respiratory symptoms is not corroborated with objective data on pulmonary function. Furthermore, the study did not include any personal monitoring of exposure. The study only indicates the presence of a gas stove and the use of a space heater or a stove/oven for space heating. The study does not differentiate between the use of a space heater or a stove/oven for heat—the latter being a practice that the CPSC and other organizations specifically identify to be avoided.[15]
- Breysse et. al. provides a study review of studies. Information presented related to unvented gas stoves reference the Hansel et. al. (2008) article that was previously addressed.[16]
- The Pacheco, et. al. study reviewed a broad range of asthma exacerbation factors but did not include even the presence of gas cooking appliances as a causative factor. Where gas cooking appliances were installed, simple recommendations for performing maintenance were given, but these were not associated with the asthma triggers by the investigators. No airborne emissions from combustion (from either outdoor or indoor sources) were measured or inferred.[17]

- The Zahran, et. al. study presents a detailed review of childhood asthma in 2016 but presents no information or conclusions about cooking appliances or combustion appliances operation as a “trigger” for asthma development or

[14] Gary Adamkiewicz et al., “Moving Environmental Justice Indoors: Understanding Structural Influences on Residential Exposure Patterns in Low-Income Communities,” American Journal of Public Health. 2011, https://www.ncbi.nlm.nih.gov/pubmed/21836112#.

[15]Nadia N Hansel et al., “A Longitudinal Study of Indoor Nitrogen Dioxide Levels and Respiratory Symptoms in Inner-City Children with Asthma,” Environmental Health Perspectives Volume 116 Number 10, October 2008, p. 1430, https://ehp. niehs.nih.gov/doi/10.1289/ehp.11349.

[16] Patrick N. Breysse et al., “Indoor Air Pollution and Asthma in Children,” Proceedings of the American Thoracic Society Volume 7 Issue 2, 2010, p. 104, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3266016/

[17] Christina M. Pacheco et al., “Homes of low-income minority families with asthmatic children have increased condition issues,” Allergy and Asthma Proceedings, 2014, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4210655/#!po=78.0000.

asthma attacks.[18]

- The Katz article focuses on racial disparities among the population of citizens subjected to respiratory illness and asthma exacerbation associated with particulate emissions and discussed in other articles but states no observations regarding indoor air or combustion appliances as sources.[19]

- The Hernandez and Bird article use detailed sociological and public health qualitative interview data to demonstrate that energy poverty is more pervasive, and results in a greater energy burden for low-income tenants. There are no observations regarding indoor air or combustion appliances as sources.[20]

- The Coker paper presents a review of the National Health and Nutrition Examination Survey (1988-1994) to examine an association between respiratory infections (pneumonia and cough) in children and behaviors related to the use of an unventilated gas stove for heat—a practice that the CPSC and other organizations specifically identify to be avoided. The study made no measurements of emissions or exposure estimates, and health conditions were self-reported.[21]

- The Colton et al. paper presents a comparative study of environmental sampling within conventional and "green" low-income multi-family homes. Environmental measurements were not associated with specific sources within the homes. The contributions to emission product concentrations from specific housing conditions such as the presence of a gas or electric stove were not determined and undistinguished from policies to restrict smoking, building and ventilation design, and implementation of integrated pest management.

- The Guarnieri and Balmes paper is a literature review covering a five-year period prior to publication on overall airborne contaminants associated with respiratory illness and asthma development and exacerbation, but it makes no reference to

[18] Hatice S. Zahran et al., Vital Signs: Asthma in Children – United States, 2001 – 2016, Centers for Disease Control and Prevention Morbidity and Mortality Weekly Report, February 9, 2018, http://dx.doi.org/10.15585/mmwr.mm6705e1

[19] Cheryl Katz, "People in Poor Neighborhoods Breathe More Hazardous Particles," Scientific American, November 2012, https://www. scientificamerican.com/article/people-poorneighborhoods-breate-more-hazardousparticles/

[20] Diana Hernández and Stephen Bird, Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy, Poverty Public Policy, November 2010, p. 6, https://www.ncbi.nlm.nih. gov/pubmed/27053989

[21] Eric S Coker et al., "A cross sectional analysis of behaviors related to operating gas stoves and pneumonia in US children under the age of 5," BMC Public Health, February 4 2015, https://www. ncbi.nlm.nih.gov/pubmed/25648867

indoor air quality issues in isolation from overall ambient air quality. The paper makes no observations or conclusions regarding indoor sources of contaminants of health concern, including use of unvented combustion appliances

- Wilhelm et al. examine outdoor pollution and associations with asthma. No information is presented related to cooking appliances.[22]

Claim 7. Ventilation is critical but is not the sole strategy to prevent exposure.

RMI presents several arguments that call attention to the issues of *residential cooking*, not gas cooking *per se*. If exhaust hoods are not the solution for everyone, then RMI is effectively arguing against residential cooking using cooktops and ovens, regardless of energy source.

Most residential cooking ranges, such as ovens, cooktops, and combinations, are design certified to operate without outdoor exhaust systems, add-on exhaust hoods, or requirements for exhaust. No model codes require outdoor exhaust systems for residential cooking appliances.

Most states and local jurisdictions allow the installation of unvented combustion heating appliances. Also, all dryers—not just gas dryers—are "exhausted," not "vented," to remove moisture from homes, as moisture from dryers is a major source of diminished indoor air quality. (RMI interprets the International Fuel Gas Code incorrectly; it does not cover the "venting" of stoves.)

All research on exhaust hoods is justified based upon the mitigation of cooking effluent accumulation as the principal benefit. Removal of combustion products from gas cooking appliances is incidental by comparison. The control of cooking effluent is the central purpose of a range hood. A properly-designed and installed recirculating range hood to achieve high "capture" and filtration would accomplish the principal goal of the range hood. The efficient capture of cooking effluent can be a significant shortcoming of all residential range hoods (true for exhausted to the outdoors and recirculating hoods) and has been the focus of research. Model codes and standards may be insufficient in this respect.

Claim 8. Electric cooking is a cleaner household cooking option.

A focus on electrification as a strategy to address indoor air quality would not address several emissions products and concerns, could be counterproductive in terms of reducing specific pollutants like particulate matter, and could place burdensome costs on many consumers.

[22] Michael Guarnieri and John R. Balmes, "Outdoor air pollution and asthma," Lancet, May 3 2014, p. 8, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4465283/

Studies have consistently found that emissions from the cooking process—not from the burner or heat source operation—represent the chief source of concern concerning indoor air quality. RMI's contention that electric stoves are inherently cleaner than gas stoves is based solely on claims related to potential NO2 emissions and ignores other emission products that can result from cooking with any fuel source. These products of cooking effluent are widely known and have been extensively documented for both residential and commercial cooking. As shown in literature reviews, specific pollutants may include particulates ranging down to ultrafine particulates, vapors, and particle-associated organic compounds, including polycyclic aromatic hydrocarbons (PAH) as well as heterocyclic amines, and toxic gases such as formaldehyde, acetaldehyde, and acrolein.[23]

Beyond emissions from the cooking process, a key consideration regarding indoor air quality and residential cooking is the association of emissions from the cooking of fats and oils. These emissions can include particulates, vapors, particle-associated organic compounds, as well as toxic gases. Furthermore, indoor environments can affect levels of individual exposures are also shaped by factors like the design of a building, insulation, room arrangement, outdoor infiltration, other combustion devices, and cooking methods and ingredients.[24]

Additionally, poorer heat control of electric cooktops associated with continued conductive heating from coil elements and inability to spontaneously cool these elements has been shown anecdotally to increase cooking process emissions such as greater volatilization of fats and oils and particulate generation compared to gas cooktops, where heating control is more immediate.

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[23] Abdullahi, L., Delgado S., Juana M., Harrison, R., "Emissions and Indoor Concentrations of Particulate Matter and Its Specific Chemical Components from Cooking: A Review," Atmospheric Environment, vol. 41, pp. 260-294, June 2013.

[24] Ibid.