National Carbon Monoxide Awareness Association

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Response to Draft Federal Register Notice: "Request for information on chronic hazards associated with gas ranges and proposed solutions"

Docket No. CPSC-2023-0009

May 8, 2023

U.S. Consumer Product Safety Commission
Alexander Hoehn-Saric, Chair
4330 East-West Highway
Bethesda, MD 20814

Dear Chair Hoehn-Saric,

Thank you for the opportunity to address the U.S. Consumer Product Safety Commission (CPSC) Request for Information on chronic hazards associated with **gas ranges** and proposed solutions. The National Carbon Monoxide Awareness Association (NCOAA) is a non-partisan, grassroots organization focused on eradicating carbon monoxide (CO) poisoning and helping CO poisoning survivors recover to lead happy, healthy, and productive lives. As representatives of CO survivors, we ask for your urgent attention to mitigate the CO poisoning that indoor combustion poses to households with **gas ranges** and all CO-producing consumer products.

The CPSC is an independent federal regulatory agency created in 1972 by Congress in the Consumer Product Safety Act.[1,2] In that Act, the CPSC is directed by Congress to "protect the public against unreasonable risks of injuries and deaths associated with consumer products." As such, the CPSC works to reduce the risk of injuries and deaths from consumer products by:

- developing voluntary standards with industry
- issuing and enforcing mandatory standards; banning consumer products if no standard would adequately protect the public
- obtaining the recall of products and arranging for their repair, replacement or a refund
- conducting research on potential product hazards
- informing and educating consumers through the media, state and local governments, private organizations, and by responding to consumer inquiries

The CPSC oversees thousands of consumer appliances. While fuel-burning appliances are only a portion, they present an ***exceptional and unique risk of injury and death*** due to their inherent CO production.

CO has been dubbed the 'silent killer' due to its colorless, odorless, tasteless, and non-irritating properties. It is often called the 'Great Mimicker' due to CO symptoms looking like every other illness including Alzheimer's and Parkinson's.[3] Furthermore, education on the dangers of CO

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[1] CONSUMER PRODUCT SAFETY ACT, Codified at 15 U.S.C. §§ 2051−2089; Public Law 92-573; 86 Stat. 1207, Oct. 27, 1972. https://www.cpsc.gov/s3fs-public/pdfs/blk_media_cpsa.pdf

[2] CPSC Staff, Status Report on Carbon monoxide Alarm Testing, Donald Switzer, June 2004. https://www.cpsc.gov/s3fs-public/pdfs/alarmtet.pdf

[3] The Brain Lesion Responsible for Parkinsonism After Carbon Monoxide Poisoning
Young H. Sohn, MD; Yong Jeong, MD; Hyun S. Kim, MD; et al

has been inconsistent and marked with outdated research. For example, CO alarms present CO levels to consumers through a digital display. However, the voluntary standard governing CO alarms prevents displays from showing anything but 0 until CO levels reach 30 ppm. This type of inconsistency provides consumers with a false sense of security as highlighted in a 2020 CPSC survey revealing "85% (of respondents) believed that their alarms would alert them if carbon monoxide were present.[4] No other product type or hazard presents such a formidable and overwhelming challenge for consumers when trying to protect themselves and their loved ones.

Thousands of fuel-burning and CO-releasing appliances are available to consumers including ***gas ranges,*** furnaces, hot water heaters, room heaters, wood stoves, portable generators, off-road utility vehicles (UTV), engine-driven lawn tools and power tools (EDT). These consumer products rely on the combustion of various carbon-based fuels, including coal, wood, charcoal, oil, kerosene, propane, gasoline, and natural gas. Combustion of these various fuels is always **incomplete**, producing toxic pollutants including, nitrogen oxides (NOx), particulate matter (PM), and CO. **Complete** combustion is commonly referred to as Theoretical or Stoichiometric Combustion and is the process of burning all the carbon (C) to (CO_2), all the hydrogen (H) to (H_2O) and all the sulfur (S) to (SO_2), complete combustion never occurs.[4]

Gas ranges are a unique CO-producing consumer product. All other CO-producing consumer products are required to vent combustion fumes to the outside of a building. Outdated information suggests ***gas ranges*** uniquely burn clean. However, any time fuel is burned it results in incomplete or imperfect combustion, as noted above, and all CO-producing consumer appliances pose a threat to public health due to the undue risk of CO poisoning. This is particularly true of ***gas ranges*** given the lack of required venting, lack of maintenance, lack of educational information, and lack of awareness of the dangers by consumers.

CO-producing consumer appliances can emit low-level CO that may go undetectable by CO alarms for months or years. Low-level CO is defined as amounts beneath the trigger point of CO alarms designed and manufactured to the voluntary standard UL 2034, of 70 parts per million (ppm) for no more than 4 hours. The World Health Organization recommends exposure limits far below this trigger point: 3.5 ppm for no more than 24 hours, 8.7 ppm for no more than 8 hours, and 30.5 ppm for no more than one hour. The U.S. Environmental Protection Agency recommends a CO ambient air quality standard of not more than 9 ppm. For homes where CO reaches dangerous levels, the CO detector may not sound the alarm because the level of CO may not maintain a 70 ppm average for 4 hours. According to the Consumer Product Safety Commission (CPSC), CO alarms are designed to be lifesaving devices, not long-term injury prevention devices.[5] As a result, millions of Americans are at risk for long-term debilitating diseases resulting from, or exacerbated by chronic low-level CO poisoning.

The Environmental Protection Agency (EPA) reported average levels of carbon monoxide in homes without **gas ranges** measure were between 0.5 to 5.0 parts per million (ppm); however, in homes with **gas ranges**, that number is regularly as high as 5 to 15 ppm, with poorly adjusted

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Joo H. Im, MD; Jin-Soo Kim, MD. August 2000
Arch Neurol. 2000;57(8):1214-1218. doi:10.1001/archneur.57.8.1214

[4] Consumer Product Safety Commission (CPSC) Staff's Statement on EurekaFacts Report on "SCOA Survey Findings from the Washington DC Metro Area Door-to-Door Pilot. November 18, 2020.

[5] United States Consumer Product Safety Commission. (2016). Carbon Monoxide Alarms. CPSC.Gov. https://www.cpsc.gov/Regulations-Laws--Standards/Voluntary-Standards/Carbon-Monoxide-Alarms

ranges causing levels of 30 ppm or higher.[6] There is no estimate of how many people have a poorly-adjusted range, but they will continually exceed the WHO 1-hour CO guideline (30.5 ppm) until serviced. There is little to no data on **gas range** servicing, so households may be exposed to the negative health impacts of poorly-adjusted **gas ranges** for the life of the product.

In this letter, we will discuss the chronic hazards of unvented **gas range** combustion indoors, including:

1. Dangerous levels of CO emissions associated with **gas ranges**.
2. The startling lack of properly functioning CO alarms in U.S. residences.
3. The design of CO alarms as life-safety devices; not injury-prevention devices.
4. The impact of chronic, low-level CO poisoning on health.

BACKGROUND

Carbon monoxide (CO) is a colorless, odorless, and tasteless non-irritating gas that is imperceptible to human senses. CO poisoning is a leading cause of poisoning in the United States (US) and accounts for more than 20,000 emergency room (ER) visits annually.[7] The annual number of 400 deaths from CO poisoning in the US is likely significantly higher than estimated due to the imperceptible nature of CO, the wide array of CO poisoning symptoms, and a lack of robust diagnostic tools. Health effects of CO poisoning range from mild symptoms such as fatigue, dizziness, headache, confusion, and nausea to more severe symptoms such as disorientation, unconsciousness, long-term neurological disabilities, coma, cardiorespiratory failure, and death.[8] CO exposure is commonly underdiagnosed or misdiagnosed due to the nonspecific nature of the clinical effects.[9] Moreover, CO poisoning disproportionately affects marginalized communities, particularly those who are socially and economically disadvantaged.[10] As such, mitigating further CO poisoning is critical to creating a healthier and more equitable nation.

Historical Background on CO Alarms

In 1994, Chicago became one of the first cities in the US to adopt an ordinance requiring the installation of CO alarms in new and existing single-family homes that had oil or gas furnaces. This ordinance was passed on October 1, 1994. In the months that followed the installation of CO alarms across Chicago, Chicago fire departments experienced a large volume of calls related to CO alarms. Specifically, between October 1 and December 31, 1994, Chicago fire departments reported that they responded to approximately 8,600 CO alarm calls. As described further below, a number of different factors likely contributed to elevated CO levels in Chicago homes and the subsequent CO alarm activations during the winter of 1994. However, in the subsequent news coverage of this event (dubbed the "Night of Sirens"), many headlines referred to the thousands of alarms as “nuisance alarms” or “false alarms”, and, as a result, many citizens and first responders began to ignore CO alarm activations altogether.

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[6] US Environmental Protection Agency. (2022). Carbon Monoxide’s Impact on Indoor Air Quality. https://www.epa.gov/indoor-air-quality-iaq/carbon-monoxides-impact-indoor-air-quality

[7] United States Centers for Disease Control and Prevention. (2018). Carbon Monoxide Poisoning—Frequently Asked Questions. https://www.cdc.gov/co/faqs.htm

[8] United States Environmental Protection Agency, O. (2019). What is carbon monoxide? [Overviews and Factsheets]. US EPA.https://www.epa.gov/indoor-air-quality-iaq/what-carbon-monoxide-0

[9] Harper, A., & Croft-Baker, J. (2004). Carbon monoxide poisoning: Undetected by both patients and their doctors. Age and Ageing, 33(2). https://doi.org/10.1093/ageing/afh038

[10] National Energy Action. (2017). NEA: Understanding Carbon Monoxide Risk in Households Vulnerable to Fuel Poverty.
https://www.nea.org.uk/publications/understanding-carbon-monoxide-rise-in-households-vulnerable-to-fuelpoverty/

But, were these alarm activations truly “false alarms”? Were Chicago first responders and HVAC professionals adequately equipped with the necessary CO detection equipment and training to accurately detect and measure CO when responding to a CO alarm? Did the rapid evolution of CO detection technology negatively impact the reliability of CO alarms? Were thousands of Chicago residents actually exposed to dangerous levels of CO in their homes?

To collect data relevant to these and other questions, the CPSC organized a public hearing on February 21, 1996.[11] As part of this hearing, the CPSC solicited scientific, medical, and technical information from all interested parties related to the health effects of CO, the 1994 Chicago CO alarm activations, indoor and outdoor CO levels, CO alarm standards, consumers' ability to differentiate between warning signals and urgent alarms, and the needs of individuals responding to CO alarm activations. Speakers at the public hearing included nonprofit organizations, science and medical professionals, firefighters, government officials and representatives from the gas utility industry. The majority of speakers at the public hearing agreed that low-level CO exposure is a concern, particularly among susceptible populations (including pregnant women, children, individuals with preexisting health conditions, and the elderly).

Speakers at the public hearing also raised concerns related to CO alarm accuracy, repeatability, life expectancy, humidity interference, and multiple gas interference. Several speakers believed changes made to the voluntary standards in 1995 would address these concerns.

Expert testimony further argued that the Chicago 1994 alarm activations were not actually “false alarms”, but instead reflected accurate CO detection, and were likely incorrectly labeled as “false alarms” due to inadequate CO safety equipment and training for first responders to appropriately investigate CO leaks. Other factors contributing to the large number of CO activations were also discussed at the hearing, including incorrect placement of CO alarms, lack of public education, and a rare temperature inversion, which trapped pollutants (including CO) close to the ground. Moreover, despite news outlets claiming that first responders were overwhelmed by the thousands of CO alarm calls in 1994, this claim was refuted at the public hearing, with speakers indicating that the Chicago fire department had adequate resources to respond to the CO alarm activations.

Despite widespread support of low-level alarms at the public hearing and testimony from medical experts stressing the dangers of low-level CO, the CO alarm limit was increased in 1998 to a 100 ppm ceiling and then later lowered to 70 ppm. At 70 ppm, the CPSC considers CO alarms life-safety, not injury-prevention devices.

Consequently, 30 years after the events in Chicago and the CPSC public hearing, CO alarm standards in the US leave our most vulnerable citizens unaware of the dangers of low-level CO in their homes and at risk for low-level CO poisoning; first responders and HVAC professionals still do not have adequate CO detection equipment and training to accurately and consistently detect CO in homes, and home CO alarm technology is outdated and confusing to both homeowners and first responders alike.

[11] United States Consumer Product Safety Commission (1996, February 21). Carbon Monoxide Detector Hearing. https://static1.squarespace.com/static/56e787dfb09f95498f2e6b60/t/604811dab081e82e2b153ce5/1615335899614/FOIA+CO+-Detector+Transcripts.pdf

CO Levels in Homes with ***Gas Ranges***
Households that cook with ***gas ranges*** have higher concentrations of carbon monoxide (CO) than homes that cook on electric ranges. The Environmental Protection Agency (EPA) reported average levels of carbon monoxide in homes without **gas ranges** measured between 0.5 to 5.0 parts per million (ppm); while in homes with **gas ranges**, CO concentrations are regularly as high as 5 to 15 ppm. Homes with poorly adjusted ranges have been found to cause CO levels of 30 ppm or higher. These estimates exceed the WHO 8-hour (8.7 ppm) and 24-hour (3.5 ppm) CO air quality guideline and the EPA 8-hour CO ambient air quality standard (9 ppm). The World Health Organization states that exposure to carbon monoxide should not be higher than 3.5 ppm over a period of 24 hours.[12] There is no estimate of how many people have a poorly adjusted range, but they could be regularly exceeding the WHO 1-hour CO guideline (30.5 ppm). The health impacts of CO on households with **gas ranges** remain largely invisible.
Importance of Ventilation in Homes with ***Gas Ranges***

The use of a ventilation hood, when vented to the outside, reduces concentrations of CO emitted during the cooking process. However, ventilation will not completely mitigate CO exposure. Ventilation works best when the hood is directly over that burner but building regulations have not always required **gas range** ventilation and that requirement varies by state. It is unknown how many households have external ventilation over **gas ranges**. as they are not required to be vented to the outdoors. If a household has a ventilation hood and it vents to the outside also requires a user to turn them on to initiate ventilation, which people do not do regularly. In the U.S. around 38% of homes cook on a **gas range** yet, For those people who do have adequate ventilation, surveys have found that people do not regularly use it, which leaves many households exposed to unhealthy concentrations of CO when they cook.

Importance of Properly Functioning CO Alarms in Homes with ***Gas Ranges***
Because incomplete combustion of fuel, including natural gas and propane, produces CO, alarms are an essential protective device in any home with a combustion appliance. CO alarms are only required in homes in 27 U.S. states, and only an estimated 14% of homes in the U.S. have a properly functioning CO alarm. This leaves many households with **gas ranges** unprotected because they won't know if their **gas range** is emitting unhealthy or unsafe levels of CO.

Health Effects of Acute CO Poisoning
The exact symptoms of CO poisoning can vary widely and depend on the concentration and duration of CO exposure and the preexisting health status of each individual. Mild CO exposure typically causes dizziness, nausea, headache, chest pain, confusion, shortness of breath, and fatigue.[7,8] Due to the similarity between these symptoms and viral illnesses such as the seasonal flu, mild CO poisoning is often undetected and/or misdiagnosed.[9]

With increasing concentrations or duration of CO exposure, individuals may begin to experience shortness of breath, chest pain, syncope (fainting), tachypnea (rapid breathing), and tachycardia (rapid heart rate). Severe CO poisoning is life-threatening and can lead to reduced blood flow to the heart, irregular heartbeat, dangerously low blood pressure, heart attack, difficulty breathing or inability to breathe, seizures, unconsciousness, coma, and death.[7,8]

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[12] Penney, D., Benignus, V., Kephalopoulos, S., Kotzias, D., Kleinman, M., and Verrier, A. (2010). Carbon Monoxide. In: WHO Guidelines for Indoor Air Quality: Selected Pollutants, 55-102. World Health Organization. https://www.ncbi.nlm.nih.gov/books/NBK138710/#

Another well-documented, yet poorly understood long-term health effect of CO poisoning is delayed encephalopathy (brain disease) or delayed neuropsychological sequelae (DNS). DNS is the sudden appearance of neuropsychological abnormalities weeks to months after a period of recovery from initial CO symptoms. The typical features of DNS may include amnesia, fecal/urinary incontinence, gait and/or speech disturbances, anxiety, depression, and Parkinsonism.[13,14] The overall likelihood of developing DNS after CO poisoning could be as high as 40%. Of those that develop DNS, 25% of all cases are permanent.[15,16] Long-term health issues like DNS create significant socioeconomic consequences for those affected by CO poisoning, their families, and their communities.

Health Effects of Low-Level, Chronic CO Poisoning

While the dangers of acute CO exposure have been known for centuries, it has more recently become apparent that chronic low-level CO exposure is also a major public health concern. Chronic low-level CO exposure has been linked to heart failure, stroke, cognitive and memory impairments, sensory-motor deficits, emotional changes, congenital defects, and low birth weight, among others. For a detailed list of studies that examine the health effects of chronic CO exposure see NCOAA's white paper, "An Urgent Call to Action to Lower the Alarm Set-Point of Carbon Monoxide Alarms," available for free at www.ncoaa.us.

Costs to Society of CO Poisoning

According to Hampson (2017): "Societal costs for accidental, non-fire, residential CO poisoning are approximately $3.47 billion annually, about 10% of them stemming from gas stoves. With an estimated cost of $348 million annually for alarms, prevention of greater than 10% of residential CO poisoning costs must be achieved in order for alarms to be cost-effective."[17]

Prevention and Proactive Risk Reduction Regarding CO: A Framework For CPSC Action

When managing significant risk it is always best to be proactive and preventative. As evidenced above, CO exposure from ***gas ranges*** can exceed WHO and EPA recommended limits and cause harm to consumers. The United Kingdom has recently implemented the following pragmatic solutions to improve CO safety and other countries are in the process of adopting similar guidelines. We recommend a similar approach be adopted by the CPSC.

1. Create a national hotline to respond to consumer inquiries with consistent and up-to-date information on CO safety.
2. Implement a mandatory standard to add CO shutoffs to new fuel-burning appliances and add retrofit shutoffs to existing ones.

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[13] Oh, S., & Choi, S.-C. (2015). Acute carbon monoxide poisoning and delayed neurological sequelae: A potential neuroprotection bundle therapy. Neural Regeneration Research, 10(1), 36–38. https://doi.org/10.4103/1673-5374.150644

[14] Sönmez, B. M., İşcanlı, M. D., Parlak, S., Doğan, Y., Ulubay, H. G., & Temel, E. (2018). Delayed neurologic sequelae of carbon monoxide intoxication. Turkish Journal of Emergency Medicine, 18(4), 167–169. https://doi.org/10.1016/j.tjem.2018.04.002

[15] Pepe, G., Castelli, M., Nazerian, P., Vanni, S., Del Panta, M., Gambassi, F., Botti, P., Missanelli, A., & Grifoni, S. (2011). Delayed neuropsychological sequelae after carbon monoxide poisoning: Predictive risk factors in the Emergency Department. A retrospective study. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 19(1), 16. https://doi.org/10.1186/1757-7241-19-16

[16] Kim, H., Choi, S., Park, E., Yoon, E., Min, Y., & Lampotang, S. (2018). Serum markers and development of delayed neuropsychological sequelae after acute carbon monoxide poisoning: Anion gap, lactate, osmolarity, S100B protein, and interleukin-6. Clinical and Experimental Emergency Medicine, 5(3), 185–191. https://doi.org/10.15441/ceem.17.217

[17] Hampson, N.B. (2017). Cost effectiveness of residential carbon monoxide alarms. UHM, 44(5), 393-397.

3. Revise CO alarm standards to align with current health guidelines, require accurate digital displays of the ambient CO levels in a home, and improve the user interface.
4. Conduct a nationwide prevalence study to determine the frequency and severity of CO poisoning in the United States.
5. Facilitate research in CO poisoning diagnostics and treatment.
6. Provide training and detection equipment for emergency responders.
7. Mandate certification of anyone working on or installing fuel-burning appliances.
8. Require CO testing anytime a fuel-burning appliance is installed or maintenance is conducted and a checklist documenting CO levels is provided to the owner and tenant.
9. Encourage maintenance and certification to be performed annually as per manufacturers' instructions.
10. Advocate for CO diagnostic testing as a regular part of prenatal care, when presenting with CO poisoning symptoms, and after a CO incident.

These proven solutions provide an efficient and cost-effective framework for mitigating CO poisoning. Thus, we petition the CPSC to employ a similar methodology to protect Americans from unreasonable risks of injuries and deaths associated with fuel-burning consumer products.

In informal conversations with manufacturers, we have come to learn that adding a CO safety shut-off on a newly manufactured fuel-burning appliance would add around $5-$7 per unit to the manufacturing cost. This is an affordable solution. It is also feasible and likely cost-effective to retrofit existing appliances with CO safety shut-offs.

We cannot change the past 30 years of injury and death, but we ***can*** act now to save lives. Failure to do so will result in the loss of life and livelihood. In addition to a raised consciousness of this issue, there is currently unprecedented collaboration across many sectors to come together to improve CO safety measures, as evidenced in the Working Groups that are studying indoor air pollution from **gas ranges**. Changing product standards, such as adding a requirement for CO safety shut-offs on all fuel-burning appliances, will save far more lives than any education or awareness campaign targeted toward the public. It is more effective to stop CO exposure at the source than to educate consumers on how to protect themselves from a faulty appliance.

Sincerely,

The National Carbon Monoxide Awareness Association

RESPONSES TO SELECT QUESTIONS:

Question 1: Please provide information related to the scope and scale of potential chronic chemical hazards, exposures, and risks associated with gas range use.

1b. Please provide information on related (non-cookware) products used in conjunction with gas ranges and their frequency of use. Examples of related products of interest are range hoods (in general), CO alarms, smoke alarms, chemical sensors other than CO, portable air filters, etc.

Because incomplete combustion of fuel, including natural gas and propane, consistently produces CO, alarms are an essential protective device in any home with a combustion appliance, especially **gas ranges**, which are not required to be vented to the outdoors and also require a user to turn them on to initiate ventilation, which people do not do regularly. In the U.S. around 38% of homes cook on a **gas range**,[18] yet, CO alarms are only required in homes in 27 U.S. states,[19] and only an estimated 14% of homes in the U.S. have a properly functioning CO alarm.[20, 21, 22] This leaves many households with **gas ranges** unprotected because they won't know if their **gas range** is emitting unhealthy or unsafe levels of CO, as seen with the recent CPSC recall of high-end Z-Line **gas ranges**.This is just one example of many that can be found at www.cpsc.gov/recalls.

1d. Please provide information on the frequency of occurrence of reported gas leaks associated with gas range defects or related equipment or installation defects

According to the Census Bureau's American Housing Survey (2019), 42.8% of homes use natural gas for home heating, 4.7% use propane, and 4.8% use fuel oil, and 2.8% use some other type of fuel, such as coal or wood.[23] The same study found that 33% of homes use natural gas to fuel their cooking equipment, though that number can be as high as 55.7% in homes built between 1920 and 1929. In California, as many as 68% of homes use gas-powered cooking.[24] They also reported that in homes built between 2000 and 2009, 28.9% used natural gas for cooking appliances. Combined, about 58%

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[18] https://www.eia.gov/todayinenergy/detail.php?id=53439

[19] National Conference of State Legislators. (2018). Carbon monoxide detector requirements, laws and regulations. http://www.ncsl.org/environment-and-natural-resources/carbon-monoxide-detector-requirements-laws-and-regulations

[20] Ryan, T. J., & Arnold, K. J. (2011). Residential carbon monoxide detector failure rates in the United States. American journal of public health, 101(10), e15-e17. https://doi.org/10.2105/AJPH.2011.300274

[21] This study reports that approximately 38 million homes in the US have CO detectors installed; and, among the 30 home CO detectors tested, 57% failed to alarm as intended. To calculate the percent of US homes with functioning CO detectors, we divided the number of home CO detectors installed in the US in 2011 (38 million) by the US census statistic for the number of homes in the US in 2011 (118.68 million) and multiplied this by the proportion of homes with functioning CO detectors according to Ryan & Arnold, 2011 (43%). This calculation reveals that 14% of homes in the US have functioning CO detectors (as of 2011)

[22] A more recent pilot study (conducted in 2020) in Washington, DC by Eurekafacts on behalf of the CPSC found that 67% of homes in Washington, DC had a properly functioning CO alarm. However, given the study's small sample size and restricted geographic location, this statistic may not be representative of the entire US.

[23] Engelberg, J. & Brassel, E. (2019). Differences in Fuel Usage in the United States Housing Stock: American Housing Survey. US Census Bureau. /www.census.gov/programs-surveys/ahs/research/publications/h150-19.html

[24] American Housing Survey U.S. Census Bureau. 2019. https://www.census.gov/programs-surveys/ahs.html

of homes in the US use either gas-powered heating or cooking appliances.[25] Home heating represents the source of exposure in 71% of consumer product-related, accidental, non-fire deaths contributed to carbon monoxide; while **gas ranges** and other appliances account for about 10% of these deaths.[26] From 2012-2016, fire departments responded to about 125,000 gas leak calls per year, though the source of the leak is not identified in the data.[27]

One study found that 51% of kitchen ranges "raised CO concentrations in the room above the EPA 8-hour standard of 9 ppm. Five percent had dangerously high CO levels: above 200 ppm."[28] Sustained concentrations of CO above 150 to 200 ppm can lead to disorientation, unconsciousness, and death.[29] Logue, et al (2014) estimate that 9% of households that use natural gas cooking burners are routinely exposed to carbon monoxide levels that "exceed the acute health-based standards and guidelines" of 35 ppm over one hour or 9 ppm over eight hours.[30]

*Households with **gas ranges** regularly exceed health-based guidelines for CO*
The Environmental Protection Agency (EPA) reported average levels of carbon monoxide in homes without **gas ranges** measure were between 0.5 to 5.0 parts per million (ppm); however, in homes with **gas ranges**, that number is regularly as high as 5 to 15 ppm, with poorly adjusted ranges causing levels of 30 ppm or higher.[31] These estimates exceed the WHO 8-hour (8.7 ppm) and 24-hour (3.5 ppm) CO air quality guideline and the EPA 8-hour CO ambient air quality standard (9 ppm). The World Health Organization states that exposure to carbon monoxide should not be higher than 3.5 ppm over a period of 24 hours.[11] There is no estimate of how many people have a poorly adjusted range, but they could be regularly exceeding the WHO 1-hour CO guideline (30.5 ppm). The health impacts of CO on households with **gas ranges** remain largely invisible.

Health Disparities and Vulnerable Populations
CO poisoning does not affect all groups of people equally. Disparities are seen due to gender, race, ethnicity, age, and socioeconomic status. Black and Latino communities

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[25] US Energy Information Administration. (2021). Use of energy explained: Energy in homes. https://www.eia.gov/energyexplained/use-of-energy/homes.php
[26] Kao, L.W., & Nañagas, K.A. (2004). Carbon Monoxide Poisoning. Emergency Medicine Clinics, 22(4): P985-1018.
[27] Ahrens, M., & Evarts, B. (2018). NFPA. Natural Gas and Propane Fires, Explosions, and Leaks Estimates and Incident Descriptions. https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Hazardous-materials/osNaturalGasPropaneFires.ashx
[28] Greiner, T.H. (N.D.). Carbon Monoxide Poisoning: Gas-fired Kitchen Ranges (AEN-205). Iowa State University Department of Agricultural and Biosystems Engineering. https://www.abe.iastate.edu/extension-and-outreach/carbon-monoxide-poisoning-gas-fired-kitchen-ranges-aen-205/
[29] "Carbon Monoxide Questions and Answers," Consumer Product Safety Commission, accessed April 5, 2020, https://www.cpsc.gov/ Safety-Education/Safety-Education-Centers/ Carbon-Monoxide-Information-Center/Carbon-Monoxide-Questions-and-Answers.
[30] Logue JM, Klepeis NE, Lobscheid AB, Singer BC.(2014). Pollutant exposures from natural gas cooking burners: a simulation-based assessment for Southern California. Environ Health Perspect.122(1):43-50.
[31] US Environmental Protection Agency. (2022). Carbon Monoxide's Impact on Indoor Air Quality. https://www.epa.gov/indoor-air-quality-iaq/carbon-monoxides-impact-indoor-air-quality

are disproportionately affected by both injuries and deaths due to carbon monoxide poisoning.[32]

A recent example of racial disparities in carbon monoxide poisoning is the 2021 winter storms in Texas. Black, Hispanic, and Asian people accounted for 72% of the poisonings, despite making up only 57% of the population.[33] "Being Black or African American was associated with 1.7x higher odds of experiencing an outage for at least 24 consecutive hours compared to White or Caucasian households."[34] Exacerbating this problem was that more than 1 in 4 (26%) Texans used gas-powered ovens or cooktops to heat their homes due to power outages from this storm.[35] It should be noted that the state of Texas has no legislation requiring carbon monoxide alarms to be placed in homes.

1e. Please provide details on chronic chemical hazards associated with gas range use. Specify the nature of the chronic chemical hazard, the brand of gas range (if available), and additional context for settings and conditions related to exposures if available.

Gas ranges emit carbon monoxide due to incomplete combustion of fuel. Carbon monoxide negatively affects human health from acute and chronic exposure. Carbon monoxide kills hundreds of Americans a year and injures a hundred thousand more. Chronic low-level CO exposure has been linked to heart failure, stroke, cognitive and memory impairments, sensory-motor deficits, emotional changes, congenital defects, and low birth weight, among others. In 2021, the WHO set the limit for carbon monoxide levels to 3.5 parts per million (ppm) over 24 hours based on the following scientific evidence: epidemiological studies which demonstrate an association between low-level chronic CO exposure and cardiovascular morbidity (i.e., heart attack, congestive heart failure, and ischemic heart disease); laboratory dose-response studies which demonstrate an acute exposure-related reduction in exercise tolerance and increased symptoms related to heart disease; and retrospective and case studies describing instances of long-term CO poisoning resulting in a multitude of negative physical, emotional, and cognitive health effects.

[32] Sircar K, Clower J, Shin MK, Bailey C, King M, Yip F. Carbon monoxide poisoning deaths in the United States, 1999 to 2012. Am J Emerg Med. 2015;33(9):1140-1145. doi:10.1016/j.ajem.2015.05.002

[33] https://www.texastribune.org/2021/04/29/texas-carbon-monoxide-poisoning/#:~:text=Black%2C%20Hispanic%20and%20Asian%20Texans,share%20of%20the%20state's%20population.

[34] Flores, N.M., McBrien, H., Do, V. et al. (2023). The 2021 Texas Power Crisis: distribution, duration, and disparities. J Expo Sci Environ Epidemiol 33, 21–31.

[35] University of Houston: Hobby School of Public Affairs. (N.D.). The Winter Storm of 2021. https://uh.edu/hobby/winter2021/storm.pdf.

In the following table, summaries of study results discussed in literature reviews of carbon monoxide poisoning are presented.

Table 1: Studies on chronic conditions from carbon monoxide poisoning

Barnett, et al. (2006)[36]	
Pollution data was taken over three years (1998-2001) in 7 cities in Australia and New Zealand and analyzed against daily hospital records with a time-stratified case-crossover method. Particulate matter, ozone, nitrogen dioxide, and carbon monoxide were measured. Multi-pollutant models were conducted when health outcomes were associated with more than one pollutant.	Significant associations were found for CO exposure in elderly people and five categories of cardiovascular disease admissions. Cardiac failure admissions rose 6.0% for an increase of 0.9 ppm in 8-hour CO concentration, and total cardiovascular admissions rose 2.2% for this same increase in CO.
Bell, et al. (2009)[37]	
Hospital admissions for Medicare enrollees at least 65 years old were analyzed against EPA air pollution data from 1999 through 2005. 126 counties in the US were included, accounting for 9.3 million people on average. The risk of cardiovascular admissions due to daily CO concentrations was assessed with a log-linear overdispersed Poisson time-series model.	An increase of 1 ppm in the maximum 1-hour CO concentration was found to have a 0.55% increased risk of cardiovascular admission when adjusting for nitrogen dioxide concentrations and a 0.92% increased risk in a single-pollutant analysis.
Burnett, et al. (1997)[38]	
Hospital records between April 1981 and December 1991 from Canada's 10 largest cities were collected to analyze congestive heart failure admissions for people over 65 years old. The study population was 12.6 million people. Temperature, coefficient of haze, dew point, and carbon monoxide data were acquired for this same period from the National Air Pollution Surveillance Database. A random effects relative risk regression model was conducted.	The relative risk for congestive heart failure in the elderly, based on a 1-3 ppm increase in the daily maximum 1-hour average CO concentration of each city, ranged from 1.01 to 1.23. With multi-pollutant models, these risks ranged from 0.99 to 1.22, with the values for three cities below 1.00.

[36] Barnett, A. G., Williams, G. M., Schwartz, J. S., Best, T. L., Neller, A. H., Petroeschevsky, A. L., and Simpson, R. W. (2006). The Effects of Air Pollution on Hospitalizations for Cardiovascular Disease in Elderly People in Australian and New Zealand Cities. Environmental Health Perspectives, 114(7), 1018-1023. https://doi.org/10.1289/ehp.8674
[37] Bell, M. L., Peng, R. D., Dominici, F., and Samet, J. M. (2009). Emergency Hospital Admissions for Cardiovascular Diseases and Ambient Levels of Carbon Monoxide. Circulation, 120(11), 949-955. https://doi.org/10.1161/CIRCULATIONAHA.109.851113
[38] Burnett, R. T., Dales, R. E., Brook, J. R., Raizenne, M. E., and Krewski, D. (1997). Association between Ambient Carbon Monoxide Levels and Hospitalizations for Congestive Heart Failure in the Elderly in 10 Canadian Cities. Epidemiology, 8(2), 162-167. https://doi.org/10.1097/00001648-199703000-00011

Table 1, Continued

Morris, et al. (1995)[39]	
Seven U.S. cities were chosen for the study due to their large populations and varying climate and pollution patterns. Medicare data from these cities and environmental pollution data from the EPA were used to assess potential pollution effects on congestive heart failure. The period studied was 1986 through 1989. Attributable risk for cardiac failure admissions was determined by the difference in cases and the predicted number for each day, which had been derived from the lowess smoothing algorithm with adjustments for prevailing conditions.	The relative risk of hospital admission for congestive heart failure associated with an increase of 10 ppm in the daily maximum 1-hour CO level ranged from 1.10 (New York) to 1.37 (Los Angeles).
Kaya, et al. (2016)[40]	
A cross-sectional cohort study was conducted on 1013 emergency department patients seen for carbon monoxide poisoning between 2005 and 2007. Their outcomes were followed for 56 months on average. Diagnosis of CO poisoning was determined by a COHb level over 5%.	Ten percent of the patients experienced acute myocardial infarction, representing a group with a higher average COHb reading than those without AMI development.
Hong, et al. (2002)[41]	
Deaths due to stroke in the Seoul, South Korea area between 1995 and 1998 were assessed against data from 20 air quality monitoring stations. Relative humidity, 24-hr average temperature, barometric pressure, and pollutant measurements were taken. A generalized additive model was employed, along with a stepwise regression procedure, to determine the span for smoothing functions.	An increased risk of 2.2% for stroke mortality was found for a single pollutant model for each IQR of carbon monoxide with a 2-day lag.

[39] Morris, R. D., Naumova, E. N., and Munasinghe R. L. (1995). Ambient Air Pollution and Hospitalization for Congestive Heart Failure among Elderly People in Seven Large US Cities. American Journal of Public Health, 85(10), 1361-1365. https://doi.org/10.2105/ajph.85.10.1361

[40] Kaya, H., Coşkun, A., Beton, O., Zorlu, A., Kurt, R., Yucel, H., Gunes, H., and Yilmaz, M. B. (2016). COHgb levels predict the long-term development of acute myocardial infarction in CO poisoning. The American Journal of Emergency Medicine, 34(5), 840-844. https://doi.org/10.1016/j.ajem.2016.01.036

[41] Hong, Y.-C., Lee, J.-T., Kim, H., Ha, E.-H., Schwartz, J., and Christiani, D. C. (2002). Effects of Air Pollutants on Acute Stroke Mortality. Environmental Health Perspectives, 110(2), 187-191. https://doi.org/10.1289/ehp.02110187

Table 1, Continued

Ely, et al. (1995)[42]	
Workers who developed warehouse workers' headaches were studied for short and long-term effects, which were assessed after 2 years.	Higher expired CO levels were associated with an increased risk of acute difficulty concentrating, confusion, and higher chronic symptom scores. Symptoms seen after two years included numbness in the extremities, persistent headaches, confusion, difficulty in walking or moving the extremities, and memory loss.
Chambers, et al. (2008)[43]	
A prospective cohort study followed 256 patients, divided into less severe and more severe CO poisoning categories. Less severe poisoning was defined by a COHb less than or equal to 15%. Symptoms were assessed at 6 weeks, 6 months, and 12 months.	Of the less severe group, at 6 weeks, 39% had cognitive sequelae, 21% had depression, and 30% had anxiety. Of the more severe group, at 6 weeks, 35% had cognitive sequelae, 16% had depression, and 11% had anxiety. Significant differences were seen between the two groups with anxiety at 6 weeks and depression at 6 months, with the less severe group showing the higher prevalence of both symptoms.
Maisonet, et al. (2001)[44]	
Term low birth weight was studied in the period from 1994 to 1996 in 6 Northeastern US cities with populations greater than 100,000. Environmental carbon monoxide exposure during the period of first, second, and third trimesters was gathered from EPA pollution data, which included CO data from at least two monitors for each city. Covariate data from the NCHS was used, and variables that showed an effect of more than 10% were kept in the model. The number of infants which fit the criteria for the study was 89,557.	The adjusted odds ratio for low-weight birth due to an increase of 1 ppm in the daily average of CO during the third trimester was 1.31. With CO fitted as a continuous variable, the first trimester adjusted odds ratio was 1.43, and the third trimester adjusted odds ratio was 1.75, for each 1 ppm increase of carbon monoxide.

[42] Ely, E. W., Moorehead, B., and Haponik, E. F. (1995). Warehouse workers' headache: emergency evaluation and management of 30 patients with carbon monoxide poisoning. The American Journal of Medicine, 98(2), 145-155. https://doi.org/10.1016/S0002-9343(99)80398-2

[43] Chambers, C. A., Hopkins, R. O., Weaver, L. K., and Key, C. (2008). Cognitive and affective outcomes of more severe compared to less severe carbon monoxide poisoning. Brain Injury, 22(5), 387-395. https://doi.org/10.1080/02699050802008075

[44] Maisonet, M., Bush, T. J., Correa, A., and Jaakkola, J. J. (2001). Relation between Ambient Air Pollution and Low Birth Weight in the Northeastern United States. Environmental Health Perspectives, 109(3), 351-356. https://doi.org/10.1289/ehp.01109s3351

Table 1, Continued

Ritz, et al. (1999)[45]	
The effect of carbon monoxide exposure during the third trimester on low birth weight rates in Los Angeles was studied from 1989 to 1993. The 125,573 infants included were singletons born at term to mothers who lived within 2 miles of SCAQMD air monitoring sites. Logistic regression analyses were employed with adjustments for variables such as gestational age, maternal age, access to prenatal care, parity, and infant sex. Stratified analyses were conducted for maternal age, race, education, and infant sex.	The odds ratio for low birth weight was 1.22 for an average exposure of CO greater than 5.5 ppm in the third trimester. This risk increased in multi-pollutant models to 1.38.

In the following table, summaries of the results of studies discussed in literature reviews of carbon monoxide poisoning are presented.

Table 2: Literature reviews on carbon monoxide poisoning chronic symptoms

Review	Summary of presented study results
Townsend, et al. (2002)[46]	Associated effects of low-level chronic CO exposure: heart failure in the elderly, low birth weight Long-term effects of CO poisoning in case studies: long-term exposure to 180 ppm produced symptoms of depression, anxiety, headaches, and dizziness continuing after exposure ended; chronic, subacute poisoning of seven subjects led to symptoms including changes in memory, sleep, vision, and anxiety, psychomotor dysfunction, and balance problems even after source was removed
Wright (2002)[47]	Carbon monoxide exposure found to have associations with cardiovascular and respiratory conditions, such as myocardial infarction, increased severity of pre-existing cardiac disease, increased duration of angina, and reduction in walking distance in severe bronchitis and emphysema patients

[45] Ritz, B. and Yu, F. (1999). The Effect of Ambient Carbon Monoxide on Low Birth Weight among Children Born in Southern California between 1989 and 1993. Environmental Health Perspectives, 107(1), 17-25. https://doi.org/10.1289/ehp.9910717
[46] Townsend, C. L. and Maynard, R. L. (2002). Effects on health of prolonged exposure to low concentrations of carbon monoxide. Occupational and Environmental Medicine, 59(10), 708-711. http://dx.doi.org/10.1136/oem.59.10.708
[47] Wright, J. (2002). Chronic and occult carbon monoxide poisoning: we don't know what we're missing. Emergency Medicine Journal, 19(5), 386-390. http://dx.doi.org/10.1136/emj.19.5.386

Table 2, Continued

Rose, et al. (2017)[48]	Studies have shown A 19% incidence of cognitive deficits and 37% incidence of neurologic deficits 6 years after CO poisoning. Neurologic deficits that do not resolve are seen in cases of low-level chronic exposure. Delayed post-hypoxic leukoencephalopathy has been seen in cases of CO poisoning
Penney, et al. (2010)[49]	Chronic CO exposure effects: Hearing deficits were found in 78.3% of patients with chronic CO poisoning in one study, compared to 26.7% exhibiting hearing deficits without CO poisoning. These deficits lasted after exposure ended and improvements were only seen in 26.7% of the cases after follow-up. CO poisoning effects in children: Studies show relationships between carbon monoxide and asthma consultation, hospital admissions due to asthma, and asthma symptoms in children. One study found a 6-8% increased risk of bronchiolitis in children due to air pollutants, with carbon monoxide as the largest risk factor. Cardiovascular: Multiple studies have found links between hospital admissions for cardiovascular disease and environmental carbon monoxide exposure. Two studies show that exposure to carbon monoxide increases the incidence of low birth weight. Epidemiological studies of low-level CO among large groups: increased incidences of low birth weight, congenital defects, infant and adult mortality, cardiovascular admissions, congestive heart failure, stroke, asthma, tuberculosis, pneumonia, etc.

1f. Please provide any additional information not requested above related to the scale and scope of potential chronic chemical hazards associated with gas range use.

The cost to society due to carbon monoxide poisoning is a staggering $3.47 billion, attributable to medical care, the value of pain and suffering, the value of statistical life,

[48] Rose, J. J., Wang. L., Xu, Q., McTiernan, C. F., Shiva, S., Tejero, J., and Gladwin, M. T. (2017). Carbon Monoxide Poisoning: Pathogenesis, Management, and Future Directions of Therapy. American Journal of Respiratory and Critical Care Medicine, 195(5), 596-606. https://doi.org/10.1164/rccm.201606-1275CI

[49] Penney, D., Benignus, V., Kephalopoulos, S., Kotzias, D., Kleinman, M., and Verrier, A. (2010). Carbon Monoxide. In: WHO Guidelines for Indoor Air Quality: Selected Pollutants, 55-102. World Health Organization. https://www.ncbi.nlm.nih.gov/books/NBK138710/#

and lost earnings,10% of it stemming from gas stoves.[50] The cost to the state and federal government should also be considered. The brunt of the cost of medical care will be borne by the government for Medicare and Medicaid enrollees. Additionally, carbon monoxide poisoning can lead to enrollment in federal disability benefits. The cost to the state and federal governments has not been calculated as of yet but is estimated to be significant.

Question 2: Please provide information related to data sources and approaches CPSC should consider when completing an evaluation of chronic chemical hazards, exposures, and risks related to gas range use.

2c. Please provide product testing information that explores the impact that using different gas fuel sources has on emitted chemical substances. If available, provide supporting information on sampling and analytical methods.

Research has shown relationships between the amount of carbon monoxide emitted from a **gas range** and the characteristics of the gas fuel source. Characteristics that will be discussed are the Wobbe Index, chemical composition, and heating value of the fuel. The influence of gas composition has been investigated by Liu, et al. (2023) and Yitong, et al. (2022). Wobbe Index has been studied by Singer, et al. (2009) and Yitong, et al. (2022). Ko and Lin (2003) studied multiple range design elements, including the heating value of the operating fuel.

The Wobbe Index (WI or W), sometimes called Wobbe Number (WN or W), is an indicator of the interchangeability of fuel gasses, such as natural gas. Wobbe Index is proportional to the higher heating value of a fuel and inversely proportional to the square root of a fuel's specific gravity.[51] While Ko and Lin do not directly discuss the Wobbe Index, they discuss the heating value of the tested fuels, which will be directly proportional to the Wobbe Index of the fuel. The studies mentioned below, which investigate the effects of the Wobbe Index or heating value of the fuel used for the operation of a range, all found that an increase in heating value or W will lead to increased carbon monoxide emissions.

Ko and Lin tested a high-heating-value fuel and a low-heating-value fuel on a burner set-up, which could vary gas supply pressure, fuel regulator, primary air regulator, and loading height. Results showed that the fuel with a higher heating value produced higher CO emissions than the fuel with a lower heating value at the same gas supply pressure and thermal input. The amount of CO emissions from the higher heating value fuel can be decreased by decreasing gas supply pressure (from 150 mm H2O to 100 mm H2O for maximum effect), lowering CO emissions almost to the amount emitted from the lower heating value fuel at the higher pressure. Ko and Lin also found that CO emissions are affected by range primary aeration, gas flow rate, gas supply pressure, and loading height. They conclude that a fuel's heating value "strongly affects burner

[50]Hampson NB. (2017). Cost effectiveness of residential carbon monoxide alarms. Undersea Hyperb Med. 44(5):393-397.
[51] Lumitos (n.d.). Wobbe index. Chem Europe. https://www.chemeurope.com/en/encyclopedia/Wobbe_index.html

performance, including the combustion characteristics [...], thermal efficiency, and emissions."[52]

Singer, et al. used 13 range types and up to 5 fuels of differing WN to measure the effect of Wobbe Number on emissions during full-burn and end-of-burn range operation. Carbon monoxide emissions were measured with the Horiba PG-250 after being collected by a hood located just above the burners. The results were analyzed with bivariate linear regression. [53]

Singer, et al. found a statistically significant effect in ten of the ranges, and a likely effect in one other, for both operating conditions. The range of effect for these significant results was a 3% to 50% increase in CO emissions (ng/J) per 25 Btu/scf increase in WN. Only two ranges had a decrease in CO emissions related to WN within a 95% confidence interval, and these values were not statistically significant.[52]

Another study on the Wobbe Index and range emissions was conducted by Yitong, Chaokui, Pengfei, and Zhiguang (2022). They tested 12 fuels of varying composition and Wobbe Indices and 6 different burners, one of which had been modified to operate in a forced-mixed mode. As part of the analysis, they fitted an equation for CO emission dependent on fuel properties and three fitting factors for each burner type. The proposed relationship between Wobbe Index and CO emission is $E_{CO} \propto e^{W}$, where E_{CO} is air-free CO emission in ppm and W is Wobbe Index. Results show an increase of about 4.48 ppm in carbon monoxide emissions per 7 MJ/m3 increase in the Wobbe Index.[54]

Yitong, et al. also explored the effect of methane composition on carbon monoxide emissions in the same study. The defining equation for this relationship was

$$E_{CO} = (\omega_1 * M + \omega_2)e^{\omega_3 * W}$$

where M is the methane volume percentage of the fuel, W is Wobbe Index, and ω's are fitting coefficients. The experiment results show a decrease in CO emissions from an increase in the methane percentage of fuels with the same Wobbe Index. These findings suggest that CO emissions are dependent on both methane percentage and Wobbe Index of fuel and both properties are needed to accurately predict emissions. Equations for operating conditions are also presented, which show the effect of primary air coefficient and nominal heat input on carbon monoxide emissions.[53]

Liu, et al. studied how hydrogen introduced into a natural gas mixture affects its performance. This study used the GRI-MECH 3.0 combustion model to investigate how

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[52] Ko, Y.-C., and Lin, T.-H. (2003). Emissions and efficiency of a domestic gas range burning natural gasses with various compositions. Energy Conversion and Management, 44(19), 3001-3014. https://doi.org/10.1016/S0196-8904(03)00074-8

[53] Singer, B. C., Apte, M. G., Black, D. R., Hotchi, T., Lucas, D., Lunden, M. M., Mirer, A. G., Spears, M., and Sullivan, D. P. (2009). Natural Gas Variability in California: Environmental Impacts and Device Performance Experimental Evaluation of Pollutant Emissions from Residential Appliances. Lawrence Berkeley National Laboratory. Retrieved from https://www.osti.gov/servlets/purl/980736

[54] Yitong, X., Chaokui, Q., Pengfei, D., and Zhiguang, C. (2022). Prediction of CO emission from partially-premixed gas cooker. Case Studies in Thermal Engineering, 31, Article 101833. https://doi.org/10.1016/j.csite.2022.101833

hydrogen-doped natural gas variations would perform in a swirl **gas range**. The fuels simulated were 95%/5%, 90%/10%, and 85%/15% methane/hydrogen and 100% methane. The fuels with higher hydrogen compositions had lower simulated CO emissions when compared to the lower hydrogen percentage fuels. The authors attribute this to the lack of carbon monoxide in the combustion reaction of hydrogen gas and an earlier reaction time of the gas, which increases the ignition temperature and reduces CO production in the methane reaction.[55]

Physical experiments were conducted for the 15% hydrogen fuel, which showed less than a 3% difference in emissions from the simulation. Liu, et al. cite previous research by Haeseldonckx and D'haeseleer, which states the maximum hydrogen composition that is safe for use in ranges is 17%, providing an upper boundary for hydrogen composition in range fuels.[54]

Several of these studies also investigated elements of range design and operating conditions and concluded that altering the fuel source should only be done with these elements in mind. Emissions may not behave as expected when a new fuel is used, as the operating conditions also affect emissions. Yitong, et al. state that ranges are usually adjusted only at installation and future gas constituent changes are not considered. They say that if the fuel were to change after installation, CO emissions may increase dramatically.[53] Ko and Lin have a similar view, calling the substitution of a **gas range's** fuel with one of a different heating value "inappropriate and hazardous" due to the possibility of producing dangerous conditions, such as large increases in carbon monoxide emissions.[51]

An incident occurred this past December in Indiana, which shows how a change in fuel composition can produce a dangerous situation. In this event, the fuel for multiple Indiana cities' gas supply was altered in its composition. Propane was used to supplement the natural gas from Centerpoint due to high demand, but the propane was not heated correctly when being transferred between facilities. This resulted in greater amounts of propane in the final mixture than intended. Over 100 calls were made to emergency services regarding carbon monoxide issues, since their gas appliances were not able to properly operate with the high propane gas, and four people were hospitalized.[56] This alteration of the natural gas mixture demonstrates the importance of careful consideration of fuel composition, since appliances already in use in homes may not be designed or calibrated for differing compositions.

2d. Please provide research that explores the relationship between emissions from gas ranges and indoor air quality. This includes experimental chamber or observational field studies that reflect environmental air monitoring of chemical substances during and after gas range use and/or modeled estimates of indoor

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[55] Liu, X., Zhu, G., Asim, T., and Mishra, R. (2023). Combustion characterization of hybrid methane-hydrogen gas in domestic swirl ranges. Fuel, 333(2), Article 126413. https://doi.org/10.1016/j.fuel.2022.126413

[56] Webb, J. (2023, February 28). CenterPoint faces fine after Southern Indiana residents were exposed to carbon monoxide. Evansville Courier & Press. https://www.courierpress.com/story/news/local/2023/02/28/centerpoint-faces-fine-after-southern-indiana-carbon-monoxide-incident-clarksville/69940046007/

air concentrations based on chamber emission data. If available, provide average and peak levels and supporting information on methods.

Presented in the following table are studies on emissions of carbon monoxide from **gas ranges** in homes and the relationship with indoor air quality.

Table 3: Studies on gas ranges and indoor air quality

Logue, et al. (2014)[57]	
Methods	A population impact assessment modeling (PIAM) approach was used to determine the impact of in-home pollutant exposure on Southern California households that use **gas ranges**. Emissions from b and corresponding airflow factors were simulated with a single-zone mass-balance model. The emission factors used in this model were taken from data gathered by Singer, et al. (2010). Variables integrated into this model were residence volume, emission rate, deposition rate, air exchange rate, penetration efficiency, time, indoor pollutant concentration, and outdoor pollutant concentration. Simulations had one-minute resolution and represented a one-week period each for the summer and winter. The population represented is 11,680,000 people in 3,560,000 homes in Southern California. Characteristics of households and occupant habits in this cohort were taken from the 2003 Residential Appliance Saturation Survey database.
Results	**Gas ranges** without vent hoods in use contributed 30% and 21% of the indoor concentration of carbon monoxide in the summer and winter, respectively. The model estimated that 4-9% of occupants would be exposed to CO levels exceeding acute air quality standards if vent hoods were not used. The majority of these instances were due to **gas range** emissions. The homes with these exceedances experienced an average of 2.4 to 3.6 exceedances per week, depending on the season. These occurrences decreased greatly with vent hood use. The geometric mean of the highest 1-hour carbon monoxide concentrations in the winter was 4.2 ppm. The mean for the highest 1-hour concentrations due only to **gas range** emissions was 2.6 ppm.
National Center for Healthy Housing (2022)[58]	
Methods	Data on indoor pollutant concentrations, including carbon monoxide concentration, was collected from the main living areas of homes in Chicago and New York City. Samples were taken during three periods of 4 days, each 4 months apart. Ventilation testing was done in each household to determine the unit air exchange rate. Two multivariate models were completed for each pollutant.
Results	Carbon monoxide concentrations increased 20-22% for each additional meal cooked on a **gas range** per day (p= 0.014-0.024). Households with kitchen exhaust had 41-49% lower maximum CO concentrations than households without exhaust (p=0.011-0.099).

[57] Logue JM, Klepeis NE, Lobscheid AB, Singer BC.(2014). Pollutant exposures from natural gas cooking burners: a simulation-based assessment for Southern California. Environ Health Perspect.122(1):43-50.

[58] National Center for Healthy Housing (2022). Studying the Optimal Ventilation for Environmental Indoor Air Quality. https://nchh.org/resource-library/report_studying-the-optimal-ventilation-for-environmental-indoor-air-quality.pdf

Table 3, Continued

Mullen, et al. (2015)[59]	
Methods	Temperature, relative humidity, and carbon monoxide measurements were taken in the kitchen of California homes. Carbon monoxide data was collected in 316 homes out of a total of 323 involved in the study, 38 of which did not have any gas appliances. Samples were taken over a 6-day period either between November 2011 and April 2012 or October 2012 and March 2013. Household information was collected related to the frequency of appliance use, potential pollutant sources, kitchen exhaust fan use, and condition of range tops. Mean and 1-hour and 8-hour averages were calculated over the sampling period, then assessed against appliances present, range fuel, range frequency of use, and kitchen exhaust fan use.
Results	About 5% of homes with carbon monoxide data had at least one incident where carbon monoxide levels exceeded 20 ppm over 1 hour or 9 ppm over 8 hours, which are the acute air quality standards for carbon monoxide in California. The arithmetic and geometric means of the highest 1-hour concentrations of CO were 6.4 and 3.8 ppm. Median 1-hr CO concentrations were 1.2 ppm (without vented gas appliances) and 1.3 ppm (with vented gas appliances) in homes without **gas ranges** and 4.4 ppm (without vented gas appliances) and 3.8 ppm (with vented gas appliances) in homes with **gas ranges**. The effect of exhaust fan use on CO concentrations was somewhat unclear. Authors speculate that occasional fan use may occur during the most intensive cooking, which would disproportionately affect peak and time-integrated concentrations.
Fortmann, et al. (2001)[60]	
Methods	Thirty-two combined tests were conducted on an electric range, microwave, and **gas range**/oven unit in a test house in California. Tests included multiple types of cooking, such as stir-frying, and constituted larger quantities and longer durations than typical home cooking to get sufficient pollutant mass for measurement and analysis. Pollutant emissions were measured, including carbon monoxide.
Results	Average concentrations of carbon monoxide during cooking with the **gas range** were less than 4 ppm, but at times levels reached 9 ppm over 8 hours during the preparation of full meals.

[59] Mullen, N. A., Li, J., Russell, M. L., Spears, M., Less, B. D., and Singer, B. C. (2015). Results of the California Healthy Homes Indoor Air Quality Study of 2011-2013: Impact of Natural Gas Appliances on Air Pollutant Concentrations. Ernest Orlando Lawrence Berkeley National Laboratory. https://www.osti.gov/servlets/purl/1236693

[60] Fortmann, R., Kariher, P., and Clayton, R. (2001). Indoor Air Quality: Residential Cooking Exposures. State of California Air Resources Board Research Division. Retrieved from https://www.semanticscholar.org/paper/Indoor-air-quality%3A-residential-cooking-exposures.-Fortmann/3aa8419c913cfda8265ba00670ab2285f297d69c?sort=is-influential

Table 3, Continued

Lebowitz, et al. (1984)[61]	
Methods	Several air pollutants, including carbon monoxide, were measured in 117 households in Tucson, AZ over 72 hours. Carbon monoxide measurements were collected in living rooms, kitchens, and outside by a Bendix CO IR Analyzer. Information was collected from each household related to heating, cooling, type of range, washer and dryer, and smoking habits. Environmental concentrations in the area were taken from monitoring conducted by the Pima County Air Quality Control District. The statistical techniques used included frequency distributions, contingency tables, correlation and regression analyses, and both univariate and multivariate analyses of variance.
Results	Homes with **gas ranges** and homes with electric ranges showed differences in the measured CO concentrations ($0.05 < p < 0.10$). The mean value of CO was 1.41 ppm in homes with **gas ranges** and 0.97 ppm in homes with electric ranges. Concentrations of CO were not found to correlate with smoking habits or the presence of other gas-burning appliances.

Question 3: Please provide information on proposed solutions related to any chronic chemical hazards, exposures, and risks associated with gas range use.

3a: Please provide information related to potential tradeoffs between different hazards (i.e., chemical, fire, electrical, mechanical, or other) associated with the use of gas ranges, electric ranges (including older and newer models), and other large cooking appliances.

Many effects of carbon monoxide poisoning are due to the binding of CO with hemoglobin, creating COHb and blocking oxygen from attaching to the hemoglobin. The greater the concentration of COHb, the more severe the effects of carbon monoxide poisoning can be. The elimination of carbon monoxide takes hours due to a half-time of 100-300 minutes.[62] Thus, the effect of an exposure persists even after the exposure ends. Additional exposure will add to the carbon monoxide already present in the body. This will produce symptoms greater than those that the individual exposures could produce separately. This addition of carbon monoxide is why chronic low-level exposure still presents a danger despite a single incident of exposure to that level not being considered harmful.

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[61] Lebowitz, M. D., Corman, G., O'Rourke, M. K., and Holberg, C. J. (1984). Indoor-Outdoor Air Pollution, Allergen and Meteorological Monitoring in an Arid Southwest Area. Journal of the Air Pollution Control Association, 34(10), 1035-1038. https://doi.org/10.1080/00022470.1984.10465851

[62] Wilbur, S., Williams, M., Williams, R., Scinicariello, F., ATDSR, Klotzbach, J. M., Diamond, G. L., Citra, M., & SRC Inc. (2012). *Toxicological Profile for Carbon Monoxide*. U.S. Department of Health and Human Services. https://www.atsdr.cdc.gov/toxprofiles/tp201.pdf

Indoor carbon monoxide levels are due to several sources. Carbon monoxide can build up from outdoor concentrations, which seep into the home, and from other fuel-burning appliances used in and around the home. These include furnaces, fireplaces, water heaters, dryers, ranges, space heaters, generators, and engine-driven tools. Outside the home, people can be exposed to carbon monoxide from vehicles, boats, and workplace hazards.[61]

Many combustion appliances vent to the outside. However, malfunctions in these appliances can lead to emissions spreading through the home. Even properly functioning appliances can leak combustion products into the home due to back-drafting, leading to CO concentrations that can exceed 5 ppm.[63] **Gas ranges** do not have direct vents and often rely on the user's activation of a vent hood to have any ventilation at all. Carbon monoxide levels associated with **gas range** use can be seen in Table 3.

Due to the additive nature of carbon monoxide exposure, all potential sources of carbon monoxide should be considered as collective emitters. The emissions from a **gas range** will add to the levels of carbon monoxide to which a person has recently been exposed. This may negatively impact the person even if the individual contributing sources are considered to emit "safe levels" of carbon monoxide. Carbon monoxide-emitting appliances, like the **gas range**, should be viewed as one component of a carbon monoxide-producing home, not as an isolated appliance. To create safe homes, measures would need to be taken to reduce carbon monoxide emissions as much as possible for each carbon monoxide source, limiting the danger of cumulative exposure.

3h. Please provide information on indoor air quality (IAQ) in home environments, both related to and separate from gas ranges.

See Table 3 for information on indoor air quality related to **gas ranges**. In the following table are the results of studies on indoor air quality and comparable outdoor air quality measurements.

Table 4: Studies on indoor and environmental air quality

[63] Nagda, N. L., Koontz, M. D., Billick, I. H., Leslie, N. P., and Behrens, D. W. (1996). Causes and Consequences of Backdrafting of Vented Gas Appliances. Journal of the Air & Waste Management Association. 46(9), 838-846. https://doi.org/10.1080/10473289.1996.10467519

Miller, et al. (2009)[64]	
Indoor CO concentrations of 100 homes of recent immigrants in Commerce City, CO	Mean: 2.4 ppm
National Center for Healthy Housing (2022)[65]	
Indoor CO concentrations of houses in Chicago and New York over 3 phases of 4 days in 2018-2020	15-minute maximum GM: 2.5 ppm (C- 2.8, NY- 2.3) Max: 42.6 ppm 75th %ile: 6.5 ppm
Outdoor CO concentrations from EPA air monitoring sites in Chicago and New York 2018-2020	Chicago GM: 0.2 ppm New York GM: 0.3 ppm
Arhami, et al. (2012)[66]	
Indoor CO concentrations of homes in San Gabriel Valley and Riverside, CA over two phases of 6 weeks in 2005-2007	San Gabriel Valley: Mean: 0.64/0.78 ppm Riverside: Mean: 0.31/0.12 ppm (summer and fall/fall and winter)
Outdoor CO concentrations of homes in San Gabriel Valley and Riverside, CA over two phases of 6 weeks in 2005-2007	San Gabriel Valley: Mean: 0.59/0.69 ppm Riverside: Mean: 0.46/0.60 ppm (summer and fall/fall and winter)

Table 4, Continued

[64] Miller, S. L., Scaramella, P., Campe, J., Goss, C. W., Diaz-Castillo, S., Hendrikson, E., DiGuiseppi, C., and Litt, J. (2009). An assessment of indoor air quality in recent Mexican immigrant housing in Commerce City, Colorado. Atmospheric Environment, 43(35), 5661-5667. https://doi.org/10.1016/j.atmosenv.2009.07.037

[65] National Center for Healthy Housing (2022). Studying the Optimal Ventilation for Environmental Indoor Air Quality. https://nchh.org/resource-library/report_studying-the-optimal-ventilation-for-environmental-indoor-air-quality.pdf

[66] Arhami, M., Polidori, A., Delfino, R. J., Tjoa, T., and Sioutas, C. (2012). Associations between Personal, Indoor, and Residential Outdoor Pollutant Concentrations: Implications for Exposure Assessment to Size-Fractioned Particulate Matter. Journal of the Air & Waste Management Association, 59(4), 392-404. https://doi.org/10.3155/1047-3289.59.4.392

Offermann (2009)[67]		
Indoor CO concentrations of 108 new homes in California over 22-26 hours in 2007-2008	8-hr maximum Mean: 1.2 ppm GM: 0.7 ppm Max: 3.7 ppm	1-h maximum Mean: 1.6 ppm GM: 1.0 ppm Max: 6.8 ppm
Outdoor CO concentrations of 108 new homes in California over 22-26 hours in 2007-2008	8-hr maximum Mean: 1.9 ppm GM: 1.5 ppm Max: 4.4 ppm	1-h maximum Mean: 2.3 ppm GM: 1.9 ppm Max: 4.9 ppm
Mullen, et al. (2015)[68]		
Indoor CO concentrations of 316 homes in California over 6 days in 2011-2013	8-h maximum GM: 2.2 ppm Mean: 3.4 ppm 95th %ile: 10 ppm	1-h maximum GM: 3.8 ppm Mean: 6.4 ppm 95th %ile: 18 ppm
Outdoor CO concentrations of 352 homes in California over 6 days in 2011-2013	GM: 0.5 ppm Mean: 0.5 ppm 95th %ile: 1.0 ppm	
US EPA (2010)[69]		
Nationwide outdoor CO concentration data from EPA air quality system 2005-2007	8-h daily maximum Median: 0.5 ppm Mean: 0.7 ppm 95th %ile: 1.7 ppm 99th %ile: 2.6 ppm	1-h daily maximum Median: 0.7 ppm Mean: 0.9 ppm 95th %ile: 2.4 ppm 99th %ile: 3.8 ppm

[67] Offermann, F. J. 2009. Ventilation and Indoor Air Quality in New Homes. California Air Resources Board and California Energy Commission, PIER Energy-Related Environmental Research Program. Collaborative Report. CEC-500-2009-085. Retrieved from https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/04-310.pdf.
[68] Mullen, N. A., Li, J., Russell, M. L., Spears, M., Less, B. D., and Singer, B. C. (2015). Results of the California Healthy Homes Indoor Air Quality Study of 2011-2013: Impact of Natural Gas Appliances on Air Pollutant Concentrations. Ernest Orlando Lawrence Berkeley National Laboratory. https://www.osti.gov/servlets/purl/1236693
[69] U.S. EPA (2010). Integrated Science Assessment (ISA) for Carbon Monoxide (Final Report, Jan 2010). U.S. Environmental Protection Agency, Washington, DC. Retrieved from https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=218686

3j. Please provide information on the costs and effectiveness of any other relevant voluntary or mandatory standards (such as for gas ranges or exhaust hoods found in model building codes).

One carbon monoxide-emitting appliance used around the home with voluntary standards is the portable generator. There are two voluntary standards for this device: UL 2021 and PGMA G300. According to CPSC staff, compliance is 5% for the UL standard and 30% for the PGMA standard. In a simulation, PGMA G300 caused more deaths than UL 2021 (69 deaths vs. 0.04 deaths), mostly due to a lack of emission rate restrictions. The simulated deaths for standard-compliant generators were lower than those caused by non-compliant generators.[70] While these standards show they are effective in reducing carbon monoxide poisoning deaths, without significant compliance to these standards, many deaths will occur that otherwise could have been avoided.

CPSC staff estimated that if a mandatory standard was implemented that adopted the more protective elements of both voluntary standards, it would prevent 2148 deaths and 126,000 injuries from carbon monoxide poisoning over 30 years. The cost associated with this proposed standard is estimated to be $148.94 million per year, while the estimated benefits due to death and injury prevention are $1,046.00 million per year.[69]

These metrics show relatively low compliance of voluntary CO reduction standards for an appliance in a similar market to **gas ranges**. Voluntary standards leave room for products to continue creating dangerous situations that a protective mandatory standard would otherwise prevent. The implementation of a mandatory standard could be beneficial in multiple ways, reducing both physical harm and societal expense.

3k. Please provide any additional information related to chronic hazards associated with gas ranges and proposed solutions to those hazards that CPSC should consider, not requested above.

When managing significant risk it is always best to be proactive and preventative. As evidenced above, CO exposure from ***gas ranges*** can exceed WHO and EPA recommended limits and cause harm to consumers. The United Kingdom has recently implemented the following pragmatic solutions to improve CO safety and other countries are in the process of adopting similar guidelines. We recommend a similar approach be adopted by the CPSC.

1. Create a national hotline to respond to consumer inquiries with consistent and up-to-date information on CO safety.
2. Implement a mandatory standard to add CO shutoffs to new fuel-burning appliances and add retrofit shutoffs to existing ones.
3. Revise CO alarm standards to align with current health guidelines, require accurate digital displays of the ambient CO levels in a home, and improve the user interface.
4. Conduct a nationwide prevalence study to determine the frequency and severity of CO poisoning in the United States.
5. Facilitate research in CO poisoning diagnostics and treatment.

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[70] [U.S. Consumer Product Safety Commission]. (2023, March 15). *Commission Meeting- Supp. Notice Proposed Rulemaking (SNPR) Safety Standard for Portable Generators* [Video]. YouTube. https://youtu.be/S2J79zUwVio

6. Provide training and detection equipment for emergency responders.
7. Mandate certification of anyone working on or installing fuel-burning appliances.
8. Require CO testing anytime a fuel-burning appliance is installed or maintenance is conducted and a checklist documenting CO levels is provided to the owner and tenant.
9. Encourage maintenance and certification to be performed annually as per manufacturers' instructions.
10. Advocate for CO diagnostic testing as a regular part of prenatal care, when presenting with CO poisoning symptoms, and after a CO incident.

These proven solutions provide an efficient and cost-effective framework for mitigating CO poisoning. Thus, we petition the CPSC to employ a similar methodology to protect Americans from unreasonable risks of injuries and deaths associated with fuel-burning consumer products.

We cannot change the past 30 years of injury and death, but we ***can*** act now to save lives and prevent injuries. Failure to do so will result in the loss of life and livelihood. In addition to a raised consciousness of this issue, there is currently unprecedented collaboration across many sectors to come together to improve CO safety measures, as evidenced in the Working Groups that are studying indoor air pollution from **gas ranges**. Changing product standards, such as adding a requirement for CO safety shut-offs on all fuel-burning appliances, will save far more lives than any education or awareness campaign targeted toward the public. It is more effective to stop CO exposure at the source than to educate consumers on how to protect themselves from a faulty appliance.