Embedding Public Health in Climate and Energy Policy Action:
Recommendations for Inflation Reduction Act Spending in Colorado

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ABSTRACT

Colorado should work towards rapid, equitable, and local-level decarbonization to mitigate the adverse public health impacts from climate change. Policy makers and organizations should capitalize on new funding streams from the Inflation Reduction Act to lead this charge. Actions may take several forms, but all should be centered in the following three premises:

1) Engage energy, climate change, and public health stakeholders in all parts of Inflation Reduction Act implementation;

2) Prioritize local level decarbonization through weatherization, household electrification, and adoption of electric public transportation vehicles; and

3) Match Colorado state funds with Inflation Reduction Act funding to amplify support.

The Inflation Reduction Act (2022) offers $369 billion of unprecedented opportunity for states to strengthen clean energy infrastructure, upgrade energy efficient homes, and expand electric vehicle manufacturing to radically decarbonize and reduce greenhouse gas emissions. This report aims to 1) identify climate change and energy impacts on population health; 2) evaluate Colorado’s unique positionality in leading the United States in Inflation Reduction Act implementation with a public health benefit focus; and 3) provide case-based recommendations for implementation of weatherization, household electrification, and electric public transportation vehicles in low-income communities.
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I would also like to thank my partner and family, without your support throughout my Yale experience (and through life) I would not be the woman I am today. Also, thank you to all of my friends who have kept me full of food and laughter. I couldn’t have done it without you.
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LIST OF ACRONYMS

GHG  Greenhouse gas
CO   Carbon monoxide
CO2  Carbon dioxide
NOx  Nitrogen oxides
O3   Ozone
PM2.5 Particulate matter 2.5
IRA  Inflation Reduction Act
EV   Electric vehicle
ZEV  Zero emissions vehicle
EPA  Environmental Protection Agency
CEO  Colorado Energy Office
CDPHE Colorado Department of Public Health and the Environment
SDOH Social Determinants of Health
EIA  United States Energy Information Administration
MMcf Million Cubic Feet
Bcf  Billion Cubic Feet
MSTN Thousand Short Tons
MMSTN Million Short Tons
MWh  Megawatt Hours
CHW  Community health workers
CCHS Contra Costa Health Services
ED   Emergency Department
GHHI Green and Healthy Homes Initiative
BIL  Bipartisan Infrastructure Law
NYCHA New York City Housing Authority
RIPTA Rhode Island Public Transit Authority
WHO  World Health Organization
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PART I: INTRODUCTION

Climate Change and Public Health

Human-induced climate change continues to intensify despite international agreements to limit global temperature rise to 2 degrees Celsius above 2005 levels.\(^1\) Climate change increases hazards to both human and environmental health, including heat-related illness, water- and vector-borne diseases, biodiversity loss, and mental health challenges (Mukherji et al., 2022). Figure 1 summarizes the impacts of climate change (National Institute of Environmental Health Sciences [NIEHS], n.d.). In their 2023 report, the Intergovernmental Panel on Climate Change (IPCC) declared that climate change is speeding toward catastrophe (Mukherji et al., 2022; Plumer, 2023).\(^2\) It is critical that national and subnational actors create big change and hold warming to safer levels within the next decade. This is especially important for disadvantaged communities whose health and well-being are exacerbated by inequity and marginalization linked to low income, race and ethnicity, and historical patterns of inequity.\(^3\)\(^4\)

Reducing fossil fuel combustion to address greenhouse gas (GHG) emissions also reduces traditional pollutants – e.g., carbon monoxide (CO), nitrogen oxides (NOx), ground-level ozone (O3) and particulate matter (PM2.5) – and directly improves human health. Decreasing some of these pollutants may be difficult as 2022 set the record for highest GHG emissions since the industrial age, pushing nations even further off track from their climate goals (National

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\(^1\) The Paris Agreement is a legally binding international treaty on climate change. Signed by 196 parties at the 21st United Nations Climate Conference, Article 2.1a reads “Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change” (United Nations, 2015).

\(^2\) The IPCC is the United Nations entity responsible for assessing and reporting on the science related to climate change.

\(^3\) This report uses the IRA definition of the term “disadvantaged communities” which is inclusive of the terms “disadvantaged communities,” “underserved communities,” “Indian communities,” “Tribal communities,” “Native communities,” “rural communities,” and “low- and middle-income communities.”

\(^4\) Flooding may also come from higher than average snowpack melt as is seen in Colorado in 2023 (Mullane, 2023).
Oceanic and Atmospheric Administration, 2023). Table 1 highlights short- and long-term health impacts of some pollutants associated with the combustion of fossil fuels.

The United States (US) is the second largest consumer of fossil fuels and accounts for 14% of global GHG emissions (Plumer, 2022). When President Biden took office in 2021, many of his first actions were climate directed. Rolling back President Trump’s pro-fossil fuel industry actions in office, President Biden rejoined the Paris Agreement on his first day in office, created the National Climate Task Force, and enacted Executive Order 14008: Tackling the Climate Crisis at Home and Abroad. Executive Order 14800 establishes Justice40, an initiative developed to improve equitable distribution of federal program funds and targets communities overburdened by pollution (“National Climate Task Force”, n.d.; “Justice40 Initiative”, n.d.). Importantly, Biden signed the Inflation Reduction Act (IRA or “the Act”) into law in August 2022. The IRA is the largest climate bill ever passed in the United States, investing $370 billion to solidify the US’s clean, just, and secure energy future (Glavinskas, 2022).
Figure 1: Summary of health outcomes from climate change impacts (NIEHS, n.d.).

<table>
<thead>
<tr>
<th>Climate Driver</th>
<th>Exposure</th>
<th>Health Outcome</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Heat</td>
<td>More frequent, severe, prolonged heat events</td>
<td>Elevated temperatures</td>
<td>Heat-related death and illness</td>
</tr>
<tr>
<td>Outdoor Air Quality</td>
<td>Increasing temperatures and changing precipitation patterns</td>
<td>Worsened air quality (ozone, particulate matter, and higher pollen counts)</td>
<td>Premature death, acute and chronic cardiovascular and respiratory illnesses</td>
</tr>
<tr>
<td>Flooding</td>
<td>Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events</td>
<td>Contaminated water, debris, and disruptions to essential infrastructure</td>
<td>Drowning, injuries, mental health consequences, gastrointestinal and other illness</td>
</tr>
<tr>
<td>Vector-Borne Infection (Lyme Disease)</td>
<td>Changes in temperature extremes and seasonal weather patterns</td>
<td>Earlier and geographically expanded tick activity</td>
<td>Lyme disease</td>
</tr>
<tr>
<td>Water-Related Infection (Vibrio vulnificus)</td>
<td>Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity</td>
<td>Recreational water or shellfish contaminated with Vibrio vulnificus</td>
<td>Vibrio vulnificus induced diarrhea &amp; intestinal illness, wound and bloodstream infections, death</td>
</tr>
<tr>
<td>Food-Related Infection (Salmonella)</td>
<td>Increases in temperature, humidity, and season length</td>
<td>Increased growth of pathogens, seasonal shifts in incidence of Salmonella exposure</td>
<td>Salmonella infection, gastrointestinal outbreaks</td>
</tr>
<tr>
<td>Mental Health and Well-Being</td>
<td>Climate change impacts, especially extreme weather</td>
<td>Level of exposure to traumatic events, like disasters</td>
<td>Distress, grief, behavioral health disorders, social impacts, resilience</td>
</tr>
</tbody>
</table>

Rising temperatures will lead to an increase in heat-related deaths and illnesses.
Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
Increases in water temperatures will alter timing and location of Vibrio vulnificus growth, increasing exposure and risk of waterborne illness.
Rising temperatures increase Salmonella prevalance in food; longer seasons and warming winters increase risk of exposure and infection.
Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.
Table 1: Pollutants and Human Health Impacts (Pope et al., 2009; U.S. Global Change Research Program, 2018; Naiyer and Abbas, 2022; “Climate Change Decreases the Quality of the Air We Breathe, n.d.).

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Where do pollutants come from?</th>
<th>Short-Term Health Impacts</th>
<th>Long-Term Health Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>Fossil fuel emissions</td>
<td>Reduce oxygen to the body</td>
<td>Combustion processes, motor vehicles</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>Fossil fuel emissions</td>
<td>Digestive system problems</td>
<td>Health risks associated with temperature rise (See Table 1: Extreme Heat), digestive system problems</td>
</tr>
<tr>
<td>Nitrogen Oxides (NOx)</td>
<td>Fossil fuel emissions, industrial processes</td>
<td>Aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), hospital admissions and visits to emergency room</td>
<td>Reproductive health problems, respiratory health issues, impaired DNA repair</td>
</tr>
<tr>
<td>Ozone (O3)</td>
<td>NOx and organic gasses interact with sunlight</td>
<td>Aggravate asthma, aggravate eyes, reduce lung capacity, and increase susceptibility to respiratory illnesses, including pneumonia and bronchitis</td>
<td>Aggravate lung disease, asthma</td>
</tr>
<tr>
<td>Particulate Matter 2.5 (PM2.5)</td>
<td>Combustion byproducts from cooking, heating (especially wood), environmental tobacco smoke, and candles, vehicle emissions, dust, wildfire smoke, dirt</td>
<td>Asthma, eye aggravation, chronic bronchitis, and heart attacks</td>
<td>Aggravate asthma, reduce lung capacity, and increase susceptibility to respiratory illnesses, including pneumonia and bronchitis</td>
</tr>
</tbody>
</table>

5 This table is not a comprehensive list of pollutants or their associated health impacts.
The Inflation Reduction Act

The IRA will strengthen the US’s clean energy infrastructure, upgrade energy efficient homes, accelerate clean energy deployment, expand electric vehicle (EV) manufacturing, and drastically reduce GHG emissions (Glavinskas, 2022; Bipartisan Policy Center, n.d.). Its transformative power has the capacity to reduce net US emissions by up to 42% below 2005 levels by 2030, compared to 24-35% without the Act (Center for American Progress, 2022; Rhodium Group, n.d.). To encourage household clean energy transition, the IRA promotes accessibility to energy efficient appliances and programs through multiple funding mechanisms like grants, rebates, and tax credits. Tax credits for equity-centered investments are multiplied. Studies on the Act found that utilizing initiatives within the IRA can create over 9 million jobs over the next decade and can cut household energy costs up to an additional $112 on average per household in 2030 (O’Boyle and Esposito, n.d.; Rhodium Group, n.d.).

Many aspects of the IRA, such as tax credits or tax rebates, are self-actuating and do not require state or federal authority for funding (Bipartisan Policy Center, n.d.). While some parts of the IRA provide direct funding access for homes, businesses, and clean energy developers, much of the funding will be applied by the states (Bipartisan Policy Center, n.d.). So, it is up to each state to ensure that the Act’s benefits are maximized.

The IRA offers an unprecedented opportunity for Colorado to bolster its framework on climate and clean energy initiatives. Addressing community level emissions reduction is a highly effective means of improving community health (Environmental Protection Agency [EPA], 2018). Yet, rarely does climate or energy policy directly address how health will be impacted by new policy measures (Sauerborn et al., 2009; Salas et al., 2020). Including health measures into
climate and energy policy action can directly impact health and mindful policy design can lessen health disparities (Frohlich and Potvin, 2008).

**The IRA is uniquely situated for Colorado**

Colorado is well positioned to lead the US in IRA implementation with a public health benefit focus. As one of the few states with a combined environmental and public health department, Colorado is familiar with incorporating health into environmental actions and legislation. Furthermore, the Colorado Energy Office (CEO), the Colorado Department of Public Health and the Environment (CDPHE), and the Colorado legislative branch have a track record of collaboration and bipartisan initiatives. The 2018 election of Governor Jared Polis further positioned Colorado as a climate change leader. In 2019, Governor Polis proposed a plan for 100% renewable electricity generation by 2040, and the Colorado General Assembly passed House Bill 19-1261, the Climate Action Plan to Reduce Pollution. In 2021, Colorado released a GHG emission reduction plan establishing incremental goals to reach 90% emissions reduction from 2005 levels by 2050 (Colorado Energy Office [CEO], n.d.; Colorado General Assembly, 2019).

To establish IRA initiatives that provide the greatest benefit to Colorado residents, the state should include health measures into its clean energy initiatives.

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6 Kansas and South Carolina both have joint health and environment departments (CDC, 2023).
7 The CEO and Greenhouse Gas Pollution Reduction Roadmap states, “In January 2021, Colorado released its Greenhouse Gas Pollution Reduction Roadmap detailing how the state plans to reduce its greenhouse gas emissions by 26% from 2005 levels by 2025, 50% by 2030, and 90% by 2050.”
Making the case for public health

The following sections will make the case for why public health benefits should be included in energy and climate interventions and planning. Part II of this report will provide a background on public health and the housing stock in Colorado, as well as information on three key sections of local level impact in the IRA: weatherization, household scale electrification, and electric vehicle adoption. Part III will describe the methods used to select and analyze case studies. Part IV will explore case studies at the intersections of health with weatherization, household scale electrification, and electric vehicle adoption. Finally, Part V will present key takeaways from the case studies and will consider how these efforts should (or should not) be executed in Colorado. This assessment furthers our understanding of how health policy and program interventions coupled with energy efficiency and clean energy efforts can protect individuals and communities from climate-related health impacts.

PART II: BACKGROUND

This section contextualizes the IRA and public health in Colorado and discusses the three key sections of focus within this report. Specific case studies in weatherization, household-scale electrification, and electric vehicle adoption are explored in Part IV and Part V.

Public Health in Colorado

Overall the population of Colorado is physically active, many people play outdoor sports, and the state attracts outsiders with similar interests. America’s Health Rankings rated Colorado first in physical health in 2022, with only 16.7% reporting physical inactivity compared to 23.7% of Americans reporting inactivity (United Health Foundation, 2022). Colorado was rated tenth
in overall health. Seven of the ten leading causes of death are chronic diseases. These include heart disease, cancer, chronic lower respiratory diseases, stroke, Alzheimer’s disease, chronic liver disease, and diabetes. COVID-19 was the third leading cause of death in 2022. As of March 2023, 329 cases per day were reported in Colorado in the previous week, COVID cases have decreased by 23 percent from the average two weeks ago, and deaths from COVID have decreased by 25 percent (The New York Times, 2023). In 2020, the prevalence of asthma among adults in Colorado was 9.6% and about 6.9% among children. Childhood asthma leads to high healthcare costs, is one of the leading causes of school absenteeism, and requires that a caretaker stay home from work to help care for the child, leading to missed wages.

The above mentioned chronic diseases are exacerbated by climate conditions, such as excessive heat and air pollution. A 2022 study estimated that air pollution led to an estimated 800 premature deaths annually in Colorado (Miller, 2022). Another rated Denver amongst the seven highest ozone-polluted cities in the country. In Colorado, most air pollution is produced from annual wildfires, vehicle emissions, and the use of fossil fuel to heat and power homes (Min et al., 2023). This air pollution comes in the form of PM2.5, CO, and O3 from both ambient (outdoor) and indoor air pollution.

Social determinants of health (SDOH) also play a factor in Colorado’s population health. SDOH, refers to the environment in which one lives, works, learns, and plays, as shown above

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8 Detailed reports on Colorado health are included in Appendix B.
in Figure 2. SDOH can affect many aspects of health. Vulnerable populations across the state are exposed to potentially harmful environments (Norton et al., n.d.). Table 2 presents the state demographics of some vulnerable populations, this is not inclusive of all demographics and does not include low-income residents.

**Table 2:** Colorado Demographics 2021 (Colorado State Demography Office)

<table>
<thead>
<tr>
<th>Demographic Component</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>% living in Poverty</td>
<td>9.6</td>
</tr>
<tr>
<td>Under 18</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Over 65</td>
<td>872,000</td>
</tr>
<tr>
<td>% Hispanic</td>
<td>22.2</td>
</tr>
<tr>
<td>% Black</td>
<td>4</td>
</tr>
<tr>
<td>% Asian</td>
<td>3.35</td>
</tr>
<tr>
<td>% Pacific Island/Native Hawaiian</td>
<td>0.15</td>
</tr>
<tr>
<td>% American Indian/Native American</td>
<td>0.64</td>
</tr>
<tr>
<td>% Two or more race/ethnicity selected</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Figure 3, on the following page, shows EnviroScreen, Colorado’s Environmental Justice Mapping Tool (Colorado Department of Public Health and the Environment [CDPHE], 2022). This tool identifies areas in Colorado that are more likely to have environmental health injustices, such as dangerous health impacts from higher vehicle emissions (CDPHE, 2022). Government agencies and organizations can then use this information to prioritize resources and improve public health in these areas. EnviroScreen scores each county by population characteristics and environmental burdens. Such burdens include environmental exposures,
environmental effects, climate vulnerability, sensitive populations, and county demographics. Scores range from 0-100% with higher percentile indicating higher burden.

**Figure 3:** Colorado EnviroScreen Scores (CDPHE, 2022)

Denver County is highlighted by the orange bar with a Score of 84, showing a high level of burden. In Colorado, Denver has one largest temperature differences between formerly redlined and non-redlined areas. Housing complexes and industries were regularly built in redlined areas due to the inexpensive land (Hoffman et al., 2020). There is also evidence of the connection between federally subsidized major highway projects and low-income neighborhoods (Hoffman et al., 2020). These massive overhauls in physical infrastructure increased asphalt and

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9 A score of 84 indicates that 84% of other Colorado counties have a lower environmental health burden than Denver County.
removed greenspace, thus exacerbating the urban heat island effect. But increased neighborhood average heat is not the only area impacted.

COLORADO ENERGY USE

Colorado’s energy consumption is dominated by natural gas, but the state’s renewable energy net generation is growing and accounts for 35% of the state’s total energy generation. Colorado accounts for 4% of total US crude oil production, 90% of which comes from Weld County (United States Energy Information Administration [EIA], 2022). Both of the state’s petroleum refineries are located in the Denver area (Min et al., 2023). The refineries process crude oil into motor gasoline, diesel fuel, and other petroleum products. The transportation sector accounts for over four-fifths of all petroleum consumed in Colorado. Colorado also has 4% of the nation's natural gas reserves.

Residential homes account for about one third of the state’s natural gas demand and about 7 out of 10 households use natural gas as their primary heating source (EIA, 2022). Natural gas is commonly used for operating cooking appliances, such as ovens and stovetops. Only about 25% of Colorado residents use electricity as their main home heating source compared to the US average of 41% (EIA, 2022). Traditional combustion appliances burn oil and natural gas at very high temperatures to create energy, resulting in pollution emission from the chemicals contained within the fuel source and as a byproduct of their combustion. These emitted pollutants include PM2.5, NOx, CO, CO2, and O3.

Table 3 provides an overview of Colorado energy use. Energy measurement units are defined below:

- MMcf – Million Cubic Feet
- Bcf – Billion Cubic Feet
- MSTN – Thousand Short Tons
- MMSTN – Million Short Tons
- MWh – Megawatt Hours

**Table 3: Colorado Energy Overview (EIA, 2022)**

<table>
<thead>
<tr>
<th></th>
<th>Colorado</th>
<th>Idaho</th>
<th>Montana</th>
<th>Utah</th>
<th>Wyoming</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>5.8 million</td>
<td>1.9 million</td>
<td>1.1 million</td>
<td>3.4 million</td>
<td>581,381</td>
<td>331.9 million</td>
</tr>
<tr>
<td>Housing Units</td>
<td>2.25 million</td>
<td>775,267</td>
<td>521,892</td>
<td>1.9 million</td>
<td>274,371</td>
<td>142.2 million</td>
</tr>
<tr>
<td>Annual Energy Consumption</td>
<td><strong>1,451 trillion Btu</strong></td>
<td><strong>550 trillion Btu</strong></td>
<td><strong>429 trillion Btu</strong></td>
<td><strong>829 trillion Btu</strong></td>
<td><strong>504 trillion Btu</strong></td>
<td><strong>92,862 trillion Btu</strong></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>499 Bcf</td>
<td>133 Bcf</td>
<td>82 Bcf</td>
<td>262 Bcf</td>
<td>153 Bcf</td>
<td>30,615 Bcf</td>
</tr>
<tr>
<td>Coal</td>
<td>14 MMSTN</td>
<td>n/a</td>
<td>7 MMSTN</td>
<td>13 MMSTN</td>
<td>21 MMSTN</td>
<td>546 MMSTN</td>
</tr>
<tr>
<td>Annual Energy Production</td>
<td><strong>3,775 trillion Btu</strong></td>
<td><strong>152 trillion Btu</strong></td>
<td><strong>757 trillion Btu</strong></td>
<td><strong>789 trillion Btu</strong></td>
<td><strong>5,884 trillion Btu</strong></td>
<td><strong>95,711 trillion Btu</strong></td>
</tr>
<tr>
<td>Crude Oil</td>
<td>408 Mbpd</td>
<td>n/a</td>
<td>58 Mbpd</td>
<td>141 Mbpd</td>
<td>244 Mbpd</td>
<td>12,462 Mbpd</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>1,879 Bcf</td>
<td>n/a</td>
<td>38,693 MMcf</td>
<td>239,405 MMcf</td>
<td>1,109 Bcf</td>
<td>37,328 Bcf</td>
</tr>
<tr>
<td>Coal</td>
<td>11,875 MSTN</td>
<td>n/a</td>
<td>28,580 MSTN</td>
<td>12,434 MSTN</td>
<td>238,773 MSTN</td>
<td>577,431 MSTN</td>
</tr>
<tr>
<td>Electric Power</td>
<td>5,345,000 MWh</td>
<td>1,497,000 MWh</td>
<td>2,468,000 MWh</td>
<td>3,510,000 MWh</td>
<td>4,047,000 MWh</td>
<td>347,437,000 MWh</td>
</tr>
</tbody>
</table>

**Energy Source Used for Home Heating** (share of households)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>66.0 %</td>
<td>50.7%</td>
<td>51.3%</td>
<td>77.4%</td>
<td>59.6%</td>
<td>46.5 %</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>0.1 %</td>
<td>1.7%</td>
<td>0.6%</td>
<td>0.2%</td>
<td>0.1%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Electricity</td>
<td>26.1 %</td>
<td>35.1%</td>
<td>26.9%</td>
<td>18.0%</td>
<td>23.8%</td>
<td>41.0 %</td>
</tr>
<tr>
<td>Propane</td>
<td>4.9 %</td>
<td>5.5%</td>
<td>12.7%</td>
<td>2.5%</td>
<td>10.9%</td>
<td>5.0 %</td>
</tr>
<tr>
<td>Other/None</td>
<td>2.9 %</td>
<td>7.0%</td>
<td>8.6%</td>
<td>1.9%</td>
<td>5.7%</td>
<td>3.5 %</td>
</tr>
</tbody>
</table>

10 All information from US Census Bureau and US Energy Information Association State Profiles.
KEY SECTIONS OF THE IRA

This section will describe the basics of the three sections of focus within IRA – weatherization, household scale electrification, and electric vehicle adoption – and their intersection with public health.

WEATHERIZATION

Weatherization basics

Weatherization is the whole-home approach to energy saving by protecting the building from outside elements, such as wind and snow, via building envelope improvements and can include energy efficient upgrades. Following a home energy audit to understand the home’s energy use, recommended renovations can include adding insulation in the attic, floors, or walls; sealing the home to prevent air leakage; protecting against rain penetration; and replacing appliances such as stoves and water heaters. Weatherization improvements can decrease household energy burden, reduce GHG emissions, strengthen resilience to climate change, and improve human health.

Weatherization and public health

Growing research highlights weatherization’s impact on positive health outcomes and impact on SDOH. The US’s legacy of environmental injustice is directly related to low income residents' exposure to housing-related health problems (GHHI, 2017). Such weatherization benefits include: fewer temperature related deaths, decreased risk of asthma and fewer asthma symptoms, decreased risk of heart disease and other chronic disease, decreased stress and anxiety, and reduced energy burden (Tonn et al., 2014; GHHI, 2017; Drehobl et al., 2020). High
energy burden is defined as spending 6% or more of one’s income on household energy costs (Drehobl et al., 2020). Households with high energy burdens are most likely to remain in cycles of poverty (Drehobl et al., 2020).

In chronic disease treatment, one’s physical environment can directly impact health care treatment plans. Social programs are working to combat housing health disparity outcomes and understand what parts of the home may be impacting someone’s health (Tonn et al., 2014; GHHI, 2017). Weatherization measures are also associated with fewer temperature-related deaths and less incidence of hypertension when indoor temperature and humidity are improved. Figure 4 below describes some of the measures that may be taken in residential weatherization and the subsequent human health impacts. For example, adding home insulation leads to improved indoor temperature and humidity, causing fewer temperature-related deaths and less incidence of hypertension.

**Figure 4: Occupant Health and Indoor Environmental Benefits of Residential Energy Efficiency (E4TheFuture, 2016)**

- **Insulation Air Sealing**: Warmer drier air, improved indoor temperatures & relative humidity
- **Heating System Upgrades**: Fewer heat or cold related deaths, Less hypertension, heart disease
- **Ventilation Vent Dryers**: Fewer asthma, respiratory, Chronic Obstructive Pulmonary Disease risks, Fewer heart disease risks, headaches
- **Efficient Cooking Appliances**: Fewer cancer risks due to radon, formaldehyde, other sources, Less stress, better mental health
- **Reduced hospital or medical visits**: Lower bills, better comfort
HOUSEHOLD SCALE ELECTRIFICATION

Household electrification basics

Household scale electrification is the shift from fossil fuel powered home appliances, such as gas stoves, to ones that utilize clean electricity for cooking or heating, such as induction stoves and heat pumps. Indoor combustion occurs with fossil fuel powered appliances, releasing gasses and particles, such as CO and PM2.5. The International Residential Code requires that space and water heating combustion appliances be vented outdoors to prevent indoor exposure to harmful exhaust, which increases outdoor pollutant concentrations (Batterman Burge, 1995). Indoor leakage from these combustion heaters can still occur and cause increased indoor concentrations. Upgrading an HVAC system to a heat pump increases energy efficiency and reduces the household number of appliances. Heat pumps replace both an air conditioning and a central heating system. Gas stoves can be removed in favor of electric or induction stoves. Figure 5 highlights the efficiency differences between gas, electric, and induction stovetops.

Figure 5: Gas, Induction, or Electric Stovetops? (WE ACT, 2023)
Household Electrification and Public Health

As mentioned in the above section, combustion from household appliances releases gasses and particulate matter which impact public health both indoors and out. Ambient air pollution from indoor combustion appliances can increase the effects of climate change and lead to illness and death. Global PM air pollution, specifically, is estimated to cause 4 million premature deaths annually (World Health Organization [WHO], 2021). Zu et al. (2018) found that if combustion appliances were electrified in California, 354 deaths would be avoided and there would be approximately $3.3 billion in monetized health benefits.

Household electrification has several indoor public health benefits. The negative health impacts of PM2.5 are well studied and associated with increased risk for respiratory diseases and inflammation (Xing et al., 2016). Other pollutants, including CO and NOx, also contribute to poor indoor air quality (Belanger and Triche, 2008).

Low-income individuals may live in older homes with leakier windows and less insulation. This plus the high costs may lead households to leave the door to a gas oven open for supplemental heating. High concentrations of CO can cause carbon monoxide poisoning and death (“Carbon Monoxide Poisoning”, n.d.). High natural gas prices can also lead to the heat-or-eat dilemma in which households have to make a trade-off between food consumption and paying for heating (Burlinson et al. 2022). Electrifying household appliances can lessen this burden on households and will improve indoor air quality.

As states, including Colorado, promote stricter emissions standards, consumers may be more likely to purchase electric stoves when renovating or building new homes (Leber, 2021; Colorado Energy Office [CEO], n.d.). Electric appliances can have higher upfront costs. For example, the cost of a new heat pump ranges from $2,000-$10,000 but can increase if other
construction must occur to properly install them (Technology, n.d.). Compare this to the average cost of an oil furnace is $4,700 and it's unlikely any changes in hook up are required for installation. Regardless of upfront cost, electric appliances remain the healthiest option for individuals.

**ELECTRIC VEHICLE ADOPTION**

**Electric vehicle adoption basics**

Vehicles fall into two categories: light duty and heavy duty. The EPA classifies light duty as those vehicles that weigh under 8,500 lbs, and heavy duty are those vehicles that weigh over 8,500 lbs. Generally light duty vehicles range from a small sedan to a large sport utility vehicle and heavy duty is everything else (Joshi and Gokhale-Welch, 2022). This report focuses on adoption of heavy duty electric vehicles, specifically school buses and public transit vehicles.

**Electric Vehicle Adoption and Public Health**

EVs continue to provide greater health, energy, and cost benefits than their fossil fueled counterparts. Transitioning to EVs from traditional fossil fuel powered vehicles provides a range of health and economic benefits (“Electric Vehicle Basics”, 2019; Joshi & Gokhale-Welch, 2022). For example, EVs do not emit GHGs or PM2.5 from tailpipe exhaust. This decreases global climate change as well as local and regional air pollution. Many reports note that the EV transition will benefit many people, but vulnerable, low-income communities will be left behind (Karner et al., 2020; Hardman et al., 2021; University of Michigan News, 2023). The IRA includes tax credits/rebates towards personal EVs but these do not come off of the initial car
price and are applied later on, making this purchase more difficult for those without the financial means.

Growing attention has been placed on the heavy-duty EV transition. Heavy-duty zero emissions vehicles (ZEVs) require robust infrastructure change to ensure buses are ready for their routes (Rhode Island Department of Transportation, 2021).\textsuperscript{11} Individuals in vulnerable communities are more likely to live closer to roadways and take a bus over a personal vehicle, thus putting them at higher risk of inhaling carcinogenic vehicle emissions (WHO International Agency for Research on Cancer, 2012; Moses, 2023). There is also evidence that neighborhoods most impacted by air pollution were especially devastated by COVID-19 due to a lifetime exposure to PM2.5 pollution (Wu et al., 2020).

PART III: METHODS

Why Colorado and the IRA were chosen

The IRA is the largest climate bill in the history of the US. With $370 billion available toward climate and clean energy goals, states have a lot of work to do to ensure this funding influx provides the best benefits. To do so, states should focus on local level actions and target weatherization, electrification, and electric vehicle adoption in their planning. Colorado has a history of cross-disciplinary communication and action as well as vested interests in both renewable energy and fossil fuels.

Government websites, policy reports, news articles, and peer-reviewed literature were used to contextualize the IRA in Colorado. Seminars and semi-structured interviews were also used to further understand case study examples. Information from the US Census Bureau,

\textsuperscript{11} ZEVs are any vehicle that does not use a combustion engine and does not emit exhaust gas or other pollutants (NC DOA, n.d.).
Colorado Demographics Office, and the US Energy Information Administration (EIA) were used to explore population and energy use trends in Colorado compared to other states in the Rocky Mountain Region.\(^\text{12}\)

**How case studies were chosen**

Often, public health studies are done after the program implementation following energy or climate policy to evaluate health co-benefits. For example, an International Energy Agency (IEA) study found that after implementation of low-income energy-efficiency programs, utilizing the appropriate forms of energy for heating reduced the risk of accidents, fire, and carbon monoxide (CO) poisoning (IEA, n.d.). Most often, energy program evaluation is limited to energy bill savings. Drawing from Crowe and Stake’s case study research in the social sciences, case studies were instead chosen for their intrinsic characteristics (Stake, 1995; Crowe et al. 2011). An intrinsic case study is undertaken to learn about a unique program and what distinguishes it from others. Here, to understand the impact of public health metrics, cases were chosen for their direct inclusion of public health in the planning and execution of the energy initiative or program.

**How case studies were analyzed**

In Part IV, each case study discusses problem orientation, study objective, study design, and analysis. Individual analysis is touched upon within each case study, but more detailed cross-case study analysis is found in Part V. Case studies were evaluated based on effectiveness and efficiency. Effectiveness asks, “Is this intervention achieving its objectives?” and “Did the initiative successfully address inequity?” Efficiency asks, “How well are resources being used?”

\(^\text{12}\) The Rocky Mountain Region includes Colorado, Idaho, Montana, Utah, and Wyoming (EIA, 2022).
Part V collectively reviews the case studies in weatherization, household electrification, and electric vehicle adoption and how they may benefit Colorado. Here feasibility and public health impact are also included. Appendix A includes a list of questions and sub-questions used in the analysis. Sub-questions were taken from CDC, OECD, and the Food and Agriculture Organization of the United Nations (FAO).

PART IV: CASE STUDIES

1. WEATHERIZATION
Case study: King County Weatherization-Plus-Health

Problem orientation

A 2004 Seattle-King County Healthy Homes study focused on asthma outreach and education for children living in low-income households (defined as income below 200% of 2001 poverty threshold or the child’s enrollment in Medicaid) (Krieger et al., 2019). Researchers explored the differences in high- and low-intensity asthma interventions. Both interventions included basic asthma education and an initial home assessment of indoor environmental asthma triggers. The high-intensity group was also provided with additional social support and materials to decrease exposure to asthma triggers. Results also showed decreased asthma symptom days and increased caregiver quality of life.

However, researchers noted that due to resource constraints, the study did not cover all possible interventions. Namely, that necessary structural home improvements for low-income children were not provided. The 2010 King County Weatherization-Plus-Health study sought to close this research gap.
Study Objectives

The King County Weatherization-Plus-Health study assessed the benefits of adding weatherization-plus-health initiatives to a community health worker asthma education program. This was the first study to explore the direct impact of weatherization upgrades on asthma outcomes (Breysse et al., 2014; US Department of Energy [DOE], 2012).

Study Design

Researchers used a mixed methods, quasi-experimental design to demonstrate causality between the addition of weatherization to Community Health Workers (CHWs) in-home education programs. In both the study and comparison groups, children and their caregivers were interviewed to classify their asthma as well controlled, not well controlled, or very poorly controlled in accordance with National Heart, Lung, and Blood Institute (NHLBI) guidelines (National Heart, Lung, and Blood Institute [NHLBI], 2007). Interviews also included a caregiver quality of life assessment. The study group received in-home “weatherization” and “health” audits to determine the scope of structural intervention. The weatherization audit included diagnostic tests of air tightness, combustion safety, heating, and moisture-related problems. The health audit assessed asthma triggers that may be treated by weatherization interventions beyond routine measures. Replacing carpet and installing bathroom fan timers were the most common structural interventions performed post-audit, occurring in 91% and 82% of homes, respectively.

Stakeholders

The King County Weatherization-Plus-Health study community partners included rental property owners, the King County Housing Authority, Public Health Seattle–King County, the

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13 Quasi-experimental studies are studies that aim to evaluate interventions but that do not use randomization.
National Center for Healthy Housing, Highline School District, Neighborhood House, community health workers, weatherization contractors, and, importantly, low-income residents (Breysse et al., 2014; Eklund, 2017).

**Analysis of Study Objectives**

**Effectiveness**

By understanding the disparities in asthma morbidity from disproportionate indoor environmental trigger exposure, researchers prioritized low-income residents in this study, a commonly excluded group (Breysse et al., 2014). The study also provided evidence toward weatherization as a means of asthma control and general health improvement. The percentage of children with poorly controlled asthma decreased more in the study group than the comparison, from 100% to 28.8% and 100% to 51.6%, respectively (Breysse et al., 2014). Further, caregiver quality-of-life improved by a “clinically important difference” \( (P = 0.002) \) in the study group compared to that of the comparison. These effects can further be attributed to weatherization changes as improvements to caregiver cleaning activities were not found between groups.

**Efficiency**

This project had initial inefficiencies in implementation and service integration. King County Weatherization-Plus-Health was the first to work on both weatherization and health simultaneously rather than to assess human health co-benefits following a study. Both the weatherization and education programs ran in parallel causing participants to meet many specialists delivering a wealth of information early on (Breysse et al., 2014). Some participants were left feeling overwhelmed and dropped out of the study (Eklund, 2017). This experience did,
however, allow researchers in a similar 2017 weatherization and health study to improve their efficiency and service integration. Instead, the 2017 study lagged weatherization installations 6-9 months behind the initial home visits as not to overburden participants (Eklund, 2017).

Initial enrollment design led to inefficiencies in later parts of the study. Study participants were selected from interested families with at least one child using asthma medication during the school day and who had medical verification of an asthma diagnosis (Breysse et al., 2014). Outside of residing in a rental property, housing type did not determine study eligibility. This resulted in limited weatherization intervention availability in single apartments within multi-family establishments because the housing authority was not treating the entire building. Had this study’s enrollment stemmed from weatherization needs as opposed to asthma needs, the housing authority would have more likely treated the entire building, rather than only the study child’s apartment. Also, the housing authority may perform limited weatherization interventions if at least 50% of the residents of a multifamily home are income-eligible (Breysse et al., 2014).

**Case study: Contra Costa Asthma Initiative**

**Problem orientation**

Contra Costa, a California county east of San Francisco, suffers from poor health and significant health disparities (Maizlish et al, 2017; Klein et al., 2019). The county is ranked in the top 25% of California counties for asthma prevalence and asthma-related ED visits – around 5,000 of the county’s 1.15 million residents visited the ED for asthma in 2017 (Klein et al., 2019). Also, the county’s 2015 Health Services report showed gross within-county disparities. This included 8% of wealthier adults self-reporting fair or poor health compared to 29% of the
poorest adult residents self-reporting fair or poor health (Contra Costa Health Services [CCHS], 2010; Maizlish et al., 2017).14

Both the county and California have several initiatives that address potential climate change impacts, however the Contra Costa Health Services’ (CCHS) Ombudsman identified a gap in health and weatherization efforts (Contra Costa County Department of Conservation and Development, 2015; Kent, 2023).15 Public health nurses and community health workers (CHWs) were teaching in-home asthma education and weatherization retrofits were happening in the homes of low-income individuals, but these efforts were disconnected. CCHS saw the need to combine these programs to optimize health benefits and began the Contra Costa Asthma Initiative.

**Study Objectives**

The Contra Costa Asthma Initiative (“the Initiative”) was designed to fill the gap between traditional clinical asthma care and National Heart, Lung, and Blood (NHLBI) recommendations for effective asthma management. NHLBI recommendations include control of environmental factors, of which many can be accomplished by weatherization (NHLBI, 2007; Klein et al., 2019)). The Initiative sought long-term impact by directly addressing racial health inequities within housing (Green and Healthy Homes Initiative [GHHI], 2019).

The Initiative stood out from others because it addressed the direct connection between energy efficiency and asthma mitigation and used this connection to seek bolstered opportunities

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14 Contra Costa County health data from 2010 is the most recent available. The same numbers are cited in Maizlish et al. 2017.
15 An Ombudsman works for a government agency and responds to the publics’ questions and concerns about the agency's activities. (CCHS, n.d.)
for cross-disciplinary partnerships, such as with medical insurance and local energy efficiency groups.

**Study Design**

The Initiative was designed to supplement existing care structures by adding in-home asthma education with public health nurses or CHWs (Klein, 2019). This expansion occurred in two ways, the program included a remediation service, and the leaders of the initiative worked to develop an operational proficiency guide for a home-based delivery model. This guide would act as the future for generalizability of this model and would serve as a blueprint for securing funding to address SDOH.

Contra Costa established partnerships between CHWs and weatherization contractors to work on a referral system (Kent, 2023). Emergency department (ED) physicians would recommend that their asthma patients contact CCHS, who would then put the individual in touch with the Initiative. From there, workers with the Initiative would coordinate next steps with contractors and CHWs. CCHS did not conduct a randomized control trial to analyze changes in asthma symptoms or asthma-related ED care. Rather the goals were to work cross-disciplinary and make changes in real-time.

This was a multi-component effort that included home visits, assessment and remediation, weatherization services, and program support functions. Home assessments were completed by Contra Costa Health Plan’s Population Health program as trained by GHII. During home assessments, CHWs were able to capture asthma information before and after the initiative for later analysis.
Stakeholders

Initially, the only groups involved were CCHS, CHWs, GHHI, weatherization contractors, and participants (Kent, 2023). But after finding the start to be helpful for participants, the California Health Department and Regional Asthma Management and Prevention reached out for partnership and together applied for additional funding through EPA grants (Klein, 2019; Kent, 2023).¹⁶ This continued as more organizations became interested in the joint weatherization-health effort. Additional partners included: BayREN, MCE, Sierra Health Foundation, and local energy efficiency groups.¹⁷

Analysis of Study Objectives

Effectiveness

Due to the Initiative’s chosen research methods and the lack of study data, effectiveness cannot be quantified. However, the Initiative has been recognized by the EPA as a good model for cross-sector solutions in addressing indoor environmental determinants of health and for reimagining asthma care, climate resilience, and equity (EPA, 2023). Project participants also recognized and appreciated the effectiveness of the Initiative. One participant felt that “[their] communities don’t get the attention we need. I feel most healthcare services are negligent towards us. I’m thankful that our communities are being targeted. It’s making a difference for my family and is very helpful” (Klein, 2019).

¹⁶ The Regional Asthma Management and Prevention (RAMP) works to build capacity to reduce the health burden of asthma (RAMP, n.d.).
¹⁷ BayRen (Bay Area Regional Energy Network) is a network of nine California county governments who promote regional level resource efficiency to improve community resilience (Bay Area Regional Energy Network, 2023). MCE is a not-for-profit renewable electricity utility company serving many California communities, including Contra Costa county (MCE Community Choice Energy, n.d.). The Sierra Health Foundation is a private philanthropy focused on improving health equity in California (Sierra Health Foundation, n.d.).
The Initiative was unable to work with some research institutions due the nature of their study, and therefore lost some funding opportunities. However, because of its non-research based model, the program was able to change as stakeholders saw fit based on real world circumstances. For example, the initial recruitment process involved a virtual and in-person assessment of the participants and their home and followed by intervention confirmation by the landlord (Kent, 2023). However, CCHS found this recruitment method to be a waste of time as landlords rarely agreed to the renovations. Instead, the program pivoted to a 30-minute phone assessment to determine household eligibility for energy efficiency improvements. Then, CCHS would get permission from the landlord on making changes. This would have been less feasible in a structured study.

GHHI applied their evidence base to the Contra Costa model to estimate the financial impact. With approximately $3500 spent per client, if one ED visit is avoided then the cost per participant breaks even (Kent, 2023). If two visits are avoided, there is approximately net $3000 per client.

Further, the Initiative was awarded an EPA technical assistance grant in 2018 to continue their work (EPA, 2023).

**Efficiency**

The efficiency of the pilot Initiative cannot be determined with available information. However, the efficiency of the start of the 2018 extension can be evaluated and provides helpful insight for Colorado implementation.

Following the receipt of the EPA grant, continuing work into 2019 proved difficult and inefficient. Originally planned to begin in 2019, the Initiative could not continue as planned until
winter/spring 2023 (Kent, 2023). COVID-19 slowed home weatherization assessments and remediations as CCHS workers were not allowed inside. However, CHWs were still able to provide asthma education surrounding mitigation and management of indoor environmental triggers (Kent, 2023). Staff turnover left the Initiative without enough CHWs. Once one was hired, training took another six months before work started again (Kent, 2023).

From 2018–2020 there have not only been many budget changes, but energy efficiency and administration costs are also higher than anticipated. This likely impacted both effectiveness and efficiency as there were fewer staff than required to complete the amount of work necessary, as seen in the above staff turnover example.

2. HOUSEHOLD ELECTRIFICATION

Case study: WE ACT – Out with Gas, In with Justice

Problem orientation

As part of New York City’s climate commitment, the New York City Housing Authority (NYCHA) plans to electrify all of its buildings by 2050 (Slanger, 2020; WE ACT for Environmental Justice [WE ACT], 2023). By as early as the end of 2023 New York City will ban all gas heaters, stoves, and water heaters in new buildings. New York City must then work to retrofit existing buildings for electrification, including public housing (Daoda et al., 2023; WE ACT, 2023). Minimal research has focused on the electrification transition in low-income housing, particularly public housing (WE ACT, 2023).

As mentioned in Part II, residential gas use disproportionately impacts low-income people of color as these communities are more likely to live in older housing with old appliances in disrepair. Understanding the transition to household scale electrification in these communities is imperative to ensuring culturally competent installation and long-term electrification success.
WE ACT for Environmental Justice (WE ACT) is a New York City-based organization dedicated to ensuring that low-income residents and residents of color have access to healthy communities in a healthy environment. Much of WE ACT’s centers on social determinants of health, such as housing, and researchers sought to fill the research gap in electrifying public housing (Daoda et al., 2023; WE ACT, 2023).

**Study Objectives**

To understand the nuances in retrofitting old New York City buildings and to determine its feasibility, WE ACT piloted Out of Gas, In with Justice. This pilot study explored potential hurdles in switching from gas to electric stoves with public housing tenants. Additionally, the pilot compared improvements in both indoor air quality and participant satisfaction across households that transitioned to an induction stove (the case group) and those that kept their gas stove (the control group). The final objective of Out of Gas, In with Justice was to provide policy recommendations for electrification and indoor air quality in affordable housing.

**Study Design**

Twenty apartments at the Sotomayor Houses, a 96-unit NYCHA building, were split into intervention and control groups, those that received an induction stove and those that kept their gas stoves. Induction stoves were chosen over electric stoves as they are more energy efficient, cook food faster, and once a pot is removed from an induction burner, the heating stops (WE ACT, 2023). This reduces the possibility of accidents.

Week-long air quality monitoring periods were done three times over 10 months in each residents’ home. Researchers were looking for how the air quality changed over time with the
addition of the induction stove. Controlled Cooking Tests were performed to compare air quality while cooking on a gas stove versus an induction stove while controlling for cooking conditions. Stove usability focus groups encouraged study participants to share their thoughts on the stove and transition.

Following the study’s completion, participants in the control group were also transitioned to induction stoves.

**Stakeholders**

WE ACT’s community partners included the NYCHA, the Association for Energy Affordability, Berkeley Air Monitoring Group, Columbia University Mailman School of Public Health, RMI, and independent electric contractors. The project also partnered with a local chef to create instructional videos (in English and Spanish) for prepping healthy, affordable, culturally relevant meals using their new induction stove.

**Analysis of Study Objectives**

**Effectiveness**

This intervention was highly effective in gaining insight into all three of WE ACT’s objectives. The Controlled Cooking Tests found that when cooking with gas stoves, apartments had NO2 concentrations 190% higher than those with induction stoves (WE ACT, 2023). Households with induction stoves also experienced a 35% reduction in daily NO2 concentrations, when controlling for temperature and apartment-level factors. Elevated NO2 levels are problematic as even low concentrations (20-40 ppb) can increase mortality risk in older populations by 3% (Yaguang Wei et al., 2021).

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18 Parts per billion (ppb).
Out of Gas, In with Justice research also considered culturally appropriate outreach within the study. Outreach staff were representative of the participants, spoke English and Spanish, and were able to remove research jargon to clarify study health and safety benefits to participants (WE ACT, 2023).

The qualitative themes found during focus group discussions were generally positive. Participants loved the switch to induction (WE ACT, 2023). They found that food cooked faster, the stovetop was easier to clean, and that the stove created a safer cooking environment. Many also had expressed safety concerns about gas leaks. One individual stated about a recent gas leak that “[the gas smell] was really bad, so strong that you would have probably passed out [...] God forbid if someone was in the hallway and lit a match; I would’ve been blown to smithereens.” With the change to an induction stove, participants “don’t have to worry about a fire in the apartment. The rest doesn’t matter” (WE ACT, 2023). These quotes illustrate the worry and mental health concerns that individuals face regarding old gas appliances in their home.

Negatively, however, focus group discussions also uncovered that many participants felt a lack of respect from the study and that there was an absence of human dignity. Induction stove retrofits required new electrical wiring to handle the increased electrical load. The wiring installation did not take home aesthetics or resident preference into account. While this may have been due to installation efficiency and cost, participants expressed discontent (WE ACT, 2023). One stated, “Why would you bring the cable casing all the way around the house like we don’t matter? Just because it’s NYC housing (meaning NYCHA housing), we don’t matter.” Clearly, future programs should strive to treat the participants with dignity and respect and give them a voice in the process.
Efficiency

The Sotomayor Houses have limited electrical capacity. This restricted the amount of participants that could be enrolled, even though they were interested and met the requirements. Scheduling multiple partners to work in participating households decreased efficiency. Also, some data was lost due to limited apartment access when researchers were not always able to fix malfunctioning equipment in time.

Utilizing public housing and working in partnership with the NYCHA allowed the pilot to bypass potential landlord problems. Many tenant-focused electrification projects face hurdles due to split incentives (WE ACT, 2023). The high upfront cost removes motivation for landlords to upgrade old gas appliances to electric as they are not paying the electricity bills, which will be lower over time.
Maryland’s Proposal for State Energy Security: An example of IRA funding potential

Figure 6: Federal and State Resources Available to Maryland (GHHI, 2023)

While not a complete case study, Maryland’s proposal for state energy security provides an example of IRA funding potential. Sustained inequities in Maryland’s housing sector have increased energy insecurity in disadvantaged communities and distanced the state from their climate goals. Left behind, low-income households only received 57 cents per dollar contributed to EmPOWER, the state’s largest energy efficiency program (GHHI, 2023).

Within new funding available through IRA and the Bipartisan Infrastructure Law (BIL), Maryland needs to figure out a new way to meet low-income home energy needs. The Maryland Department of Housing and Community Development proposed an initiative focused on whole-home retrofits from a one-stop-shop approach. The program would encompass health and safety interventions, weatherization,
electrification, and energy assistance for low-income individuals. The cross-sectoral approach fosters fund coordination and program flexibility to real-time circumstances.

Researchers estimated that Maryland would receive $2 billion in funding over a decade. The IRA could provide almost a quarter of the proposed funding, $471.3 million and the most allocated from the federal level, as shown in Figure 6 on the left (GHHI, 2023). The opportunity to utilize IRA funding to improve equity is paramount.

3. ELECTRIC VEHICLE ADOPTION

Case study: Rhode Island VW Settlement Funds

Problem orientation

Volkswagen reached a $3 billion settlement with the EPA following Volkswagen’s violation of the Clean Air Act. Illegal emissions control software was installed in several Volkswagen diesel vehicle models resulting in emissions 40 times the NOx concentration allowable by the EPA (BBC News, 2015; Casale and Mahoney, 2019). The Environmental Mitigation Trust, created by the $3 billion settlement, established pollution reducing transportation projects in efforts to mitigate the harm done by Volkswagen through their emissions cheating (Casale and Mahoney, 2019). Funds were distributed to impacted states, including Rhode Island.

Rhode Island received over $14M in settlement funds from the Environmental Mitigation Trust (Callahan, 2018). Transportation is the largest source of GHG in Rhode Island and the state recognizes that vehicle emissions are linked to public health (Rhode Island Department of

19 A full list of affected diesel vehicle models is found on the EPA Volkswagen Violations website (EPA, 2015).
Transportation, 2021). A recent study found that 119 premature deaths were attributable to vehicle emissions in 2016 (Arter et al., 2021; Rhode Island Department of Transportation, 2021). Rhode Island KIDS COUNT, a policy and advocacy organization focused on equitable improvements in the lives of children, found that Black and Hispanic children had much higher rates of asthma-related ED visits than their white peers (Rhode Island KIDS COUNT, 2022; Rhode Island KIDS COUNT, n.d.). Importantly, Rhode Island recognizes this unequal impact of vehicle emissions on people of color and environmental justice communities (Callahan, 2018, Rhode Island Department of Transportation, 2021).

Presented with a unique opportunity to accelerate transportation electrification, Rhode Island used the Environmental Mitigation Trust funding to address methods of air quality improvement in historically marginalized communities (Callahan, 2018; Rhode Island Department of Transportation, 2021). Rhode Island provides an excellent example of a data driven and health equity-centered approach to vehicle emissions reduction.

Study Objectives

Rhode Island’s Beneficiary Mitigation Plan Volkswagen Environmental Mitigation Trust Agreement strove to reduce emissions in poor air quality areas and areas that receive disproportionate concentrations of air pollutants from diesel engines (Callahan, 2018). The state believed that advancing electrification through the public transportation sector would be most impactful. To test this, Rhode Island Public Transit Authority (RIPTA) leased three electric buses to explore air quality changes and public impact from 2018–2021 (Callahan, 2018).
Study Design

Rhode Island's plan contained two project categories. Category one included the RIPTA bus replacement project and category two invested in light-duty ZEV supply equipment. This case study focuses solely on category one.

The RIPTA bus replacement plan had two phases (Callahan, 2018). In Phase 1, RIPTA leased three all-electric public transit buses and the associated charging equipment for three years. Leasing the vehicles was chosen over purchasing as the waitlist to purchase was two years long (CleanTechnica, 2022). If the ZEV buses were determined to be effective and efficient, Phase 2 would then involve upgrading more of the public transit fleet to ZEV buses.

The study also allocated approximately 15% of funds ($2.15 million) to administrative expenditures (Callahan, 2018). This spending included training, construction costs associated with facility alterations, and required semi-annual reporting on the status of mitigation project implementation.

To prioritize bus route electrification, researchers mapped RIPTA bus routes relative to environmental justice areas, Rhode Island schools, children living in poverty, and the total NOx emissions per county. Figure 7, on the left, shows a map of RIPTA bus routes relative to environmental justice areas, Rhode Island schools, and total NOx emissions percentages by county. Figure 9, on the right, shows a map of the percent of children ages 7-12 with an asthma claim, 2010-2012, and the percent of children under 18 living below poverty level.

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20 Zero-emission vehicles (ZEVs) include battery electric vehicles (EVs), plug-in hybrid electric vehicles, and fuel cell electric vehicles (California Air Resources Board, 2023).
**Figure 7:** Map of RIPTA Bus Routes Relative to Environmental Justice Areas, Rhode Island Schools, and Total NOx Emissions Percentages by County. Created from National Emissions Inventory 2014 data (Callahan, 2018)

**Figure 8:** Map of the Percent of Children Ages 7-12 with an Asthma Claim, 2010-2012, Three-Year Average, with the Percent of Children Under 18 Living Below Poverty. Created by The Providence Plan (Callahan, 2018)
**Stakeholders**

Study stakeholders included the Government of Rhode Island, RIPTA, local nonprofits, and the communities the buses served.

**Analysis of Study Objectives**

**Effectiveness**

Electrified bus routes were planned to span the state, including throughout Providence which has high asthma rates, high emissions concentrations, and environmental justice communities. Instead, all three of the RIPTA electric buses ran on one route, the R-Line, which runs from Washington Park to Pawtucket and has the highest ridership in Rhode Island. This change occurred because, once the 40-foot buses arrived, it was determined that they could not make tight turns as required on the originally planned routes (Anderson, 2022). Also, though marketed as having a 300 mile range per charge, the buses could only go about 100 miles per day (Anderson, 2022). The R-Line route fit within these boundaries and was the piloted route for the electric buses.

This complication could have been minimized had more research been done into various models of ZEV buses to determine the best fit for RIPTA and the environmental justice-centered routes. Even with the above changes, RIPTA deemed phase one of the ZEV pilot effective and has gone on to purchase more ZEVs for phase two.

**Efficiency**

Given the above problems with bus routes, this was not a very efficient project. Again, had more research into various bus models occurred prior to leasing, time might have been saved
later in the study process. However, even with the changes the project still fell within the planned time constraints. The electric buses were leased from 2018–2021 and electric buses for phase two were purchased for 2022.

PART V: ANALYSIS AND RECOMMENDATIONS

This section reviews the overall feasibility and equity considerations of the weatherization, household scale electrification, and electric vehicle adoption initiatives discussed in Part IV. Part V also provides recommendations for Colorado’s implementation of IRA funds, as well as the limitations of this report.

Administrative and Political Feasibility

Colorado is uniquely set up for a successful health-centered implementation of weatherization, electrification, and electric bus adoption initiatives using IRA funds. Governor Polis’ tenure in Colorado has made immense gains in climate and health equity. These include House Bill 19-1261, the Climate Action Plan to Reduce Pollution, and the GHG Pollution Reduction Roadmap. Colorado's obvious executive commitment paired with state funds and incoming IRA funding can bolster Colorado population health.

For maximum impact, Colorado should set targeted SMART goals for state decarbonization. SMART goals are goals that are Specific, Measureable, Achievable, Relevant, and Time-Bound. None of the case studies discussed SMART goals and instead focused on exploratory analysis or initial pilot testing. While exploratory analysis is important, measurable goals ensure appropriate evaluation of benchmarks and improvement. The Colorado Environmental Justice Action Task Force’s Final Report of Recommendations (2022) prioritizes
establishing measurable goals to reduce environmental health disparities in disadvantaged communities. SMART goals will also help close data gaps within these communities and impact further development.

Resource constraints limit the speed of program implementation. To most thoughtfully and practically use Colorado and IRA resources, the state should focus on whole-home retrofits prior to electric vehicle adoption.

Whole-home retrofits pair health, weatherization, electrification, and energy efficiency improvements to jointly address all conditions that make homes healthy (York et al., 2022; WE ACT, 2023; GHHI, 2023; Brookings, n.d.). The transition to electrification encompasses many health benefits. However, household energy costs will remain high if a home is leaky and allows warm air to escape in the winter and cold air to leak in the summer. Weatherization is very important in sealing the housing envelope and decreasing outdoor pollutants’ infiltration indoors, especially as wildfires continue to increase in Colorado (Mills, 2021). Pairing these efforts into one program optimizes costs and allows for cross-sectoral communication and coordination (GHHI, 2023). By creating a singular force, low-income households will see greater health and economic benefits and reduced energy burden.

Heavy-duty transit, including both public transportation buses and school buses, is still very difficult given current grid constraints. More infrastructure changes need to be made before this is feasible and more cost-effective. Also, in comparison to the Rhode Island public transportation case study, the state of Colorado is a much larger area to drive and assess for most equitable bus routes.21 The Front Range may be a good location to start a pilot endeavor for continuation of large scale ZEV buses. The area between Fort Collins and Colorado Springs

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21 Rhode Island has 1.1 million residents and the state covers 1,545 square miles. The population of Colorado is 5.8 million and the state covers 104,185 square miles.
houses 83% of the state’s population, is the most densely populated area in the state and rates amongst the highest in ozone pollution and environmental justice burden (Loevy, 2012). The distance between these two cities is approximately 130 miles, slightly above the distance Rhode Island determined their electric bus could run on a single charge. However, Flagstaff, Arizona, uses electric buses for public transportation and has found that regenerative braking can regenerate power units and recharge the buses battery (“Mountain Line unveils first fully electric buses in Flagstaff”, 2023). Colorado may find that a similar setup works within the Front Range.

Yet, focusing solely on the Front Range ignores the input of rural communities, where public transportation is less readily available. The Roaring Fork Transportation Authority (RFTA) is the largest rural public transportation system in the state and the second largest rural public transit system in the US (Roaring Fork Transportation Authority [RFTA], n.d.). RFTA is primarily located in wealthier portions of the state. Pitkin County, which is supported by RFTA, has a median income of $92,708 compared to $80,184 in Colorado and $69,021 in the US (United States Census Bureau, n.d.). However, as technology continues to improve, more opportunities will arise for cost-effective, widespread heavy-duty public EV implementation.

**Equity Considerations**

Equity and respect are established principles in environmental justice and should be addressed by training, planning, and implementation (WE ACT, 2023). WE ACT’s Out of Gas, In with Justice and Rhode Island’s Volkswagen Environmental Beneficiary Mitigation Plan were the only studies examined that received direct community input. Out of Gas, In with Justice hosted focus groups to understand the direct and indirect impacts the electrification change made in the public housing tenants lives (WE ACT, 2023). For Rhode Island’s Volkswagen

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22 Environmental justice burden determined from EnviroScreen Score.
Environmental Beneficiary Mitigation Plan, the state’s Department of Environmental Management hosted a 30-day public comment period for plan feedback and hosted a two-hour information session to address community questions.

Responses from Out of Gas, In with Justice focus groups directly impacted researchers' next steps and recommendations. For example, human dignity emerged as a core measure within home electrification and should be considered throughout the process. Also, adjusting policies to meet the needs of low-income tenants who have limited control on their home environment was recommended. This highlights researchers' respect for meeting tenants where they are. It is unclear if other studies used community input in study design or in qualitative data analysis.

Equity must also be considered in EV adoption. Equity considerations were detailed in the Rhode Island Volkswagen settlement example, but it is also important that Colorado consider the impact of electric school buses. Diesel powers approximately 95% of school buses in the US (Freehafer and Lazer, 2023; American Lung Association, n.d.). This poses a threat for the 20 million children that ride the bus annually and their communities (Freehafer and Lazer, 2023).23 Diesel engine exhaust is labeled a carcinogen by the World Health Organization and can increase the chance of developing respiratory diseases, cardiovascular diseases, and cancer (World Health Organization, 2012). One study found that retrofitting school buses to eliminate the need for diesel fuel was associated with a significant increase in English test scores and smaller gains in math (Austin et al., 2019). School buses also produce self-pollution as diesel exhaust from the tailpipe enters the in-cabin environment (Li et al., 2015). This in-cabin pollution can be $10^6$ times greater for a student on the bus compared to the average community member (Marshall and Behrentz, 2005). Diesel exhaust contamination may have more effect on low-income children,

---

23 An exact count of Colorado school bus riders was not found, but Colorado’s school bus fleet totals 6,838 total school buses. Less than 1% of Colorado school buses are electric (WRI, 2022; CoPIRG Foundation, n.d.).
Black students, students with disabilities, and those living in rural areas who are more likely to use the bus and to travel longer distances. (Freehafer and Lazer, 2023; EESI, n.d.) Adoption of electric buses in low-income communities offers a solution.

However, the US’s history of structural racism is reflected in school budgets. Electric school buses are more likely to be adopted in wealthier, white communities. School budgets usually come from local taxes (“$23 Billion Full Report”, n.d.; Freehafer and Lazer, 2023) which impacts the ability of low-income areas to purchase electric school buses. However, if programs are designed with equity in mind, then the health impacts can greatly improve across communities. With new funding from both the IRA and the Clean School Bus Program within the BIL, states have the potential to make the jump to electric school buses.

Cultural competency is also important in equity and respect. Competency was highlighted in Out of Gas, In with Justice through the choice of outreach staff and recipe preparation. Outreach staff were representative of the neighborhood in which they worked. Researchers noted that this was the “only reason” recruitment was successful. Researchers worked with a local chef to prepare a recipe book and videos showing how to make culturally relevant items. This was done in both English and Spanish. This included culturally relevant meals, recipe presentation in native languages, and presentation in video format, thus not assuming literacy level. WE ACT’s Out of Gas, In with Justice does an excellent job of understanding the community and context in which they are working and learning what can be improved in the future.
Recommendations

Colorado’s opportunity to allocate IRA funding on vulnerable communities cannot be minimized. To have the most equitable and widespread impact on health, Colorado should include the following actions in their policy planning and action steps:

1. **Engage energy, climate change, and public health stakeholders in all parts of Inflation Reduction Act conversations.** The Contra Costa Asthma Initiative’s engagement with many different entities, from health departments and local energy efficiency organizations, enabled the Initiative to change course as needed for maximum health benefit. The cultural competencies applied in WE ACT’s Out of Gas, In with Justice pilot, such as including focus groups and supplying recipe books in multiple languages, gave a voice to communities usually left behind. Ensuring ideas flow across sectors and include public health organizations knowledgeable in energy injustice and equity considerations will bolster the health of the entire state, not just the wealthy.

2. **Prioritize local level decarbonization.** Targeted local level decarbonization impacts local pollution and health as well as global GHG concentrations. Household weatherization and electrification and electric vehicle public transportation have immediate community-level health benefits. Starting at this level allows all community voices to be heard and incorporated into policy action.

3. **Match state funds with IRA funding to amplify support.** The IRA offers enormous opportunities from federal funding. Maryland’s proposal for state energy security provides an example of amplifying health interventions with state and federal funding. By marrying state funding, the health effects can provide greater impact.
Limitations

This report lacks substantial stakeholder input and lacks any community input. One semi-structured was performed with a leader of the Contra Costa Asthma Initiative. While this did provide information not available through research, it is limited to the input of one individual. As noted in the above equity and cultural competency discussion, practical and effective program implementation should not be done without community input. As much of this report comes from literature review there is also the potential for publication bias. Publication bias is failure to publish results if they are not inline with study expectations (DeVito and Goldacre, 2018). Also, as some of the case studies evaluated are recent, in addition to the Act at the center of this analysis, limited literature is available on the outcome or of followup evaluation.

PART VI: CONCLUSION

Climate change impacts the health of vulnerable populations more drastically than other populations. The Inflation Reduction Act offers a once-in-a-generation opportunity to strengthen community health through weatherization, household electrification, and electric vehicle adoption (United States Department of Energy, 2022). Weatherization retrofits decrease the risk of temperature-related deaths and diseases, such as Chronic Pulmonary Disease and heart disease. Pollutants from household combustion appliances and vehicle emissions degrade indoor and ambient air quality, contribute to the warming effects of climate change, and lead to a host of short- and long-term health impacts for Colorado residents. By taking decisive action, Colorado can lead the nation in equitable, health-centered IRA implementation.
REFERENCES


About | Bay Area Regional Energy Network. (n.d.). Retrieved April 17, 2023, from https://www.bayren.org/about


Climate Action Plan To Reduce Pollution, HB19-1261, Colorado General Assembly, 2019 Regular Session.

CLIMATE CHANGE DECREASES THE QUALITY OF THE AIR WE BREATHE. (n.d.).


EPA. (2023, March 29). Reimagining Asthma Care, Climate Resilience & Equity in Contra Costa, CA: Partnering to Address IEDOH.

EV transition will benefit most US vehicle owners, but lowest-income Americans could get left behind. (2023, January 11). University of Michigan News.
https://news.umich.edu/ev-transition-will-benefit-most-us-vehicle-owners-but-lowest-income-americans-could-get-left-behind/


Kent, M. (2023, April 3). Updates and Details on the Contra Costa Asthma Initiative [Personal communication].


The U.S. needs better, more accessible home weatherization programs. (n.d.). Retrieved April 17, 2023, from https://www.brookings.edu/blog/the-avenue/2022/10/10/the-u-s-needs-better-more-accessible-home-weatherization-programs/


World Resource Institute, Dataset of Electric School Bus Adoption In The United States. https://datasets.wri.org/dataset/electric_school_bus_adoption, Dataset-version 3, sheet 6, cell C8, data through June 2022, last accessed 29 August 2022.


APPENDIX A: Questions and Sub-questions Used in Case Study Analysis

<table>
<thead>
<tr>
<th>criteria</th>
<th>main question</th>
<th>sub-questions</th>
</tr>
</thead>
</table>
| effectiveness             | To what extent did the project achieve its planned outputs and expected/revised outcomes? | Is there evidence of improved livelihoods from the program/initiatives activity?  
|                           |                                                                               | Did the initiative successfully address inequity?                               
|                           |                                                                               | What factors contributed to its effectiveness?                                  |
| efficiency                | How efficient was the project in achieving planned outputs and outcomes?     | Where mechanisms for efficiency were used in the project?                      
|                           |                                                                               | Were the organizational and communication arrangements appropriate?            |
| public health and equity impact | How does the program/initiative address the issue? | What populations will benefit?                                                 
|                           |                                                                               | Will populations be negatively impacted? Why?                                  
|                           |                                                                               | Will the policy impact health disparities?                                     
|                           |                                                                               | Are there data gaps?                                                           
|                           |                                                                               | How does the program/initiative impact morbidity and mortality?                |
| feasibility               | What is the likelihood that the program can be successfully adopted and implemented in Colorado? | What are political barriers?                                                     
|                           |                                                                               | What are the economic impacts?                                                  |
APPENDIX B: Colorado Health Rankings

Continued on next page.
Colorado

State Health Department Website: cdphe.colorado.gov

Summary

Strengths:
- Low prevalence of obesity
- Low economic hardship index score
- Low prevalence of physical inactivity

Challenges:
- High prevalence of excessive drinking
- Low rate of high school graduation
- Low prevalence of having a dedicated health care provider

Highlights:

Smoking
- 34% from 18.3% to 12.0% of adults between 2011 and 2021.

Frequent Mental Distress
- 28% from 11.1% to 14.2% of adults between 2018 and 2021.

Multiple Chronic Conditions
- 19% from 6.4% to 7.6% of adults between 2019 and 2021.

---

Measures

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<th>State Rank</th>
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<th>U.S. Value</th>
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<td>8.8</td>
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<td>Preventive Services</td>
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* Value is a sum of weighted, ranking measure z-scores (the number of standard deviations a state value was above or below the U.S. value).
* Higher summation scores are better. Scores are not calculated for the District of Columbia.
* Disparity measures compare the group with the highest or lowest rate and the white rate.
* Non-ranking measure.

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Overall Rank: 10
### HEALTH OUTCOMES

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<td>Poor mental health days²</td>
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<td>Low birthweight*</td>
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### HEALTH FACTORS

### HEATH BEHAVIORS

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<td>Alcohol and Drug Use</td>
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<td>Access to exercise opportunities</td>
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<td>Alcohol-impaired driving deaths</td>
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<td>Sexually transmitted infections</td>
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<td>Teen births*</td>
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<td>Preventable hospital stays*</td>
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<td>Injury deaths*</td>
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### PHYSICAL ENVIRONMENT

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<tr>
<td>Severe housing problems</td>
<td>2%</td>
<td>Comprehensive Housing Affordability Strategy (CHAS) data</td>
<td>2014-2018</td>
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<tr>
<td>Driving alone to work*</td>
<td>2%</td>
<td>American Community Survey, 5-year estimates</td>
<td>2016-2020</td>
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<tr>
<td>Long commute - driving alone</td>
<td>1%</td>
<td>American Community Survey, 5-year estimates</td>
<td>2016-2020</td>
</tr>
</tbody>
</table>

*Indicates subgroup data by race and ethnicity is available; ¯Not available in all states; ¹2018 data for New Jersey.
<table>
<thead>
<tr>
<th>Measure</th>
<th>Source</th>
<th>Years of Data</th>
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<tbody>
<tr>
<td>COVID-19 age-adjusted mortality</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2020</td>
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<tr>
<td>Length of Life</td>
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<tr>
<td>Life expectancy*</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2018-2020</td>
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<tr>
<td>Premature age-adjusted mortality*</td>
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<td>2018-2020</td>
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<td>Child mortality*</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2017-2020</td>
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<td>Infant mortality*</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2014-2020</td>
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<tr>
<td>Quality of Life</td>
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<tr>
<td>Frequent physical distress¹</td>
<td>Behavioral Risk Factor Surveillance System</td>
<td>2019</td>
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<tr>
<td>Frequent mental distress¹</td>
<td>Behavioral Risk Factor Surveillance System</td>
<td>2019</td>
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<tr>
<td>Diabetes prevalence¹</td>
<td>Behavioral Risk Factor Surveillance System</td>
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<tr>
<td>HIV prevalence¹</td>
<td>National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention</td>
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<tr>
<td>Health Behaviors</td>
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<tr>
<td>Food insecurity</td>
<td>Map the Meal Gap</td>
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<td>Diet and Exercise</td>
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<td>Limited access to healthy foods</td>
<td>USDA Food Environment Atlas</td>
<td>2019</td>
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<td>Drug overdose deaths*</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2018-2020</td>
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<tr>
<td>Alcohol and Drug Use</td>
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<td>Motor vehicle crash deaths*</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2014-2020</td>
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<tr>
<td>Insufficient sleep</td>
<td>Behavioral Risk Factor Surveillance System</td>
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<td>Other Health Behaviors</td>
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<tr>
<td>Uninsured adults</td>
<td>Small Area Health Insurance Estimates</td>
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<tr>
<td>Uninsured children</td>
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<td>Access to Care</td>
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<td>Other primary care providers</td>
<td>CMS, National Provider Identification</td>
<td>2021</td>
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<td>Social &amp; Economic Factors</td>
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<td>High school graduation*</td>
<td>EDFacts</td>
<td>2018-2019</td>
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<td>Disconnected youth</td>
<td>American Community Survey, 5-year estimates</td>
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<td>Reading scores**</td>
<td>Stanford Education Data Archive</td>
<td>2018</td>
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<tr>
<td>Math scores**</td>
<td>Stanford Education Data Archive</td>
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<td>Income</td>
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<td>School funding adequacy*</td>
<td>School Finance Indicators Database</td>
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<td>Gender pay gap</td>
<td>American Community Survey, 5-year estimates</td>
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<td>Median household income*</td>
<td>Small Area Income and Poverty Estimates</td>
<td>2020</td>
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<td>Living wage</td>
<td>The Living Wage Calculator</td>
<td>2021</td>
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<td>Family and Social Support</td>
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<td>Residential segregation - Black/White</td>
<td>American Community Survey, 5-year estimates</td>
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<tr>
<td>Residential segregation - non-White/White</td>
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<td>Childcare cost burden</td>
<td>The Living Wage Calculator, Small Area Income and Poverty Estimates</td>
<td>2021 &amp; 2020</td>
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<td>Childcare centers</td>
<td>Homeland Infrastructure Foundation-Level Data (HIFLD)</td>
<td>2021</td>
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<td>Community Safety</td>
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<td>Homicides*</td>
<td>National Center for Health Statistics - Mortality Files</td>
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<td>Suicides*</td>
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<td>Firearm fatalities*</td>
<td>National Center for Health Statistics - Mortality Files</td>
<td>2016-2020</td>
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<td>Juvenile arrests*</td>
<td>Easy Access to State and County Juvenile Court Case Counts</td>
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<td>Physical Environment</td>
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<td>Traffic volume</td>
<td>EJSCREEN: Environmental Justice Screening and Mapping Tool</td>
<td>2019</td>
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<td>Housing and Transit</td>
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<td>Homeownerships</td>
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<td>Severe housing cost burden</td>
<td>American Community Survey, 5-year estimates</td>
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<tr>
<td>Broadband access</td>
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See additional contextual demographic information and measures online at [www.countyhealthrankings.org](http://www.countyhealthrankings.org)