Exploring Links Between Climate Change, Infant Mortality, and Gender-Based Violence in the U.S.

Abstract- This study explores the intersection of climate change, infant mortality rates (IMR), and gender-based violence in the United States, focusing on the role of environmental stressors such as CO_2 emissions and various extreme weather events. Using a two-way fixed effects model, the analysis uncovers counterintuitive findings, including a negative association between CO_2 emissions, most air pollutants, and IMR, potentially reflecting the indirect benefits of economic development. Conversely, NO_2 exhibits a positive relationship with IMR, emphasizing its harmful impact on infant health. The study highlights income disparities as a key factor, with economic stability reducing IMR despite environmental risks. These findings emphasize the necessity for integrated policies that tackle environmental, social, and economic vulnerabilities to improve public health and promote gender equity in the context of climate change.

Index Terms- *Infant Mortality, Climate Change, Environmental Stressors, Social Inequality*

I. INTRODUCTION

The intersection of climate change and social outcomes, particularly gender-based violence (GBV) and infant mortality (IMR), is a critical but underexplored area of research in the United States. Environmental stressors such as CO_2 emissions and extreme weather events exacerbate pre-existing social inequalities, disproportionately impacting vulnerable populations. Women and children are especially affected due to intersecting vulnerabilities, including limited economic resources, restricted healthcare access, and exposure to social and physical violence.

Research demonstrates that GBV and IMR are interconnected through multiple pathways. GBV, encompassing intimate partner violence and other forms of domestic violence, disrupts maternal health by increasing physical and psychological stress, limiting access to prenatal care, and exacerbating adverse birth outcomes like preterm delivery and low birth weight. These factors contribute significantly to higher rates of infant mortality (Brinda et al., 2015). Similarly, GBV-induced maternal malnutrition and restricted autonomy hinder women's ability to seek healthcare, further elevating risks for their children (Raj & Boehmer, 2013). Evidence also shows that maternal exposure to GBV, including physical and emotional violence, increases childhood morbidity and mortality by impairing caregiving abilities and disrupting the mother-child bond (Dadi et al., 2024).

Climate change increases economic instability, leads to family displacement, and causes resource shortages. These factors contribute to a rise in GBV and negatively impact maternal and child health. For instance, women who are displaced by severe weather events often experience isolation, making them more susceptible to violence. Additionally, the economic strain from climate-related disruptions raises tensions in low-income households, which further elevates the risk of intimate partner violence and its detrimental effects on children's health.

This study explores the impact of climate-related stressors, including CO_2 emissions and extreme weather events, on infant mortality in U.S. states. It focuses on the mediating role of GBV and the influence of socioeconomic factors such as household income. Utilizing a two-way fixed effects model, this research analyzes how environmental stressors exacerbate existing social inequalities, which contribute to public health crises. By clarifying these connections, the study highlights the urgent need for integrated policies that address both environmental and social vulnerabilities, thereby promoting resilience, public health, and gender equality in response to climate change.

II. LITERATURE REVIEW

A comprehensive examination of this complex relationship is presented through two primary sections. The first section explores how environmental stressors exacerbate social inequality, gender-based violence, and collective violence, emphasizing the demographic and social impacts of climate change. The second section assesses the public health implications of climate change, focusing on its effects on fertility, infant mortality, and general health outcomes, including the spread of infectious diseases and mental health challenges.

I. Public and Demographic Impacts of Climate Change

Climate-induced shifts in environmental resources exacerbate existing inequalities, disproportionately affecting vulnerable populations. Gender dynamics play a pivotal role in shaping these outcomes. Ergas et al. (2021) highlight how gender equality influences the carbon intensity of well-being (CIWB), a measure of CO_2 emissions per unit of life expectancy. Their study reveals that increased female representation in parliament and access to education enhance ecological efficiency by reducing CIWB, while, paradoxically, higher female labor force participation can sometimes counteract these gains. This complexity highlights how gender roles, carbon emissions, and levels of economic development are connected.

Disruptions caused by environmental crises also elevate the risks of GBV, particularly in resource-scarce settings. For example, Agrawal et al. (2023) demonstrate how the COVID-19 pandemic intensified food insecurity, disproportionately impacting women and marginalized populations. Such findings emphasize the urgent need for targeted interventions to address GBV in the context of environmental shocks. Similarly, Barbier and Hochard (2018) document how cycles of poverty and environmental degradation in low-elevation coastal zones and marginal agricultural areas perpetuate social inequalities. These regions face compounded risks, including higher infant mortality rates and increased vulnerability to violence driven by resource scarcity and displacement.

The wider effects of these dynamics are clear in research that connects climate change to both group violence and individual violence. Levy et al. (2021) demonstrate that competition over diminishing resources fuels collective violence, while Henke and Hsu (2020) show that extreme weather events exacerbate intimate partner violence, particularly in economically disadvantaged households. Interventions that expand women's economic opportunities, such as increasing labor market participation, have been shown to mitigate both resource-driven and expressive forms of violence (Henke & Hsu, 2020). These findings underscore the need for integrated policies that address environmental, economic, and social vulnerabilities simultaneously.

II. Health Impacts of Climate Change on Fertility and Public Health

Climate change has various health implications, including changes in fertility patterns, higher mortality rates, and the rise of new public health challenges. Rising global temperatures significantly influence fertility rates, particularly in economically vulnerable regions. In tropical countries near the equator, agricultural disruptions caused by climate variability lead to higher fertility rates and reduced investment in education, exacerbating inequities between poorer regions and wealthier northern nations, where fertility rates decline alongside rising educational investments (Casey et al., 2019). These demographic shifts underscore how climate change perpetuates cycles of poverty and inequality. Higher carbon emissions are correlated with negative health outcomes, including reduced life expectancy and higher mortality rates, although these effects vary by nation (Li et al., 2023). Nonrenewable energy consumption, particularly in lower- and upper-middle-income countries, mediates the relationship between energy use and infant mortality through increased carbon emissions. This dynamic is evident in regions such as Asia and the Pacific, where carbon-intensive energy usage indirectly raises infant mortality rates (Adeleye et al., 2023).

Beyond its immediate effects, climate change poses broad and long-term risks to public health, encompassing the spread of infectious diseases, increased natural disasters, and mental health challenges (McMichael et al., 2006). Vulnerable populations are more severely impacted because they frequently do not have the necessary resources and infrastructure to cope with increasing threats. The intensification of these risks due to rising global temperatures highlights the critical need for public health initiatives and climate adaptation strategies to reduce the future health consequences of climate change.

III. DATA AND METHODOLOGY

This study utilizes a comprehensive dataset that encompasses multiple U.S. states over various time periods, sourced from reliable agencies such as the Centers for Disease Control and Prevention (CDC) and the Environmental Protection Agency (EPA). The dataset captures a diverse range of variables, carefully selected for their relevance to public health and social vulnerability. Environmental factors include CO2 emissions, which serve as a proxy for overall environmental degradation and climate change. While CO2 itself does not directly harm health, it reflects systemic changes like global warming and ecological imbalances that can disrupt maternal and child health (WHO, 2024). Air quality indicators, including PM10, Ozone (O3), and Nitrogen Dioxide (NO2), offer localized assessments of pollution levels. These pollutants are closely associated with respiratory diseases, negative pregnancy outcomes, and risks to neonatal health, particularly impacting vulnerable groups. PM10, which stands for particulate matter, consists of tiny particles in the air small enough to penetrate deep into the respiratory tract. Exposure to PM10 has been associated with lower birth weights, increased risks of premature births, and respiratory infections in infants (WHO, 2024). Similarly, Ozone, a reactive gas formed from chemical reactions between sunlight and pollutants such as vehicle emissions, is known to exacerbate respiratory problems and increase the likelihood of preterm births and infant mortality (EPA, 2022). In contrast, NO2, a gas mainly generated by combustion activities such as vehicle emissions and industrial processes, is associated with lung inflammation, decreased lung function, and heightened risks of negative pregnancy outcomes.

The dataset also includes extreme weather events like droughts, floods, tropical cyclones, and winter storms, which capture the direct impacts of climate change on infrastructure, healthcare delivery, and food security. These events frequently cause displacement and hinder access to vital services. Economic indicators, such as median household income and population, complement these environmental and climatic factors. Median income reflects economic stability, a crucial determinant of public health, as higher incomes enable access to better nutrition, housing, and healthcare. Population size and density serve as proxies for urbanization, which brings both advantages, such as better healthcare facilities and challenges like pollution and resource strain.

Exploratory Data Analysis (EDA) was conducted using the R programming language to thoroughly clean and analyze the dataset. The EDA included visualizations such as graphs showcasing the averages of IMR, CO2 emissions, and air quality pollutant. These visualizations also captured the interaction between variables, offering insights into how environmental and socioeconomic factors correlate with IMR. Multiple tables highlighted the top states with the highest IMR and CO2 emissions, along with states that showed significant variations, offering a clearer insight into geographic differences. The relationship between these various variables across states and over time was examined using a two-way fixed effects model. This model was chosen for its ability to account for unobserved differences by including state-level and time-level fixed effects, enabling the isolation of the impact of independent variables from consistent confounders across states or time periods (Wooldridge, 2010). A weighted regression method was used, with population size as the weight, to ensure that larger states had a proportional impact on the analysis. Robust standard errors were clustered at the state level to account for heteroskedasticity and possible serial correlation, ensuring that the results were statistically valid and reliable.

IV. EMPIRICAL RESULTS

Infant mortality rates have shown a declining trend over the years, reflecting improvements in healthcare access, public health initiatives, and socioeconomic conditions. However, occasional peaks suggest that certain regions heightened IMR, potentially driven by environmental or climatic stressors. Graphs in the appendix visually juxtapose these trends with CO2 emissions, which initially rose steadily before declining in recent years, likely due to the implementation of environmental policies and advancements in cleaner technologies. The comparative analysis of states, illustrated in the appendix, reveals further nuances. States such as New Jersey and Connecticut experience high IMR and high CO2 emissions, driven by energy-intensive industries and associated socioeconomic disparities. In contrast, states like Massachusetts and Delaware maintain low IMR despite high CO2 emissions, highlighting the role of robust healthcare systems and progressive environmental policies. Meanwhile, states like Mississippi and Alabama, with high IMR but relatively low CO2 emissions, underscore the influence of deep-seated economic inequities and limited healthcare access on infant health outcomes.

Pollutants like NO2, PM10, and Ozone show varying trends. NO2 and PM10 demonstrate consistent declines, indicating the success of air quality regulations, whereas Ozone levels vary because of its complicated formation processes. Extreme weather events, such as tropical cyclones and droughts, fluctuate in frequency across states, with tropical cyclones and severe storms having the most significant health and economic impacts. States frequently experiencing such events, like North Carolina, Georgia, Alabama, Mississippi, and New York, often have higher IMR, highlighting the strain these disasters place on healthcare systems and infrastructure. Southeastern states—North Carolina, Alabama, Mississippi, and Georgia—are especially prone to hurricanes, severe storms, and flooding, which disproportionately affect rural and low-income communities with limited disaster preparedness and healthcare access. New York, while less frequently affected, also faces risks from hurricanes and urban flooding, particularly in underserved areas. Coastal states like North Carolina and New York benefit from stronger infrastructure, which can reduce some impacts. However, interior states such as Alabama and Mississippi face intensified risks due to fewer resources and weaker infrastructure.

Income disparities align with the Environmental Kuznets Curve, which suggests that pollution rises with income due to industrialization but later declines as economic prosperity grows and cleaner technologies are adopted. States like Massachusetts, Maryland, and D.C. have lower infant mortality rates despite higher CO2 emissions, reflecting the protective benefits of economic stability. These states are also economic hubs, leading to higher emissions from transportation and energy use while enabling investments in healthcare and education that mitigate environmental health impacts. Conversely, states like West Virginia and Mississippi show how low income and healthcare access worsen vulnerabilities, leading to higher IMR even with lower pollution levels. Limited resources restrict access to prenatal care and nutrition, emphasizing that economic stability is crucial for mitigating pollution's direct impacts and tackling the socioeconomic factors contributing to infant mortality.

Population density correlates with urbanization trends, which may influence both pollution exposure and access to healthcare resources. This dynamic is evident in urban states like New York, where better healthcare mitigates the adverse effects of density, compared to rural areas with less robust healthcare networks.

Two-Way Panel Analysis
Environmental Stressors

Regression Results

Variable	Coefficient	Std. Error	t-Value	P-Value
(Intercept)	357.431	54.199	6.595	0.000
PCCO2	0.000	0.000	-2.614	0.009
Density	1.777	1.450	1.226	0.221
Log_MHI	-30.306	4.821	-6.286	0.000
PM10	-0.157	0.041	-3.852	0.000
Ozone	-0.106	0.030	-3.525	0.000
NO2	0.235	0.065	3.616	0.000
Drought	0.828	1.475	0.561	0.575
Severe_Storm	-6.462	1.318	-4.902	0.000
Tropical_Cyclone	8.239	1.626	5.066	0.000
Flooding	0.150	1.957	0.077	0.939
Winter_Storm	-5.088	1.872	-2.718	0.007
Wildfire	3.261	1.999	1.631	0.103
Freeze	-3.411	3.576	-0.954	0.340

Notes:

Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

This study identifies a statistically significant, though small, negative relationship between per capita CO2 (PCCO2) emissions and infant mortality rates, with an estimate of -0.0002 ($p = 0.009$). While the magnitude of the effect is negligible, the negative direction is counterintuitive, as CO2 emissions are typically associated with environmental harm and adverse health outcomes. A possible explanation for this finding is the indirect benefits of economic development that often accompany higher PCCO2 levels. Regions with high CO2 emissions often have developed economies, which can offer improved healthcare systems, better maternal and infant health services, and effective public health measures, leading to lower IMR. Comparable findings have been reported in broader research. Adebayo et al. (2024) observed a negative relationship between CO2 emissions and life expectancy (LEXP) in the United States, attributing this inconsistent finding to socioeconomic advantages in high-emission regions, such as better education, income levels, and healthcare systems. Although their study focused on long-term outcomes, such as LEXP, our findings suggest that short-term health metrics like IMR may also benefit indirectly from these socioeconomic factors.

Unexpected negative relationships were observed for both PM10 and O3 in this study, with PM10 showing a coefficient of -0.157 and O3 a coefficient of -0.106. These findings stand in stark contrast to prior research, which consistently links higher levels of these pollutants to increased infant mortality. For example, Woodruff et al. (2008) found that a 10 µg/m³ increase in PM10 was associated with a 16% rise in respiratory-related post neonatal mortality, while a 10-ppb increase in O3 was linked to a 20% higher risk of sudden infant death syndrome (SIDS). Further supporting this relationship, Kihal-Talantikite et al. (2020) conducted a systematic review and meta-analysis, identifying significant pooled odds ratios for long-term PM10 exposure and elevated risks of respiratory mortality and SIDS. The differences between this study and prior findings may stem from its extended timeline (1994–2022), which spans nearly three decades of data. This broader perspective captures shifts in environmental policies, healthcare systems, and public health interventions over time. Stricter air quality regulations and advancements in neonatal care and respiratory treatments during this period may have mitigated the harmful effects of pollutants.

In contrast, this study's findings for NO2 align closely with prior research. NO2 exhibited a statistically significant positive relationship with IMR, indicating that a 1-unit increase in NO2 levels corresponds to a 0.235-unit rise in IMR. NO2 is a common byproduct of vehicle emissions and industrial activity, and its direct effects on respiratory health are well-documented. Prolonged exposure to NO2 has been associated with oxidative stress, inflammation of the respiratory tract, and increased susceptibility to respiratory infections, all of which can contribute to higher IMR (Dales et al., 2004).

Extreme Weather Events

Extreme weather events, such as droughts, storms, cyclones, and freezes, have profound implications for public health, including infant mortality. These events disrupt essential systems like healthcare, sanitation, and food supply, disproportionately impacting vulnerable populations. Historical evidence highlights the significant influence of temperature extremes on mortality. For example, it has been estimated that extreme cold contributes to approximately 27,940 deaths annually in the United States, accounting for 1.3% of total mortality, with the most severe effects seen in low-income areas (Deschênes and Moretti, 2009). In contrast, extreme heat results in short-term mortality displacement, where deaths occur earlier than expected without a lasting impact on overall mortality rates. Over the 20th century, heat-related mortality in the U.S. declined by approximately 80%, primarily due to the widespread adoption of residential air conditioning (Barreca et al., 2013). However, this reliance on air conditioning may increase greenhouse gas emissions, highlighting the trade-offs of adaptation strategies.

Tropical cyclones emerged as the most impactful extreme weather variable in this study, showing a significant positive relationship with infant mortality. These events cause widespread destruction, including displacement, damage to healthcare infrastructure, and interruptions to maternal and child health services. The findings align with studies highlighting both immediate and long-term impacts of cyclones. For instance, tropical cyclone exposure during gestation has been linked to increased risks of preterm births, reduced educational attainment, and lower lifetime earnings (Lin et al., 2021). Cyclones also impose significant economic costs, with Hurricane Harvey causing $160 billion in damages in 2017 and Hurricane Katrina in 2005 remaining the costliest storm in U.S. history at $200 billion (NCEI, 2024). Conversely, severe and winter storms exhibited a significant negative relationship with infant mortality, an unexpected finding that contrasts with the traditionally harmful effects of extreme weather. This result may reflect strong disaster preparedness measures and effective emergency response systems in areas frequently affected by such storms. Communities prone to these events often have advanced forecasting systems, preemptive evacuations, and accessible healthcare infrastructure, which mitigate their adverse effects on public health.

Other extreme weather variables, including drought, flooding, wildfires, and freezes, did not show significant associations with infant mortality in this study. While this could suggest that robust infrastructure and localized response strategies buffer their broader health impacts, it is also possible that their effects are more indirect or inadequately captured within the scope of this analysis. For example, long-term droughts may indirectly affect infant health through nutritional deficiencies or economic strain rather than immediate mortality. Similarly, while wildfires pose acute risks to respiratory health, their direct impact on infant mortality may be less pronounced, especially in regions with effective air quality management systems.

Socioeconomic Factors

Socioeconomic disparities significantly influence infant mortality rates. This study finds a strong negative association between household income and IMR, with showing a coefficient of -30.306. This highlights the vital role of economic stability in improving access to healthcare, nutrition, and maternal education. Mohamoud et al. (2019) similarly found that infants born in high-poverty U.S. counties had a 1.3 times higher risk of mortality, even after controlling for individual maternal factors. Baird et al. (2011) demonstrated that aggregate income shocks in 59 developing countries led to substantial increases in IMR, with a one-unit decrease in log GDP linked to an additional 18 to 44 infant deaths per 1,000 live births. Their study also revealed that female infants were especially vulnerable during economic downturns. Ensor et al. (2010) further emphasized that a 10% drop in GDP per capita was associated with a 2% rise in IMR in low- and middle-income countries, illustrating how economic instability disrupts both household health investments and public health systems.

In contrast, this study found no significant relationship between population density and IMR, illustrating the nuanced effects of urbanization. Densely populated areas, while potentially facing challenges like pollution and overcrowding, often benefit from better healthcare infrastructure that can offset adverse outcomes (Dallolio et al., 2012).

II. POLICY IMPLICATIONS AND DISCUSSION

Policies on Air Quality

Although CO_2 emissions unexpectedly showed a negative association with infant mortality, the significance of pollutants like NO_2 highlights the urgency of targeted air quality interventions. Policies aimed at improving municipal energy efficiency and expanding renewable energy sources have proven effective in reducing emissions while bolstering local economies (Palermo et al., 2020). Decentralized, subnational strategies, including state-level regulations and incentives for renewable energy, have proven effective in stabilizing emissions and promoting solutions tailored to local needs, as illustrated by California's stringent air quality standards (Lutsey & Sperling, 2008). Public acceptance is crucial for the success of these measures. Policies perceived as fair and effective, such as carbon taxes with equitable redistribution or investments in green infrastructure, tend to receive stronger public support (Dechezleprêtre et al., 2022). Community involvement in decision-making and transparent communication about policy effectiveness can further enhance adoption.

Air pollution interventions are crucial for improving public health by reducing respiratory and cardiovascular disease-related morbidity and mortality. This study highlights the importance of targeted reductions in pollutants like NO_2, which are strongly associated with IMR. Globally, localized measures such as congestion charging in London and low-emission zones in Berlin and Rome have demonstrated significant health benefits, including reductions in premature mortality and hospital admissions (Wang et al., 2016). These examples highlight the effectiveness of targeted interventions in mitigating the health effects of air pollution. Metrics like the Air Pollution Control Efficacy Index (APCI) illustrate international disparities in air pollution control and its health outcomes. Countries with higher APCI scores, indicating better control of $PM_{2.5}$ relative to CO_2 emissions, experience lower infant and under-five mortality rates, emphasizing the importance of integrating air pollution control with broader climate strategies (Han et al., 2021). Coordinated efforts in Europe, such as the Clean Air Act and EU Air Quality Directives, have significantly reduced concentrations of PM_{10}, $PM_{2.5}$, and NO_2, leading to improved life expectancy and fewer premature deaths (Henschel et al., 2012). However, not all populations benefit equally from these interventions. For instance, limited traffic zones in Rome have shown greater health gains among affluent residents, potentially exacerbating existing inequities (Cesaroni et al., 2012). To address such disparities, air quality policies must incorporate health equity, ensuring that cleaner air and its associated health improvements reach socioeconomically disadvantaged groups as well.

Disaster Preparedness and Cyclone Mortality

Effective disaster preparedness policies are essential for reducing the severe effects of cyclones on vulnerable populations. This study emphasizes the connection between tropical cyclones and infant mortality rates, highlighting the necessity for strong preparedness and response strategies. The Bangladesh Cyclone Preparedness Program (CPP) exemplifies successful community-based approaches, utilizing a network of 42,000 volunteers and over 2,000 storm shelters to drastically reduce cyclone-related mortality. The CPP's ability to disseminate warnings within 15 minutes has transformed Bangladesh into a global leader in cyclone risk reduction (Habib et al., 2012). Expanding on the theme of community engagement, Willison et al. (2019) emphasize the significance of incorporating marginalized populations in disaster planning and response initiatives. Their research demonstrates that inclusive policies not only improve overall outcomes but also ensure that the benefits of disaster preparedness are equitably distributed among all community members, including those from low-income and rural areas.

In more technologically advanced settings, innovative disaster resilience strategies highlight the integration of technology with public health infrastructure. Geospatial mapping and real-time epidemiological surveillance can improve emergency response efforts by utilizing data from mobile networks, health records, and meteorological forecasts to direct interventions toward vulnerable populations, including infants (Balsari et al. 2021). Adapting such technologies to cyclone-prone regions with fewer resources could significantly enhance preparedness efforts by concentrating resources on the most vulnerable communities.

Policies Related to Income

Income-focused policies are crucial for reducing health inequities and improving infant health outcomes. Programs like Brazil's Bolsa Família illustrate the transformative potential of conditional cash transfers, which tie financial incentives to health and education requirements. Between 2004 and 2009, Bolsa Família reduced child mortality rates by 17%, with the greatest benefits seen among the poorest households (Soares et al., 2010). Conditional cash transfers help reduce financial burdens and encourage lasting enhancements in maternal and child health by tackling fundamental social factors.

Globally, income inequality remains a significant barrier to improved infant health. Countries with equitable income distribution and robust social policies, such as Scandinavia's universal welfare systems, consistently achieve better infant health metrics than nations with high inequality. Progressive taxation, expanded healthcare access, and comprehensive social safety nets have proven effective in narrowing health disparities and enhancing birth outcomes, even in high-income contexts (Kim & Saada, 2013). In low- and middle-income countries, disparities in healthcare delivery often prevent essential maternal and child health services from reaching the most disadvantaged populations. Wealthier households disproportionately benefit from interventions like immunization and skilled birth attendance, exacerbating existing inequities (Leventhal et al., 2021). Equitable delivery models, like community health workers and mobile clinics, are especially effective in addressing these gaps by focusing on underserved populations.

These results show the importance of coordinated and equitable strategies to reduce income inequality and improve access to healthcare. In different countries, health disparities can be significantly reduced, and newborn health outcomes can be enhanced by integrating targeted delivery methods, structural changes, and economic support.

Limitations

While offering valuable insights into factors affecting infant mortality rates the analysis lacks detailed data on regional policies and healthcare infrastructure. State-specific factors, such as disaster preparedness, healthcare access, and local policies, likely play a significant role in shaping IMR, particularly during extreme weather events. Incorporating localized data in future research would enhance both the accuracy and practical relevance of the findings. Using IMR as a proxy for understanding the effects of climate change on gender-based violence presents limitations due to the absence of direct measures of GBV. The lack of state-level and longitudinal data on domestic and intimate partner violence remains a key challenge. Future research should prioritize collecting and integrating comprehensive GBV data to better understand its interactions with environmental stressors.

Additionally, the socioeconomic variables included in this analysis, such as median household income and population density, represent only a subset of relevant factors. Factors such as unemployment rates, maternal education levels, and access to childcare significantly affect infant health outcomes and should be included in future analyses for a comprehensive understanding. Furthermore, potential multicollinearity among air pollutant variables, may have obscured their individual effects. While clustering and regression techniques were employed to address this issue, advanced modeling approaches could provide greater clarity and precision in isolating these relationships.

III. CONCLUSION

IV.

This study explores the relationship between climate change, infant mortality, and gender-based violence across various U.S. regions. Our findings show considerable regional disparities in public health outcomes, underlining the importance of localized data in future study to better understand the unique effects of environmental stresses on social inequalities. In the United States, economic advancements often bring improved infrastructure and services that can both mask and mitigate the visibility and incidence of gender-based violence. This apparent reduction in GBV visibility might not necessarily indicate a decrease in incidence but could reflect an evolution in how violence is reported and addressed. Enhanced social services and legal protections could lead to underreporting or different reporting methods, complicating direct comparisons with less developed countries where GBV may be more evident due to inadequate protective systems. Furthermore, the presence of robust federal and state support systems, alongside this economic prosperity and advanced infrastructure, introduces a complex layer in measuring the direct impacts of environmental degradation on GBV. These support systems and infrastructural advantages can obscure the immediate effects of environmental stress by providing temporary relief or mitigation. Additionally, the roles of cultural factors and comprehensive policy frameworks in developed economies are crucial, as they promote resilience and adaptation strategies that are not as prevalent or effective in less developed countries.

While our study offers initial insights into how climate change affects public health, particularly infant mortality and GBV, further research into regional variations and more direct data on GBV is crucial. Such research could determine whether economic progress truly reduces GBV or merely changes how it is perceived and reported, enhancing our approach to integrating environmental and social policies to ensure effective and equitable interventions.

V. APPENDIX

TABLES:

Summary Statistics

	Year	Total Area	Median Household Income	CO2 Emissions(MMT)	PM10	Ozone	NO2	Avg Drought Severity	Population	Live Births (Residence)	Infant Deaths (Residence)	IMR
Min	1985.00	68.00	40060.00	2.40	0.00	0.00	0.00	0.00	453.40	5133.00	15.00	0.02
X1st.Qu.	1996.00	35380.00	59765.00	39.82	27.25	24.57	22.47	9.22	1454.07	22425.50	139.25	5.52
Median	2004.50	56273.00	67320.00	77.30	38.16	38.13	31.42	15.31	3875.93	55667.50	381.00	6.92
Mean	2003.88	74445.96	68681.73	105.34	37.06	37.80	29.66	16.69	5682.01	81929.15	547.71	9.63
X3rd.Qu.	2013.00	84897.00	76555.00	131.54	46.71	50.48	39.23	22.71	6613.52	96648.25	694.75	8.60
Max	2021.00	665384.00	113000.00	684.80	99.84	156.72	84.23	73.08	39503.20	3891494.00	4670.00	226.82

Percentage Occurrence of Each Extreme Weather Event

Disaster.Type	Percentage....
Severe Storm	54.10
Tropical Cyclone	20.28
Flooding	13.14
Winter Storm	22.14
Wildfire	16.06
Freeze	3.08

Top 10 States by Total Disasters

State	Total Disasters	Average IMR	CO2 Emissions per Unit Area
North Carolina	54	14.039918	0.0826082
Texas	53	6.281371	0.0793335
Georgia	48	14.523310	0.0872478
Virginia	47	7.292722	0.0860213
Mississippi	46	10.242898	0.0410751
Pennsylvania	44	7.465346	0.1877909
Alabama	43	15.440152	0.0801881
Louisiana	43	10.063125	0.1277697
Tennessee	43	8.336426	0.0890345
New York	42	25.162755	0.1185538

Top 10 States by Infant Mortality Rate

State	Total Disasters	Average IMR	CO2 Emissions per Unit Area
Florida	35	66.91422	0.1153381
New York	42	25.16275	0.1185538
New Jersey	32	22.19253	0.4431835
Alabama	43	15.44015	0.0801881
Colorado	31	14.61976	0.0273614
Georgia	48	14.52331	0.0872478
North Carolina	54	14.03992	0.0826082
Connecticut	25	12.29807	0.2376222
Oklahoma	37	10.47536	0.0472918
Mississippi	46	10.24290	0.0410751

Top 10 States by CO2 Emissions per Unit Area

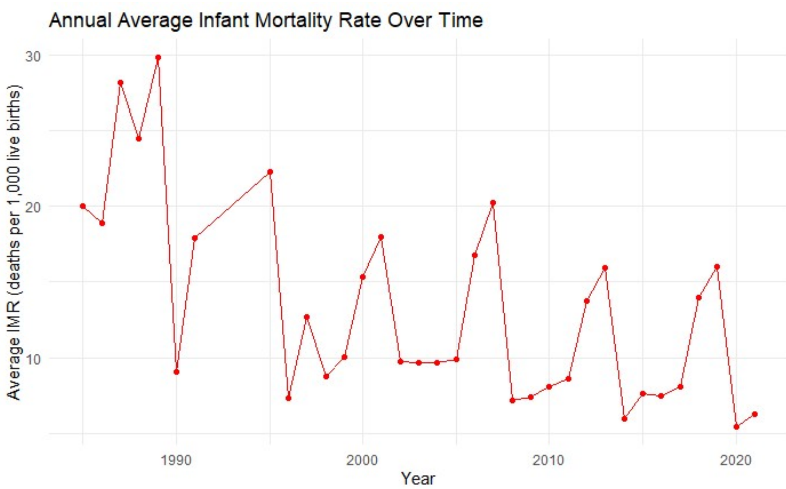
State	Total Disasters	Average IMR	CO2 Emissions per Unit Area
District of Columbia	0	4.973524	1.8532353
New Jersey	32	22.192531	0.4431835
Massachusetts	21	5.096484	0.2430775
Rhode Island	18	6.580282	0.2404013
Connecticut	25	12.298073	0.2376222
Delaware	17	4.609059	0.2149458
Indiana	33	7.937430	0.1930967
Maryland	35	7.708849	0.1916669
Pennsylvania	44	7.465346	0.1877909
Ohio	38	7.897962	0.1837880

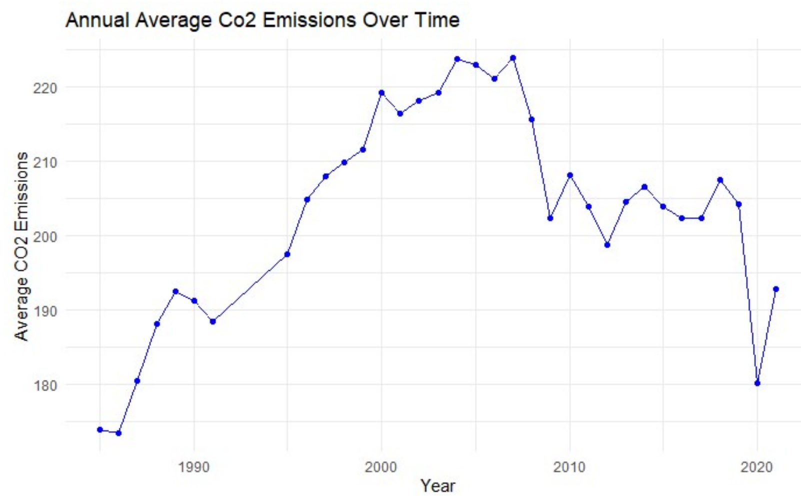
Summary Statistics for Extreme Weather Events, CPI Cost, and Related Disaster Deaths

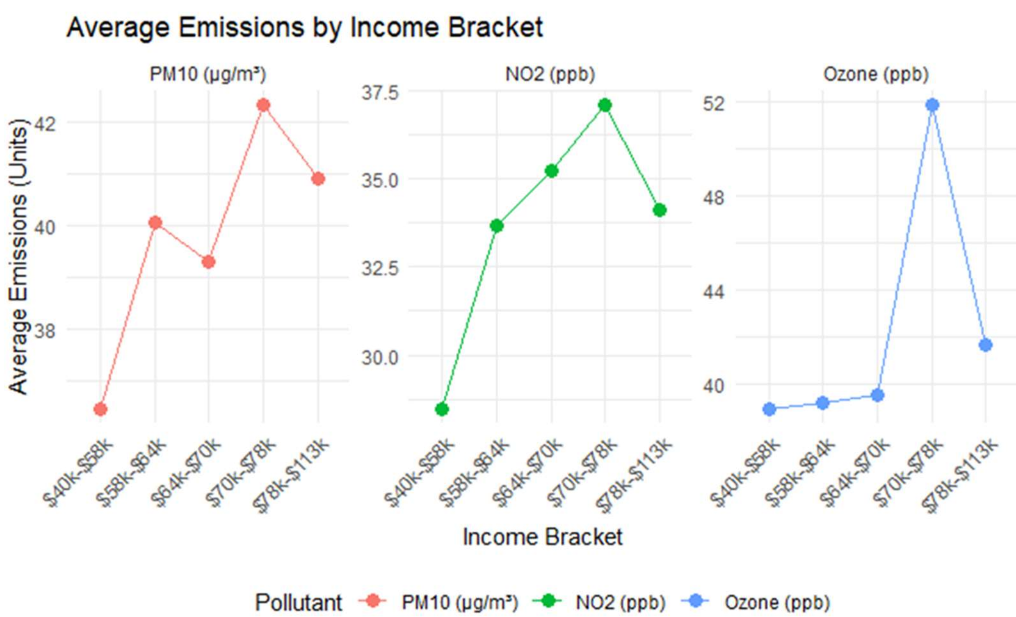
Summary Statistics

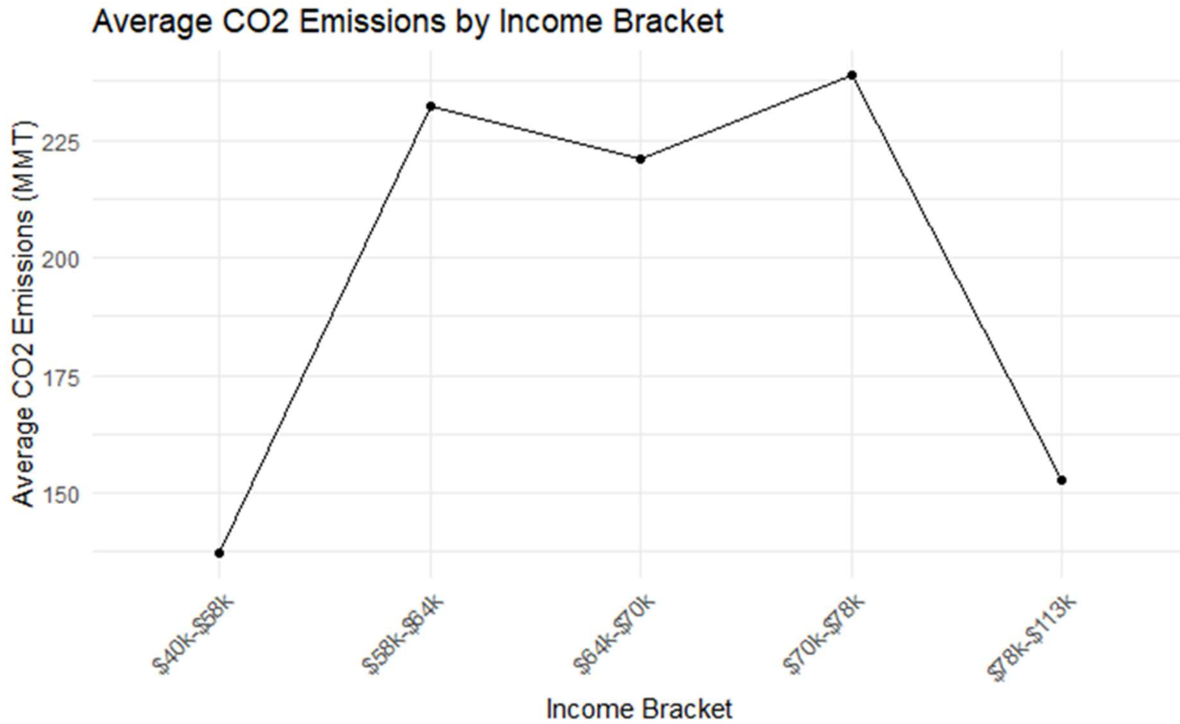
	Severe_Storm	Tropical_Cyclone	Flooding	Winter_Storm	Wildfire	Freeze	CPI-Adjusted Cost	Death Disaster
Min	0.00	0.00	0.00	0.00	0.00	0.00	1126.00	0.00
X1st.Qu.	0.00	0.00	0.00	0.00	0.00	0.00	3811.80	10.00
Median	1.00	0.00	0.00	0.00	0.00	0.00	8783.40	38.00
Mean	0.53	0.19	0.12	0.22	0.15	0.03	18497.03	110.04
X3rd.Qu.	1.00	0.00	0.00	0.00	0.00	0.00	18369.90	121.00
Max	1.00	1.00	1.00	1.00	1.00	1.00	264724.50	2002.00

GRAPHS:









REFERENCES

[1] Adebayo, T.S., Nwosu, L., Alhassan, G.N., Uzun, B., Özkan, O., & Awosusi, A.A. (2024). Effects of health expenditure, death rate, and infant mortality rate on life expectancy: A case study of the United States. Energy & Environment.

[2] Adeleye, B. N., Azam, M., & Bekun, F. V. (2020). Infant mortality rate and nonrenewable energy consumption in Asia and the Pacific: The mediating role of carbon emissions. Energy, Ecology and Environment, 5(4), 239–251.

[3] Agrawal, P., Post, L., Glover, J., Hersey, D., Oberoi, P., & Biroscak, B. (2021). The interrelationship between food security, climate change, and gender-based violence: A scoping review with system dynamics modeling. Global Health Action, 14(1), 1886454.

[4] Baird, S., Friedman, J., & Schady, N.R. (2007). Aggregate Income Shocks and Infant Mortality in the Developing World. *Review of Economics and Statistics, 93*, 847-856.

[5] Balsari, S., Kiang, M. V., & Buckee, C. O. (2021). Data in Crisis - Rethinking Disaster Preparedness in the United States. *The New England journal of medicine*, *385*(16), 1526–1530. https://doi.org/10.1056/NEJMms2104654

[6] Barbier, E. B., & Hochard, J. P. (2018). The impacts of climate change on the poor in disadvantaged regions. Environmental and Resource Economics, 69(3), 451–466.

[7] Barreca, A., Clay, K., Deschenes, O., Greenstone, M., & Shapiro, J. S. (2013). *Adapting to climate change: The remarkable decline in the U.S. temperature-mortality relationship over the 20th century* (Working Paper No. 18692). National Bureau of Economic Research. https://doi.org/10.3386/w18692

[8] Brinda, E. M., Rajkumar, A. P., & Enemark, U. (2015). Association between gender inequality index and child mortality rates: a cross-national study of 138 countries. BMC public health, 15, 97. https://doi.org/10.1186/s12889-015-1449-3

[9] Dadi, A. F., Ahmed, K. Y., Berhane, Y., Bizuayehu, H. M., Tesema, G. A., Hassen, T. A., Kibret, G. D., Ketema, D. B., Bore, M. G., Belachew, S. A., Amsalu, E., Nhassengo, S., Shifti, D. M., Seid, A., Mesfin, Y. M., Tegegne, T. K., Odo, D. B., Kassa, Z. Y., Thapa, S., ... Ross, A. G. (2024). Intimate partner violence and childhood health outcomes in 37 sub-Saharan African countries: an analysis of demographic health survey data from 2011 to 2022. The Lancet Global Health, 12(11), e1785-e1793. https://doi.org/10.1016/S2214-109X(24)00313-9

[10] Dales, R., Burnett, R. T., Smith-Doiron, M., Stieb, D. M., & Brook, J. R. (2004). Air pollution and sudden infant death syndrome. *Pediatrics*, *113*(6), e628–e631. https://doi.org/10.1542/peds.113.6.e628

[11] Dallolio, L., Di Gregori, V., Lenzi, J., Franchino, G., Calugi, S., Domenighetti, G., & Fantini, M. P. (2012). Socio-economic factors associated with infant mortality in Italy: an ecological study. *International journal for equity in health*, *11*, 45. https://doi.org/10.1186/1475-9276-11-45

[12] Deschnes, O., & Moretti, E. (2007). Extreme Weather Events, Mortality, and Migration. *The Review of Economics and Statistics, 91*, 659-681.

[13] Dechezleprêtre, A., et al. (2022), "Fighting climate change: International attitudes toward climate policies", OECD Economics Department Working Papers, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en.

[14] Casey, G., Shayegh, S., Moreno-Cruz, J., Bunzl, M., Galor, O., & Caldeira, K. (2019). The impact of climate change on fertility. Proceedings of the National Academy of Sciences of the United States of America (PNAS), 116(36), 17702-17707.

[15] Cesaroni, G., Boogaard, H., Jonkers, S., Porta, D., Badaloni, C., Cattani, G., Forastiere, F., & Hoek, G. (2012). Health benefits of traffic-related air pollution reduction in different socioeconomic groups: the effect of low-emission zoning in Rome. Occupational and environmental medicine, 69(2), 133–139. https://doi.org/10.1136/oem.2010.063750

[16] Ensor, T., Cooper, S., Davidson, L. *et al.* The impact of economic recession on maternal and infant mortality: lessons from history. *BMC Public Health* **10**, 727 (2010). https://doi.org/10.1186/1471-2458-10-727

[17] Ergas, C., Greiner, P. T., McGee, J. A., & Clement, M. T. (2021). Does Gender Climate Influence Climate Change? The Multidimensionality of Gender Equality and Its Countervailing Effects on the Carbon Intensity of Well-Being. Sustainability, 13(7), 3956. https://doi.org/10.3390/su13073956

[18] Habib, A., Shahidullah, M., & Ahmed, D. (2012). The Bangladesh Cyclone Preparedness Program. A Vital Component of the Nation's Multi-Hazard Early Warning System.

[19] Han, C., Xu, R., Zhang, Y., Yu, W., Zhang, Z., Morawska, L., Heyworth, J., Jalaludin, B., Morgan, G., Marks, G., Abramson, M., Sun, L., Li, S., & Guo, Y. (2021). Air pollution control efficacy and health impacts: A global observational study from 2000 to 2016. Environmental pollution (Barking, Essex : 1987), 287, 117211. https://doi.org/10.1016/j.envpol.2021.117211

[20] Henke, A., & Hsu, L.-C. (2020). The gender wage gap, weather, and intimate partner violence. Journal of Public Economics, 183, 104144.

[21] Henschel, S., Atkinson, R., Zeka, A. et al. Air pollution interventions and their impact on public health. Int J Public Health 57, 757–768 (2012). https://doi.org/10.1007/s00038-012-0369-6

[22] Kihal-Talantikite W, Marchetta GP, Deguen S. Infant Mortality Related to NO_2 and PM Exposure: Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2020 Apr 11;17(8):2623. doi: 10.3390/ijerph17082623. PMID: 32290393; PMCID: PMC7215927.

[23] Kim, D., & Saada, A. (2013). The Social Determinants of Infant Mortality and Birth Outcomes in Western Developed Nations: A Cross-Country Systematic Review. International Journal of Environmental Research and Public Health, 10(6), 2296-2335. https://doi.org/10.3390/ijerph10062296

[24] Leventhal, D. G. P., Crochemore-Silva, I., Vidaletti, L. P., Armenta-Paulino, N., Barros, A. J. D., & Victora, C. G. (2021). Delivery channels and socioeconomic inequalities in coverage of reproductive, maternal, newborn, and child health interventions: analysis of 36 cross-sectional surveys in low-income and middle-income countries. *The Lancet. Global health*, *9*(8), e1101–e1109. https://doi.org/10.1016/S2214-109X(21)00204-7

[25] Levy, B. S., Sidel, V. W., & Patz, J. A. (2021). Climate change and collective violence. American Journal of Public Health, 111(2), 236-244

[26] Li, J., Irfan, M., Samad, S., Ali, B., Zhang, Y., Badulescu, D., & Badulescu, A. (2023). The relationship between energy consumption, CO2 emissions, economic growth, and health indicators. Journal of Cleaner Production, 267, 122023.

[27] Lin, Y., Liu, F., & Xu, P. (2021). Long-term effects of early-life exposure to tropical cyclones. *China Economic Review, 69*, 101662.

[28] Lutsey, Nicholas, and Sperling, Daniel. *America's bottom-up climate change mitigation policy.* United Kingdom: N. p., 2008. Web. doi:10.1016/J.ENPOL.2007.10.018.

[29] McMichael, A. J., Woodruff, R. E., & Hales, S. (2006). Climate change and human health: present and future risks. Lancet (London, England), 367(9513), 859–869. https://doi.org/10.1016/S0140-6736(06)68079-3

[30] Mohamoud, Y.A., Kirby, R.S. & Ehrenthal, D.B. Poverty, urban-rural classification and term infant mortality: a population-based multilevel analysis. *BMC Pregnancy Childbirth* **19**, 40 (2019). https://doi.org/10.1186/s12884-019-2190-1

[31] National Centers for Environmental Information. (2024). *Costliest U.S. Tropical Cyclones.* National Oceanic and Atmospheric Administration. Retrieved from https://www.ncei.noaa.gov/access/billions/dcmi.pdf

[32] Raj, A., & Boehmer, U. (2013). Girl child marriage and its association with national rates of HIV, maternal health, and infant mortality across 97 countries. Violence against women, 19(4), 536–551. https://doi.org/10.1177/1077801213487747

[33] Soares, F. V., Ribas, R. P., & Osório, R. G. (2010). Evaluating the Impact of Brazil's Bolsa Família: Cash Transfer Programs in Comparative Perspective. *Latin American Research Review*, *45*(2), 173–190. doi:10.1017/S0023879100009390

[34] Tracey J. Woodruff, Lyndsey A. Darrow, and Jennifer D. Parker 2008. Air Pollution and Postneonatal Infant Mortality in the United States, 1999–2002, Environmental Health Perspectives 116:1 CID: https://doi.org/10.1289/ehp.10370

[35] Valentina Palermo, Paolo Bertoldi, Malvina Apostolou, Albana Kona, Silvia Rivas, Assessment of climate change mitigation policies in 315 cities in the Covenant of Mayors initiative, Sustainable Cities and Society, Volume 60, 2020, 102258, ISSN 2210-6707, https://doi.org/10.1016/j.scs.2020.102258.

[36] Wang, L., Zhong, B., Vardoulakis, S., Zhang, F., Pilot, E., Li, Y., Yang, L., Wang, W., & Krafft, T. (2016). Air Quality Strategies on Public Health and Health Equity in Europe—A Systematic Review. International Journal of Environmental Research and Public Health, 13(12), 1196. https://doi.org/10.3390/ijerph13121196

[37] Willison, C. E., Singer, P. M., Creary, M. S., & Greer, S. L. (2019). Quantifying inequities in US federal response to hurricane disaster in Texas and Florida compared with Puerto Rico. *BMJ global health*, *4*(1), e001191. https://doi.org/10.1136/bmjgh-2018-001191

[38] Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*. The MIT Press. http://www.jstor.org/stable/j.ctt5hhcfr