



Article Environmental Justice and Sustainable Development: Cumulative Environmental Exposures and All-Cause Mortality in Colorado Counties

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Abstract: (1) Background: Colorado's (CO) Environmental Justice mapping tool, CO EnviroScreen, quantifies environmental injustices through "EnviroScreen Scores", highlighting areas likely affected by environmental health disparities. Identifying the specific scores most strongly associated with mortality could help prioritize interventions and allocate resources to address these issues. This study contributes to sustainable development goals by examining the relationship between environmental justice indicators and population health outcomes. By utilizing the CO EnviroScreen tool, we assess how cumulative environmental exposures and vulnerabilities impact mortality rates, providing insights for sustainable planning and public health policies. (2) Methods: We assessed the cross-sectional association between county-level all-cause mortality rates in CO, using 2019 data from the Colorado Department of Public Health and Environment, and three county-level component scores obtained from CO EnviroScreen: sensitive populations (i.e., health-related outcomes), environmental exposures (e.g., from air, water, noise), and climate vulnerability (i.e., risk of drought, flood, extreme heat, wildfire). A quasi-Poisson generalized linear model was utilized, incorporating covariates (county-level metrics for insufficient sleep, alcohol overconsumption, physical inactivity, and smoking) to explore associations adjusted for behavioral risk factors (n = 64 counties). (3) Results: The analysis revealed that a 10% increase in the "Environmental Exposures" component score was associated with a 3% higher all-cause mortality rate (95% CI: 1.00, 1.05), highlighting the importance of addressing environmental determinants for sustainable community health. No significant associations were observed for the "Sensitive Populations" or "Climate Vulnerability" component scores. (4) Conclusions: This study provides novel evidence of an association between the CO EnviroScreen score, particularly the environmental exposure component, and all-cause mortality rates at the county level in Colorado in 2019. The findings suggest that cumulative environmental exposures may contribute to geographic disparities in mortality risk, even after adjusting for key behavioral risk factors. These results underscore the importance of integrating environmental justice considerations into sustainable development strategies to promote equitable health outcomes and resilient communities. While our study demonstrates the utility of CO EnviroScreen in identifying areas at risk due to environmental factors, it does not establish a direct link to broader environmental justice outcomes. Further research is needed to explore specific environmental exposures and their direct impacts on health disparities to provide a more complete picture of environmental justice in Colorado.

Keywords: environmental justice; environmental justice mapping tool; sustainable development; Colorado EnviroScreen; mortality



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1. Introduction

Environmental justice (EJ) is a critical concern in public health, as it focuses on the disproportionate burden of environmental hazards on vulnerable populations, often defined by ethnicity, socioeconomic status, or other social factors [1]. In recent years, the EJ movement has gained significant traction, driven by a growing awareness of the disproportionate environmental burdens faced by vulnerable communities. This has led to an increased demand for comprehensive EJ mapping tools and policies designed to identify, quantify, and address environmental health disparities [2]. These tools, such as CalEnviroScreen in California and the U.S. Environmental Protection Agency's EJScreen, have become increasingly popular among policymakers, researchers, and community advocates, as they provide a data-driven approach to prioritizing EJ interventions and allocating resources to the most affected areas [3,4].

In response to this need, the state of Colorado (CO) passed the Environmental Justice Act on 2 July 2021, which defined disproportionately impacted communities and mandated the creation of an interactive EJ mapping and health screening tool called CO Enviro-Screen [5]. Launched on 28 June 2022, CO EnviroScreen is an open-access and open-source tool that provides information on potential environmental injustices at different geographical resolutions and is based on community needs identified in two community engagement sessions [6]. This tool allows the Colorado Department of Public Health and Environment (CDPHE) and other institutions to estimate an "EnviroScreen Score" for different geographies, including counties in CO, to foster equitable, data-driven decision-making to improve the health of disproportionately impacted communities [6].

CO EnviroScreen is an EJ mapping tool that incorporates 35 indicators, each representing a single environmental, socioeconomic, or health factor [6]. These indicators were chosen based on extensive community engagement, data availability, and their relevance to environmental justice concerns in Colorado. The selection process involved input from various stakeholders and aimed to capture a comprehensive picture of environmental and socioeconomic factors affecting community health. CO EnviroScreen was built by CDPHE based on these indicators that were chosen based on data availability, and community engagement, and to reflect the goal of the tool [6]. These indicators are grouped into five topic-based "component scores": sensitive populations, demographics, environmental exposures, environmental effects, and climate vulnerability. The sensitive populations score captures the potential biological susceptibility of a community, while the demographics score represents the community's social and economic vulnerabilities. The environmental exposure score indicates the community's exposure to environmental risks, and the environmental effects score represents the number of hazardous or toxic sites in a community. Finally, the climate vulnerability score reflects the community's risk of drought, flood, extreme heat, and wildfire [6]. The component scores are further combined into two "group component scores" and ultimately into a single "CO EnviroScreen score" [6]. A higher CO EnviroScreen score indicates a greater likelihood of an area being affected by environmental health injustices at various geographical levels, such as census block groups, census tracts, or counties [6].

Despite the availability of EJ mapping tools such as CO EnviroScreen, which provides component scores reflecting various environmental and socioeconomic factors, there remains a limited understanding of how these scores correlate with health outcomes. Previous studies have established connections between environmental exposures, socioeconomic factors, and health disparities [2,3,7], but the specific impact of CO EnviroScreen component scores on health outcomes, particularly mortality, has not been rigorously examined. Understanding these relationships is crucial for several reasons. First, it could validate the utility of CO EnviroScreen as a tool for identifying communities at higher risk of adverse health outcomes due to environmental and social factors. Second, it could provide valuable insights to guide public health interventions and policies aimed at reducing environmental health disparities [8].

This study aims to bridge the gap between environmental justice mapping tools and health outcomes by examining the association between CO EnviroScreen scores and allcause mortality rates at the county level in Colorado. Specifically, it seeks to quantify how variations in the CO EnviroScreen component scores correlate with mortality, providing evidence on the effectiveness of CO EnviroScreen in reflecting health disparities related to environmental justice. By doing so, we aim to validate the utility of CO EnviroScreen in identifying communities at higher risk of adverse health outcomes due to environmental and social factors. It is important to note that while this study contributes to our understanding of environmental justice issues, it does not directly measure or establish comprehensive environmental justice outcomes. This research will contribute to a deeper understanding of the tool's relevance in public health and inform future policy and intervention strategies [9,10]. This study aligns with the United Nations' Sustainable Development Goals 3 (good health and well-being) and 11 (sustainable cities and communities). Environmental justice mapping tools like CO EnviroScreen are designed to assess cumulative environmental impacts across the state, including urban and rural areas. These tools have the potential to identify regions where targeted interventions could enhance both environmental quality and public health outcomes, thereby promoting sustainability and equity across various community types.

2. Methods

This cross-sectional study of CO counties estimates the association between all-cause mortality at the county level in 2019 and the CO EnviroScreen component scores.

2.1. Data Sources

The secondary data from CO EnviroScreen was obtained from the CO EnviroScreen webpage and downloaded for the different available geographies: census block group (most granular), census tract, and county level (least granular) [6]. County-level data had the least missingness and were chosen as the level for analysis due to the lack of data availability at more granular levels for outcome and covariate data. Missingness was evaluated, revealing 3 missing values out of 64 for wastewater discharge, traffic proximity and volume, and low birth weight indicators. There were two missing values for the life expectancy indicator. County-level mortality data were obtained from a data request to CDPHE. Only the missing values were not included in the analysis. Year 2019 data were chosen to mitigate the effects of increased mortality rates due to the COVID-19 pandemic. The data included the age-standardized, all-cause mortality rate (deaths per 100,000 persons). Covariate data were obtained from the CDC PLACES (Centers for Disease Control and Prevention Population-Level Analysis and Community Estimates) website at the county level [11]. CDC PLACES collects data from the Behavioral Risk Factor Surveillance System (BRFSS), which is an annual survey of randomly selected U.S. residents. The included covariates were all quantified as age-adjusted prevalence measures among adults aged \geq 18 years. Specifically, the percentage who report usually sleeping <7 h on average during a 24-h period; the percentage who report alcohol overconsumption (having five or more drinks [men], or four or more drinks [women] on one occasion in the past 30 days); the percentage with no physical activity outside of work in the past 30 days; and the percentage who have smoked ≥ 100 cigarettes in their lifetime and currently smoke every day or some days These covariates were chosen for inclusion in the analysis because they are known to affect all-cause mortality [12]. Covariate data were manually entered twice for the 64 CO counties, and summary analysis was performed on both sets to mitigate errors during entry. The data were obtained from 2021 for all covariates except insufficient sleep, which was obtained from 2020 due to data availability. Information on rural and urban classification of counties was obtained for sensitivity analysis from the Colorado Rural Health Center [13].

2.2. Data Analysis

The Spearman rank correlation coefficients were calculated between the five Enviro-Screen component scores. The correlation matrix was visualized as a heatmap with colors representing the numerical values of the correlation. The unadjusted and adjusted associations between CO EnviroScreen component scores and the mortality rate were modeled using a quasi-Poisson regression model. We chose quasi-Poisson regression due to its ability to handle overdispersion in the mortality data, which is common in count data like mortality rates. This model allows for greater variability than the standard Poisson model, making it more appropriate for our data structure. The full model used is shown as follows:

$$\log(E(Y)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 C_1 + \beta_5 C_2 + \beta_6 C_3 + \beta_7 C_4$$
(1)

In the full model, Y is the age-standardized all-cause mortality rate for a county, X_1 is the demographics score percentile; X_2 is the environmental exposure score percentile; and X_3 is the climate vulnerability score percentile. These three score percentiles were selected due to the correlation with the other scores, and because sensitive populations included life expectancy, a correlate of the outcome in our analyses (Table 1). Environmental exposures include nine indicators that represent factors that could lead to direct exposure, versus environmental effects with seven indicators that could lead to indirect environmental exposure [6]. C_{1-4} are the covariates: alcohol overconsumption, insufficient sleep, physical inactivity, and smoking. Variable selection was based on theoretical importance and existing literature. We assessed correlations between predictors to avoid including highly correlated variables in the same model, thus minimizing potential collinearity issues. The selection of covariates was guided by their known associations with mortality rates, as established in previous studies. Estimates were multiplied by 10 to represent a 10 percentile increase in CO EnviroScreen score and then exponentiated to make a rate ratio. A 10 percentile increase was chosen arbitrarily as an easily understandable metric. In addition to the full model, mortality was regressed on the total CO EnviroScreen score percentile, which includes all the component scores. A secondary modeling approach included mortality regressed on the component scores individually, with the four covariates included in each model.

Final Score Group Component Scores Component Scores	Colorado EnviroScreen Score						
	Health and Social Factors		Pollution and Climate Factors				
	Sensitive Populations	Demographics	Environmental Exposures	Environmental Effects	Climate Vulnerability		
Indicator Scores	Asthma (2013–2017) Cancer (2015–2019) Diabetes (2015–2019) Heart Disease (2014–2017) Life Expectancy (2010–2015) Low Birth Weight (2013–2017) Mental Health (2015–2019) >65 years old (2021) <5 years old (2021)	Housing Cost Burden (2015–2019) Disability (2015–2019) Educational Attainment (2021) Linguistic Isolation (2021) Income (2021) Race and Ethnicity (2021)	Ozone (2017) Diesel Particulate matter (2014) Traffic Proximity (2017) PM 2.5 (2017) Drinking Water (2010-2020) Lead (2021) Noise (2013-2015) Air toxics (2016-2020) Other Air Pollutants (2016-2020)	Surface Water (2000–2020) Mining (2022) Oil and Gas (2016–2021) Wastewater (2019) Hazardous Chemicals (2021) Hazardous Waste (2021) Superfund site (2021)	Drought (2016–2020) Flood (2016) Extreme Heat (2016–2020) Wildfire (2020)		

Table 1. Colorado EnviroScreen data included in the component and composite scores with years of data obtained.

To explore the linearity of the exposure–response association, mortality was regressed on natural splines for each component score with three degrees of freedom. Three degrees of freedom were chosen to adequately capture the flexibility of the underlying trend, as well as minimize the complexity and the risk of overfitting, given the sample size. Each spline was then plotted over a scatterplot with points representing individual CO counties. In total, six plots were created to explore the data, five for each component score and one for the overall CO EnviroScreen score.

2.3. Sensitivity Analyses

First, Mineral County was excluded from the analysis due to the high mortality rate in 2019, which made it an outlier in terms of annual average mortality. Second, counties were categorized into rural and urban classifications to explore how climate vulnerability impacts might differ based on geographic and demographic factors. It was hypothesized that the sources of climate vulnerability would vary between these classifications. For example, rural counties were expected to be more affected by drought, whereas urban counties would be more impacted by heat exposure and air pollution. A third sensitivity analysis was performed using the environmental effects component score percentile instead of the climate vulnerability score percentile due to the theory that climate vulnerability was more important to mortality than environmental effects. The same regression models and statistical methods used in the main analysis were used in each sensitivity analysis to ensure consistency. All analysis and mapping were performed in R Version 4.2.1 [14].

3. Results

The final dataset included the 64 Colorado counties. The correlation analysis showed a moderate correlation between demographics and sensitive populations (0.56) and environmental exposures and environmental effects (0.53) (Figure 1). Sensitive populations were removed from the analysis because they include life expectancy and other health indicators, which are highly correlated with mortality. Environmental effects were removed because of collinearity, and environmental exposures have more indicators included in the score and are more comprehensive. Other component score correlation values ranged between -0.5 and 0.5 (Figure 1).

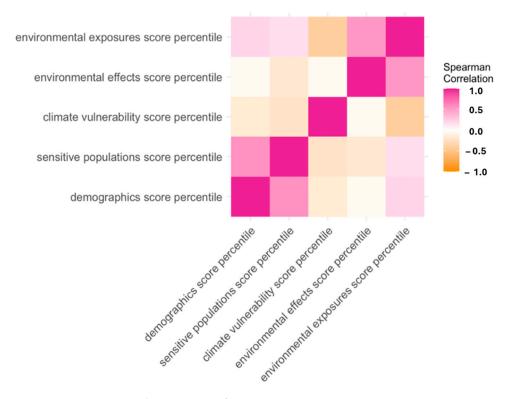


Figure 1. Spearman correlation matrix of CO EnviroScreen component scores.

In the unadjusted model, a 10% increase in the overall CO EnviroScreen score was found to be associated with an increase in the all-cause mortality rate (RR: 1.05, 95% CI: 1.03, 1.07) (Table 2). Demographics score percentiles, environmental exposure score percentiles,

and sensitive populations were also associated with an increase in all-cause mortality rates (Table 2). Environmental effects and climate vulnerability score percentiles were not associated with a decrease in all-cause mortality rates (Table 2).

In the fully adjusted model, the demographics score percentile was not associated with the all-cause mortality rate (Table 2). The addition of behavioral risk factors resulted in an attenuated estimate. The environmental exposure score percentile was associated with an increase in mortality (RR: 1.03, 95% CI: 1.01, 1.05) (Table 2). The climate vulnerability score percentile was not associated with the all-cause mortality rate (Table 2).

Table 2. Results of associations between all-cause mortality and total Colorado EnviroScreen score and component scores, county level, per 10 percentile increase in the component score (n = 64).

	Unadjusted				Adjusted		
Score	Rate Ratio	95% CI	p-Value	Rate Ratio	95% CI	p-Value	
CO EnviroScreen Total	1.05	1.03, 1.07	< 0.01				
Demographics	1.04	1.02, 1.07	< 0.01	0.99	0.95, 1.03	0.49	
Environmental Effects	0.99	0.97, 1.01	0.31				
Environmental Exposures	1.03	1.01, 1.05	0.02	1.03	1.00, 1.05	0.02	
Climate Vulnerability	0.98	0.96, 1.00	0.11	1.01	0.99, 1.04	0.23	
Sensitive Populations	1.06	1.04, 1.08	< 0.01				
				4.11	11. 1	.1	

All-cause mortality regressed on each component score individually, as well as the CO EnviroScreen total score. No covariates were included in any of the six models.

All-cause mortality regressed on three component scores. Covariates were included in the model. Covariates included: "insufficient sleep," "alcohol overconsumption", "physical inactivity", and "smoking".

Gray areas refer to nota applicable (N/A).

In the secondary modeling approach where mortality was regressed on the component scores included in the full model individually, with four covariates included in each model, there was no difference in results from the full model (Table S1). In the sensitivity analysis, excluding Mineral County from the analysis did not meaningfully change any of the effect estimates (Tables S2–S4). Splitting the dataset into rural and urban counties reduced the strength of the association between the environmental exposure component score and mortality in the full model for urban counties. However, it did not notably change any other effect estimates for either rural or urban counties (Tables S5–S10). Replacing climate vulnerability with environmental effects also did not have any notable effect on the rate ratios (Tables S11 and S12). Each component score showed an approximately linear relationship with mortality (Figure S1).

4. Discussion

This cross-sectional study found that an increase in the CO EnviroScreen total score and the environmental exposure component score were associated with higher all-cause mortality rates at the county level in 2019. To our knowledge, this is the first study to examine the association between the CO EnviroScreen tool and all-cause mortality. These findings contribute to the growing evidence base suggesting that cumulative environmental exposures in disproportionately impacted communities may have measurable impacts on population health [15]. The results underscore the importance of considering the joint effects of multiple environmental stressors, rather than focusing on single pollutants or hazards in isolation. Numerous studies have documented that health outcomes are influenced by a complex interplay of environmental and socioeconomic factors. For instance, research has shown that exposure to multiple pollutants has synergistic effects on health [16,17], and socioeconomic vulnerabilities often exacerbate these effects [18,19]. This comprehensive approach is important for accurately assessing and addressing environmental health disparities. The CO EnviroScreen tool is particularly valuable in this regard, as it integrates data on a wide range of exposures and vulnerabilities to provide a more comprehensive picture of environmental health disparities. By encompassing multiple dimensions of environmental stressors, such as air quality, climate factors, and socioeconomic conditions, CO EnviroScreen offers a nuanced understanding of how various factors collectively affect health outcomes.

The Environmental Exposures score, which emerged as the strongest predictor of mortality in this study, includes indicators of exposure to pollutants like PM2.5, ozone, and diesel particulate matter, as well as proximity to traffic and toxic releases. Many of these pollutants have well-established associations with cardiovascular and respiratory diseases that are leading causes of mortality [20]. For example, long-term exposure to fine particulate matter (PM2.5) has been linked to an increased risk of heart disease, stroke, and lung cancer [21]. Similarly, exposure to ozone and traffic-related air pollution has been associated with respiratory conditions like asthma and COPD [22].

The small but significant 3% increase in mortality associated with a 10 percentile increase in Environmental Exposures score may represent a substantial public health burden across Colorado counties, given the ubiquity of many of these exposures. While this study highlights a relationship between environmental exposures and mortality, it is important to note that the individual contributions of specific pollutants were not investigated. Therefore, further research is needed to disentangle the specific environmental factors driving this association within CO counties.

Interestingly, while the demographics score was associated with increased mortality in unadjusted models, this association was attenuated after adjusting for behavioral risk factors like smoking and physical activity. This suggests that the health impacts of socioe-conomic disadvantage may be mediated in part through health behaviors. For example, low-income communities often have fewer opportunities for physical activity due to a lack of safe green spaces or recreational facilities [23]. They may also have higher rates of smoking due to targeted marketing by tobacco companies and greater exposure to stress [24]. However, it is also possible that there is residual confounding by unmeasured behavioral or environmental factors, such as diet or occupational exposures. Studies have shown that these factors can also significantly influence health outcomes and may contribute to observed mortality risks [18,25].

The limited association between the other EnviroScreen component scores (e.g., climate vulnerability) and mortality may reflect the complex pathways through which the social and environmental determinants of health jointly influence mortality risk. For instance, while climate vulnerability encompasses risks such as extreme weather and environmental degradation, its impacts may be less direct compared to pollution exposures [9,26]. This suggests that some components of environmental justice, like climate resilience, have less direct or immediate impacts on health compared to pollution exposures.

Previous studies using similar cumulative EJ mapping tools have also found associations with health outcomes, supporting the validity and utility of this approach. For example, the California CalEnviroScreen score was associated with a 1.6% increase in pediatric asthma hospitalizations per 10 percentile increase [27], similar in magnitude to the association with all-cause mortality found in this study. A study in Washington State found that communities with higher environmental health disparities, as measured by the Washington Environmental Health Disparities Map, had higher rates of cardiovascular disease mortality [28]. However, direct comparisons across studies are challenging, given the differences in the component scores, indicators, and methods used to develop EJ mapping tools in different states and contexts. More research is needed to refine and standardize these tools and to examine their associations with a wider range of health outcomes across diverse populations. The findings of this study have important implications for sustainable development and environmental justice. The observed association between environmental exposures and mortality underscores the need to integrate environmental justice considerations into sustainable planning and public health policies. By identifying areas with higher environmental burdens and associated health risks, tools like CO EnviroScreen can guide policymakers in prioritizing interventions that simultaneously address environmental quality, public health, and social equity—key components of sustainable development. This approach aligns with the concept of 'just sustainability', which emphasizes the importance of considering both environmental and social justice to pursue sustainable communities.

Strengths and Limitations

This study had several strengths and limitations that should be considered when interpreting the results. A major strength was the use of the novel CO EnviroScreen tool, which provides a comprehensive assessment of cumulative environmental exposures and vulnerabilities at the county level. This tool allows for the examination of multiple dimensions of environmental justice and their potential impacts on health outcomes. Additionally, this study utilized a rigorous statistical approach, including sensitivity analyses, to assess the robustness of the findings.

However, the study design is a limitation, as it relied on aggregated data at the county level rather than individual-level data. This design is prone to ecological fallacy, where associations observed at the group level may not reflect the associations at the individual level. As a result, caution should be exercised when drawing conclusions about individuallevel relationships based on county-level data. Future studies could employ a design with individual-level data to better examine the links between environmental exposures, sociodemographic factors, and mortality risk within disproportionately impacted communities. Further, while the study adjusted for several important behavioral risk factors, such as smoking and physical inactivity, there may be other unmeasured confounders, such as occupational exposures or access to healthcare, that could contribute to the association between CO EnviroScreen scores and mortality. Additionally, the CO EnviroScreen tool itself has some inherent limitations, as it does not include all possible environmental exposures, climate impacts, health outcomes, and demographic factors due to the lack of reliable data sources [6]. This may lead to an underestimation of the true cumulative impacts of environmental injustice on health. The use of data from different years for the exposure (2010–2021), outcome (2019), and covariates (2020–2021) is another limitation that could potentially obscure the true associations. While we acknowledge the potential for heterogeneity across spatial and temporal dimensions due to data sourced from different years, we believe our approach still provides valuable insights into the relationship between environmental factors and mortality. Despite these temporal discrepancies, the use of multi-year data for environmental exposures (2010-2021) captures longer-term environmental conditions that are likely to influence health outcomes over time, rather than solely reflecting short-term fluctuations. Future studies could explore more complex modeling approaches to account for this heterogeneity. The decision to use 2019 mortality data was made to mitigate the effects of the COVID-19 pandemic on mortality rates. However, the use of covariate data from 2020 and 2021, years heavily impacted by the pandemic, may have introduced bias. Some behavioral risk factors, such as alcohol overconsumption and physical inactivity, were found to increase during the pandemic [29], which could have affected the observed relationships. While the authors believe that the overall trends in behavioral risk factors did not change substantially enough to impact the findings, this remains a potential source of uncertainty.

Despite these limitations, the county-level analysis employed in this study has important strengths from a policy and public health perspective. Counties are often the primary level at which public health interventions and resource allocation decisions are made [30]. CO operates with a decentralized public health system that follows county boundaries. Therefore, county-level findings can be more directly relevant and actionable for policymakers and administrators compared to census tract or block-level analyses. However, future studies should also consider examining within-county variability in environmental exposures and health outcomes to better understand local disparities and inform targeted interventions. To address these limitations and build upon the current findings, future research should aim to collect and integrate temporally aligned data on environmental exposures, health outcomes, and sociodemographic factors at multiple geographic scales. Longitudinal studies with individual-level data could provide a more definitive understanding of the causal pathways linking cumulative environmental exposures to mortality risk over time. Additionally, qualitative research exploring the lived experiences and perspectives of residents in disproportionately impacted communities could complement the quantitative findings and inform more community-engaged and equitable policy solutions.

5. Conclusions

This study provides novel evidence of an association between the CO EnviroScreen score, particularly the environmental exposure component, and all-cause mortality rates at the county level in Colorado in 2019. The findings suggest that cumulative environmental exposures may contribute to geographic disparities in mortality risk, even after adjusting for key behavioral risk factors. These results align with our initial aim to bridge the knowledge gap regarding how EJ mapping tools like CO EnviroScreen correlate with health outcomes. This study demonstrates that the environmental exposure component of CO EnviroScreen is a meaningful indicator of mortality risk, supporting the utility of such tools in identifying areas at higher risk due to environmental factors.

Our findings underscore the importance of considering the cumulative impacts of multiple environmental stressors on health and highlight the need for comprehensive, multi-sectoral approaches to address environmental health disparities. While our study does not directly measure comprehensive environmental justice outcomes, it contributes to the field by demonstrating the utility of the CO EnviroScreen tool in identifying areas with higher environmental exposure risks. These findings can inform future, more targeted environmental justice analyses and interventions.

It is important to note that while our study demonstrates the utility of CO EnviroScreen in identifying areas at risk due to environmental factors, it does not establish a direct link to broader EJ outcomes. Our findings contribute to the field by demonstrating the association between environmental exposure risks, as measured by CO EnviroScreen, and mortality rates. However, comprehensive EJ outcomes encompass a wider range of social, economic, and health factors that were beyond the scope of this study. Future research should explore specific environmental exposures and their direct impacts on health disparities to provide a more complete picture of environmental justice in Colorado. Additionally, while the study design limitations should be considered when interpreting the results, this research lays the groundwork for future studies exploring the links between environmental justice and health outcomes.

In conclusion, this study provides valuable insights into the relationship between environmental exposures and mortality risk, supporting the use of environmental justice mapping tools in public health research and sustainable development policy. The association between CO EnviroScreen scores and mortality rates highlights the importance of addressing cumulative environmental impacts to create more sustainable and equitable communities. This research contributes to the broader goals of sustainable development by demonstrating how environmental justice tools can inform efforts to improve both environmental quality and public health outcomes. However, further research is needed to fully understand the complex interactions between environmental justice and sustainability. Future studies should explore how interventions targeting areas with high environmental burdens can contribute to both improved health outcomes and more sustainable environments.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su16219147/s1. Table S1: Individual Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 64); Table S2: Unadjusted Association: Mortality and EnviroScreen Component Scores, County Level, per 10 percentile increase in component score, excluding Mineral County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and County (n = 63); Table S3: Individual Association: Mortality and EnviroScreen Component Scores and (n = 64); Table S3: Individual Scores (n = 64); Table S3: Individual Scores (n = 64); Table S4: Individual Sc

covariates, County Level, per 10 percentile increase in component score, excluding Mineral (n = 63); Table S4: Adjusted Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score, excluding Mineral (n = 63); Table S5: Unadjusted Urban Association: Mortality and EnviroScreen Component Scores, County Level, per 10 percentile increase in component score (n = 17); Table S6: Individual Urban Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 17); Table S7: Adjusted Urban Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 17); Table S8: Unadjusted Rural Association: Mortality and EnviroScreen Component Scores, County Level, per 10 percentile increase in component score (n = 47); Table S9: Individual Rural Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 47); Table S10: Adjusted Rural Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 47); Table S11: Unadjusted Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 64); Table S12: Adjusted Association: Mortality and EnviroScreen Component Scores and covariates, County Level, per 10 percentile increase in component score (n = 64); Figure S1: splines.

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Informed Consent Statement: Not applicable.

Data Availability Statement: All the data and analyses used in this study were obtained from CO EnviroScreen, CDPHE, and CDC PLACES, and are publicly available online on the websites, respectively, https://teeo-cdphe.shinyapps.io/COEnviroScreen_English/; https://www.datarequ est.dphe.state.co.us/; https://places.cdc.gov/?view=county (accessed on 21 October 2024).

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