Hazardous Waste Management Program
GOVERNMENTS WORKING TOGETHER FOR A HEALTHIER AND CLEANER KING COUNTY

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Developing a King County Environmental Health Disparities Map

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This report was developed in a partnership between the University of Washington and the Hazardous Waste Management Program in King County, Washington (Contract: 6388 EHS). The Hazardous Waste Management Program's customers are residents, businesses, and institutions with small quantities of hazardous wastes. Our mission is to protect and enhance public health and environmental quality in King County by reducing the threat posed by the production, use, storage and disposal of hazardous materials.

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List of Abbreviations

ACS – American Community Survey
BIPOC – Black, Indigenous, and People of Color
CDC – Centers for Disease Control and Prevention
CNT – Center for Neighborhood Technology
CSV – comma-separated values
EHD – environmental health disparities
EJTF – environmental justice task force
GIS – geographic information systems
HEAL - Healthy Environment for All
km – kilometer
lbs. - pounds
LEP – Limited English Proficiency
NOx – oxides of nitrogen
NPL – National Priorities List
OEHHA – Office of Environmental Health Hazard Assessment
PERC - perchloroethylene
PHSKC – Public Health-Seattle King County
PM2.5 – particulate matter (2.5 micrometers and smaller)
PSRC – Puget Sound Regional Council
RSEI – Risk Screening Environmental Indicators (RSEI)
TSDF – Treatment, Storage and Disposal Facilities
XLS – excel binary file format

Overview of Deliverables

This report documents the development of an environmental health disparities (EHD) mapping tool for King County, Washington and represents the primary deliverable for a project that was funded by the Hazardous Waste Management Program in King County, WA (Contract: 6388 EHS). This report is accompanied by a CSV data file and an XLS data dictionary. The CSV file includes raw values or estimates, lower and upper bounds of margin of error for estimates for each indicator. In addition, each indicator, all four categories of indicators, and the final EHD ranking also have statewide decile ranking, county percentile ranking, county decile ranking, and county quintile ranking in the file. For each indicator, Washington State Department of Health (DOH) Washington Tracking Network (WTN) uses three notations to identify census tracts that have data suppressed, data that is considered not reliable, or cases in which no data for the indicator is available (see data dictionary for details).

A mapping demo page showing the final EHD rankings for the county and state, as well as differences between the two, is included at the following link: https://uw.maps.arcgis.com/apps/MapSeries/index.html?appid=ebcb89a18d0c4b129e93bd97862944cd.

The King County EHD map data is hosted on the King County GIS open data site (https://gis-kingcounty.opendata.arcgis.com/) and the forthcoming King County Equity and Social Justice Open Data site (https://equity-kingcounty.opendata.arcgis.com/).

Executive Summary

Environmental hazards are not evenly distributed by location, which contributes to ongoing and persistent health disparities across communities. In King County and elsewhere, neighborhoods with lower resources, power, and privilege—which are overrepresented by Black, Indigenous, and People of Color (BIPOC), immigrant, and low-income residents—tend to experience higher burdens of environmental pollution. At the same time, communities more heavily impacted by pollution are often the most vulnerable to adverse health effects associated with environmental hazards. There is therefore a pressing need to identify communities within King County in which health disparities are likely to occur because of environmental injustices; this information can be used to prioritize and evaluate governmental projects and investments to reduce disproportionate environmental health impacts and improve access to healthy environments throughout the county.

The purpose of this project was to create a map of the environmental health disparities (EHD) that exist across communities in King County. This report outlines the methodology and includes a snapshot of current environmental and social conditions within King County.

The King County EHD map includes 19 indicators that capture pollution burden and population characteristics related to environmental risk. Indicators are grouped into four categories:

- Indicators that represent measures of pollutant exposures fall within the ***environmental exposure*** category
- Indicators that reflect adverse environmental conditions fall within the ***environmental effects*** category
- Community-level indicators that reflect individuals' biological susceptibility to environmental risk fall within the ***sensitive population*** category
- Community-level factors that may modify a community's risk fall within the ***socioeconomic factors*** category

These data can be used to quantify the cumulative impact of multiple environmental and social risk factors occurring within a specific community or neighborhood, and then can be compared to other areas to understand which communities are disproportionately impacted. The EHD mapping approach thus allows governmental and community stakeholders to center equity and environmental justice in their work, including when setting priorities for resource allocation or evaluating their programs and policies. Ultimately the purpose of this tool is to support efforts to reduce the disproportionate

environmental health impacts and improve access to healthy environments throughout the county.

Results from the constructed King County EHD map shows that many communities, particularly neighborhoods in the south King County area, are highly impacted by the cumulative impacts of pollution burden and population characteristics that may make these communities more vulnerable. Specifically, the tool clearly identifies that certain communities experience disproportionate burden across multiple dimensions of environmental hazards, including being exposed to higher levels of air pollution or living in closer proximity to hazardous waste treatment, storage, and disposal facilities. Further, these overburdened communities often experience worse community-level characteristics, such as higher rates of poverty or unemployment, which make residents in these areas more vulnerable to the effects of pollution and contribute to environmental health disparities in King County.

The Hazardous Waste Management Program in King County (Haz Waste Program) is a multi-jurisdictional program serving all of King County including the City of Seattle, 37 other cities, two tribes, and unincorporated areas. Their mission is to protect and enhance public health and environmental quality in King County by reducing the threat posed by the production, use, storage, and disposal of hazardous materials. Further, the Haz Waste Program is deeply committed to serving all people who live and work in King County and ensuring that race is not a determinant of hazardous materials exposure.[i] The King County EHD map can specifically enhance the Haz Waste Program's commitment to centering equity and social justice in their work. There are many ways to utilize the EHD map in the Haz Waste Program's planning and programmatic work. This report discusses only a few possibilities including meaningful community engagement, retrospective evaluation, resource prioritization, and other planning and decision-making efforts.

Section 1 | Background

Communities in Washington state experience environmental risks unevenly and unequally. People in communities with lower income, more Black, Indigenous, and People of Color (BIPOC), less access to education, or poorer health experience disproportionate health and environmental burdens. Communities overburdened by pollution, often the result of institutionalized racism and environmental racism, have worse health outcomes compared to other communities with more power and privilege. To effectively address the drivers of these disparities, a Washington state Environmental Health Disparities (EHD) Map was created to identify communities highly impacted by environmental pollution and population characteristics that may make a community more vulnerable.

King County is home to diverse populations and confronts environmental justice issues that are specific to the communities in the region. While the Washington statewide EHD map can provide a useful framework for understanding the distribution of environmental risks, there is concern that, when communities are mapped and ranked relative to all others across the entire state, the WA EHD tool may obscure local hotspots of risk within the county. A county-specific map would provide better resolution for identifying the current state of environmental health disparities and injustices occurring within and across King County communities. Moreover, a county-specific tool would provide King County government and community stakeholders with clearer information to identify and address ongoing environmental injustices.

For this reason, the Hazardous Waste Management Program in King County (Haz Waste Program) supported the creation of an EHD map specifically for communities in King County. The Haz Waste Program is a multiagency program located in Seattle, Washington that works to reduce hazardous exposure to people and the environment in King County. The Program delivers services and develops policy related to hazardous products and wastes, including promoting pollution prevention through adoption of safer alternatives and management practices and direct collection of hazardous materials for safe disposal. Importantly, the Haz Waste Program recognizes that the social structures of racism compound the effects of hazardous exposures and are well-positioned to integrate the EHD mapping tool and social justice principles into the Program's work.

In describing the EHD map that was developed for King County, it is useful to first describe the process that led to the WA statewide EHD Map. The WA EHD Map was first launched in January 2019.[ii] It is maintained by the Washington State Department of Health (DOH), Washington Tracking Network (WTN), which is currently funded through a Centers for Disease Control and Prevention (CDC) Environmental Health Tracking grant.

Prior to the development of the EHD map, the WTN hosted and shared a variety of environmental, social, and demographic data but did not combine data into a composite indicator of cumulative environmental health risk. To develop a more comprehensive tool that integrated data on environmental pollution burden with principles of social and environmental justice, a diverse workgroup of community, academic, and government stakeholders worked collaboratively to create a statewide EHD map using a cumulative impacts approach. Front and Centered, a coalition of community organizations, led the workgroup to build the map. The University of Washington Department of Environmental and Occupational Health Sciences in the School of Public Health led technical aspects of the map development. DOH, WA Department of Ecology, and Puget Sound Clean Air Agency provided additional input based on their experience and shared data, staff time, and resources to create the statewide EHD map. Importantly, the statewide EHD map reflects the lived experiences of highly impacted communities learned through a series of community listening sessions in 2017.[iii] There were other routine engagements with stakeholders outside of the workgroup – for example, a symposium, webinars, and an environmental justice summit.

Since the launch of the statewide EHD Map, it has been applied in several agencies' work and policies:

- In 2019, the Clean Energy Transformation Act (SB 5116) was passed in the Washington state legislature. DOH recommends the use of the EHD map to identify communities highly impacted by fossil fuel pollution and climate change to ensure an equitable distribution of benefits and reduction of burdens to the overburdened communities.
- In 2019, a WA state environmental justice task force (EJTF) was created through a budget proviso in the state's 2019 – 2021 operating budget (Engrossed Substitute House Bill 1109, section 221, subsection 48). The EJTF finalized a report in October 2020 with recommendations on how state agencies should incorporate the WA EHD map, and model policies or applications of environmental justice mapping tools.[iv]
- Based on these recommendations, in 2021, the Washington state legislature passed the Healthy Environment for All (HEAL) Act (SB 5141).[v] This bill requires state agencies to incorporate environmental justice into decision-making processes (including by using the EHD mapping tool), and improves government accountability to communities by developing consistent and accessible pathways for communities to meaningfully engage in government decision-making processes (including creating an environmental justice council to facilitate such processes). The bill also mandates the statewide EHD map be maintained and updated.

This report details the development of a King County EHD map, and the cumulative impacts of environmental risk based on the indicators of pollution burden and community-level

factors that may increase vulnerability to environmental risks. This involves re-scaling the data from the statewide tool to the King County level; that is, King County communities are compared to other communities within the county, rather than all other communities in Washington state. The King County EHD map provides better resolution to the current state of EHD occurring across King County communities and provides King County government and community stakeholders with information to address ongoing environmental injustices.

Section 2 | Methods

Data descriptions

For all King County census tracts, raw data for nineteen indicators were downloaded from the DOH WTN data query portal on April 9th, 2021. The indicators in the map were assigned to one of the following four categories:

1. ***Environmental exposures*** (measurement of pollutants),
2. ***Environmental effects*** (adverse environmental conditions that may pose a risk to nearby communities),
3. ***Sensitive populations*** (biological/intrinsic vulnerability in a community), and
4. ***Socioeconomic factors*** (extrinsic vulnerabilities that modify the community's experience to pollution).

The indicators are described in Table 1.

Table 1. List of 19 indicators for King County environmental health disparities map.

Category	Indicator	Indicator description	Data Source
Environmental exposure	Diesel emissions	NOx from diesel sources allocated to census tracts by annual Tons/km^2, based on AIRPACT-5 4 km by 4 km grid cells	Washington State Department of Ecology Comprehensive Emissions Inventory (2014)
Environmental exposure	Ozone	Three-year mean concentration of daily maximum 8-hour rolling averaged ozone, based on 12 km by 12 km grid cells	AIRPACT (2009–2011)
Environmental exposure	Particulate Matter $(PM)_{2.5}$	Three-year mean concentration of annual $PM_{2.5}$ based on 12 km by 12 km grid cells	AIRPACT (2009–2011)

Category	Indicator	Indicator description	Data Source
Environmental exposure	Toxic releases from facilities	Toxicity-weighted concentrations of chemical releases to air from facility emissions and off-site incineration	Risk Screening Environmental Indicators (RSEI) (2014–2016)
Environmental exposure	Traffic density	Percentage of population exposed to busy roadways within each census tract	Washington State Office of Financial Management and Washington State Department of Transportation (2017)
Environmental effects	Lead risk and exposure	Percentage of housing units built before 1980, including single homes and multiple residence units such as apartments, modeled by DOH	American Community Survey (ACS) 5-year estimates (2013-2017)
Environmental effects	Proximity to hazardous waste treatment, storage, and disposal facilities (TSDFs)	Count of all commercial Hazardous waste Treatment, Storage and Disposal Facilities (TSDF) within 5 km, divided by distance, presented as population-weighted averages of blocks in each census tract	EJSCREEN (2017)
Environmental effects	Proximity to Superfund sites	Count of sites proposed and listed on the National Priorities List (NPL)	EJSCREEN (2017)
Environmental effects	Proximity to facilities with highly toxic substances	Count of facilities that have Risk Management Plans within 5 km, divided by distance, presented as population-weighted averages of blocks in each census tract	EJSCREEN (2017)

Category	Indicator	Indicator description	Data Source
Environmental effects	Wastewater discharge	Toxicity-weighted concentration in stream reach segments within 500 meters of a block centroid, divided by distance in meters, presented as the population-weighted average of blocks in each census tract	EJSCREEN (2017)
Sensitive populations	Cardiovascular disease	Cardiovascular disease mortality age-adjusted rate per 100,000 population	Washington State Department of Health Center for Health Statistics (2014-2018)
Sensitive populations	Low birth weight	Number of live-born singleton (one baby) infants born at term (at or above 37 completed weeks of gestation) with a birth weight of less than 2500 grams (about 5.5 lbs.)	Washington State Department of Health Center for Health Statistics (2015-2019)
Socioeconomic factors	Low educational attainment	Percent of population over age 25 with less than a high school education	ACS 5-year estimates (2013-2017)
Socioeconomic factors	Housing burden	Percentages of spending greater than 30 percent of one's income on housing costs	ACS 5-year estimates (2013-2017)
Socioeconomic factors	Linguistic isolation	Percentage of population age five or older that speak English less than "very well" and "not at all"	ACS 5-year estimates (2013-2017)
Socioeconomic factors	Poverty	Percent of the population living below 185 percent of the federal poverty level	ACS 5-year estimates (2013-2017)
Socioeconomic factors	People of color	Sum of all race/ethnicity categories except White/Non-Hispanics, including Black, American Indian/Alaskan Native, Asian, Native Hawaiian other Pacific Islander, and two or more races	Washington State Office of Financial Management (2017)

Category	Indicator	Indicator description	Data Source
Socioeconomic factors	Transportation expense	Transportation costs based on percentage of income for the regional moderate household	Center for Neighborhood Technology (CNT) (2014–2015)
Socioeconomic factors	Unemployment	Percent of the population over the age of 16 that is unemployed and eligible for the labor force	ACS 5-year estimates (2013-2017)

With the exception of the low birth weight indicator, new rankings were computed specifically for the values observed for King County census tracts. For every census tract, a percentile rank was assigned to each indicator using the Microsoft Excel formula "PERCENTRANK.INC" with four significant digits. For each category (environmental exposures, environmental effects, sensitive populations, and socioeconomic factors), the average of all individual indicator percentile rank in the category is assigned a percentile rank using the same formula "PERCENTRANK.INC" using four significant digits. To calculate the final score, the pollution burden on communities (average of environmental exposure and environmental effects category) was multiplied by the population characteristics (sensitive populations and socioeconomic factors category) (Figure 1). Since the environmental effects category reflects adverse environmental conditions but not the actual level of exposure, the score for environmental effects indicators is down-weighted by half due to inherent uncertainty. This models a similar methodology used by the California Office of Environmental Health Hazard Assessment (OEHHA) CalEnviroScreen and similar tools in different states.[vi]

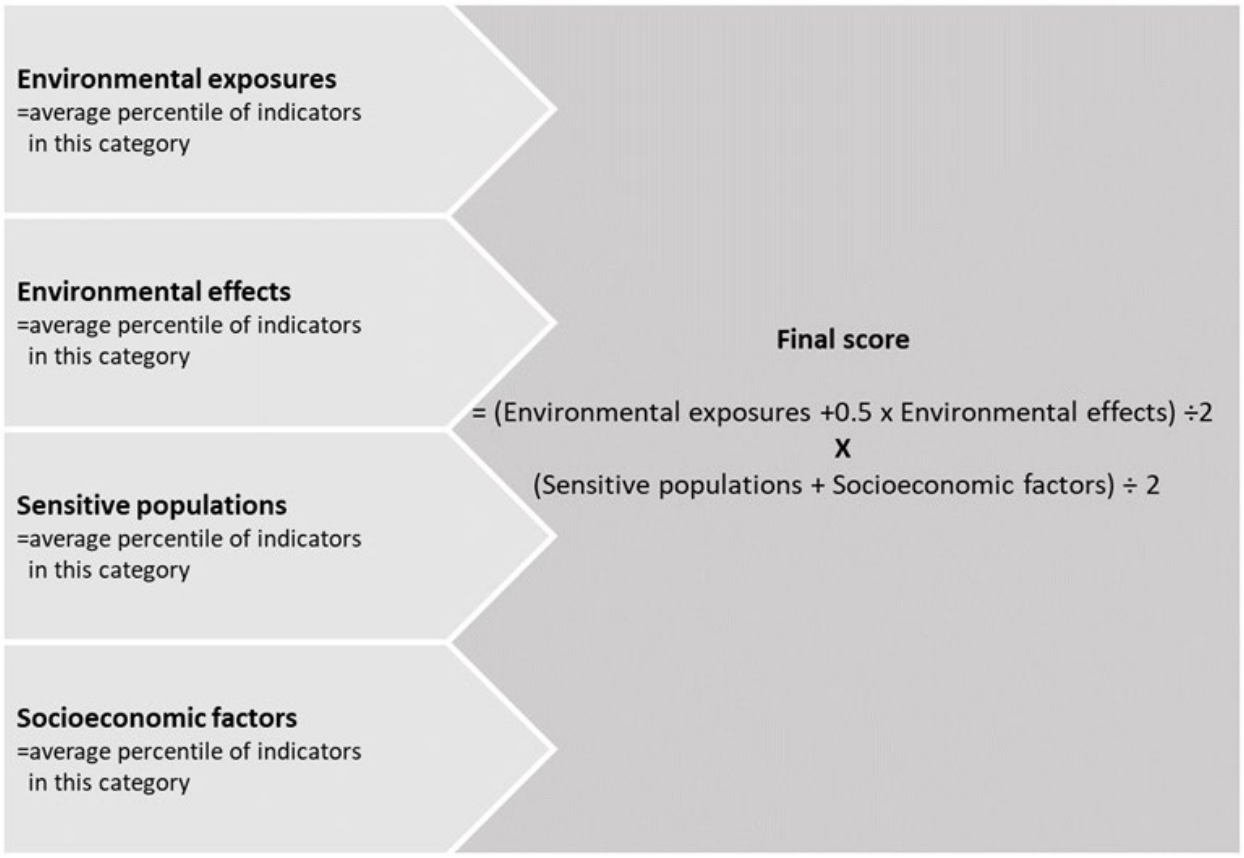


Figure 1. Formula of the final environmental health disparities score.

For individual indicators, the four categories of data, and the final EHD score, the individual census tracts were assigned decile, quintile, and percentile scores.

Limitations

There are a few limitations to note. This version of the King County EHD map only includes indicators that were used in the WA statewide map and relies on statewide or national data sources to capture the cumulative impacts of King County. It is important to note that the data sources underlying each indicator have inherent uncertainties and limitations that affect their reliability and accuracy (e.g., some indicators are based on modeling, which has inherent variability, while others are based on population estimates that may have sampling variability). In addition, there is no consensus on how to best capture the level of uncertainty associated with environmental risk factors.

There are a few caveats to note regarding the methodology used to develop the King County EHD tool:

1. State WTN tool uses "NR – not reliable" to mark census tracts when data for the specific indicator is not considered reliable due to uncertainty related to small sample size or sampling variability. The census tracts with indicator data marked as not reliable are still used to calculate ranking at the state WTN tool. The same approach was used to calculate the rankings for King County.
2. For the low birth weight indicator, statewide ranking was used due to the high level of data suppression across county census tracts. Of the 397 census tracts in King County, 11 census tracts had reliable data, 75 census tracts had data considered not reliable, and 312 census tracts had data suppressed in the public dataset due to small numbers and privacy concerns. Statewide ranking was still available in the publicly downloadable data. Table 2 shows the number and proportion of census tracts by the statewide decile ranking for the low birth weight indicator; roughly 10% of census tracts are assigned to each decile category, suggesting that the statewide decile rankings translate well to the county level.

Table 2. Breakdown of low birth weight indicator ranking for the state for King County census tracts.

State decile ranking for low birth weight	Number of census tracts in King County	Percent of King County census tracts (out of 397)*
1	36	9.07
2	33	8.31
3	37	9.32
4	41	10.33
5	32	8.06
6	36	9.07
7	46	11.59
8	46	11.59

State decile ranking for low birth weight	Number of census tracts in King County	Percent of King County census tracts (out of 397)*
9	46	11.59
10	44	11.08
*Table may not sum to 100% due to rounding.		

3. For the cardiovascular disease indicator, data for five King County census tracts is suppressed, but there is a statewide ranking assigned (census tract #53033004500, 53033005302, 53033006600, 53033010900, 53033032322). For these five tracts, the statewide ranking was used for the final calculation of EHD.

The decision to impute state-level rankings into the county-specific mapping tool for these two indicators (low birth weight and cardiovascular disease) was primarily to avoid having missing data for both indicators the sensitive populations category.

Correlation between indicators

Spearman's correlation was used to examine the relationships between each of the 19 indicators (Figure 2). Results show that many of the indicators of environmental pollution burden indicators are correlated with each other, especially toxic release from facilities and proximity to Superfund sites. The toxic release from facilities indicator was moderately or highly correlated to seven other indicators of pollution burden, including $PM_{2.5}$, ozone, proximity to superfund site indicator, lead risk and exposure, wastewater discharge, proximity to facilities with risk management plan, and proximity to hazardous waste TSDFs. The proximity to Superfund sites indicator was moderately correlated with indicators of $PM_{2.5}$, wastewater discharge, proximity to facilities with highly toxic substances, and proximity to hazardous waste TSDFs. The indicators for proximity to hazardous waste TSDFs, wastewater discharge, and $PM_{2.5}$ were each correlated to four other environmental indicators. Ozone levels were negatively correlated with toxic releases from facilities and lead risk indicators. Overall, the correlation results suggest that high levels of environmental pollution are concentrated within certain geographical areas and that these areas experience multiple environmental risks simultaneously.

Socioeconomic factors are also highly correlated to each other, showing the overlap of many social vulnerabilities within certain King County communities. In particular, communities with high proportions of residents identifying as BIPOC also tended to have higher levels of poverty, housing burden, and linguistic isolation and lower levels of educational attainment. The indicator of low educational attainment was also moderately

correlated with unemployment. As expected, the transportation expense indicator was negatively correlated with poverty, race/ethnicity, and linguistic isolation indicators. The poverty and low educational attainment indicators were associated with the cardiovascular disease indicator from the sensitive populations category.

Socioeconomic factors were also associated with higher levels of some environmental pollution burdens. The race/ethnicity indicator was moderately correlated with five indicators of environmental exposure and effects, including $PM_{2.5}$, toxic releases from facilities, proximity to Superfund sites, proximity to facilities with highly toxic substances, and proximity to hazardous waste TSDFs, suggesting BIPOC residents of King County may experience disproportionate levels of environmental pollution. Poverty and low educational attainment were each associated with the following four pollution burden indicators: $PM_{2.5}$, toxic releases from facilities, wastewater discharge, and proximity to hazardous waste TSDFs. Housing burden was also moderately correlated with $PM_{2.5}$, wastewater discharge, and proximity to hazardous waste TSDFs.

		PM 2.5	Ozone	Toxic Release	Diesel Emission	Traffic	Lead Risk	Wastewater Discharge	Superfund Sites	Facilities with highly toxic	Hazardous Waste	Cardiovascular Disease	Low Birth Weight	Poverty	Race/Ethnicity	Low Educational	Linguistic Isolation	Housing Burden	Unemployment	Transportation Expense
Environmental Expoures	PM 2.5	1																		
	Ozone	-0.45	1																	
	Toxic Release	0.70	-0.52	1																
	Diesel Emission	0.36	-0.44	0.46	1															
	Traffic	0.31	-0.07	0.29	0.35	1														
Environmental Effects	Lead Risk	0.26	-0.57	0.55	0.19	-0.04	1													
	Wastewater Discharge	0.72	-0.19	0.59	0.43	0.48	0.06	1												
	Superfund Sites	0.56	-0.24	0.84	0.46	0.33	0.29	0.57	1											
	Facilities with highly toxic sub.	0.40	-0.34	0.55	0.49	-0.02	0.12	0.29	0.52	1										
	Hazardous Waste	0.77	-0.05	0.66	0.35	0.39	0.08	0.71	0.73	0.41	1									
Sensitive Populations	Cardiovascular Disease	0.49	0.15	0.19	-0.11	0.21	-0.16	0.39	0.16	-0.02	0.46	1								
	Low Birth Weight	0.31	-0.15	0.36	0.29	0.22	-0.11	0.36	0.35	0.40	0.33	0.11	1							
Socioeconomic Factors	Poverty	0.75	-0.32	0.56	0.37	0.40	0.22	0.52	0.42	0.31	0.60	0.54	0.22	1						
	Race/Ethnicity	0.55	-0.34	0.53	0.40	0.30	0.00	0.46	0.53	0.55	0.55	0.29	0.45	0.70	1					
	Low Educational Attainment	0.68	-0.18	0.50	0.22	0.37	0.15	0.53	0.37	0.28	0.57	0.55	0.28	0.85	0.67	1				
	Linguistic Isolation	0.41	-0.17	0.39	0.35	0.37	-0.04	0.37	0.39	0.40	0.49	0.28	0.43	0.70	0.79	0.74	1			
	Housing Burden	0.68	-0.21	0.49	0.29	0.40	0.16	0.52	0.36	0.21	0.60	0.48	0.21	0.85	0.52	0.74	0.56	1		
	Unemployment	0.35	-0.05	0.18	0.02	0.05	-0.07	0.26	0.12	0.12	0.23	0.22	0.14	0.37	0.30	0.51	0.34	0.40	1	
	Transportation Expense	-0.36	0.49	-0.41	-0.55	-0.27	-0.14	-0.22	-0.35	-0.39	-0.24	0.04	-0.23	-0.61	-0.59	-0.36	-0.53	-0.47	-0.14	1

Spearman's correlation coefficient based on raw indicator values.

Weakly correlated: between -0.5 and +0.5
Moderately correlated: between 0.5 and 0.8 (either positive or negative)
Highly correlated: less than -0.8 or greater than 0.8

Figure 2. Spearman's correlation coefficient of indicators.

Section 3 | King County Environmental Health Disparities Map

The maps presented in this section are displayed using a decile rank 1-10, with 1 being the "least impacted" and 10 being the "most impacted" (Figure 3).

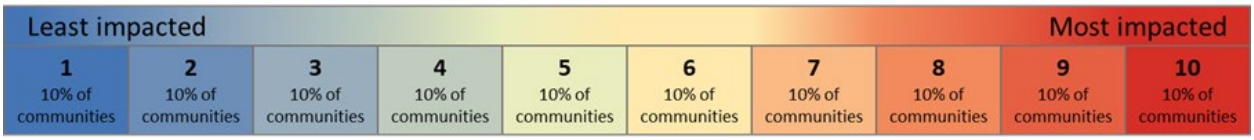


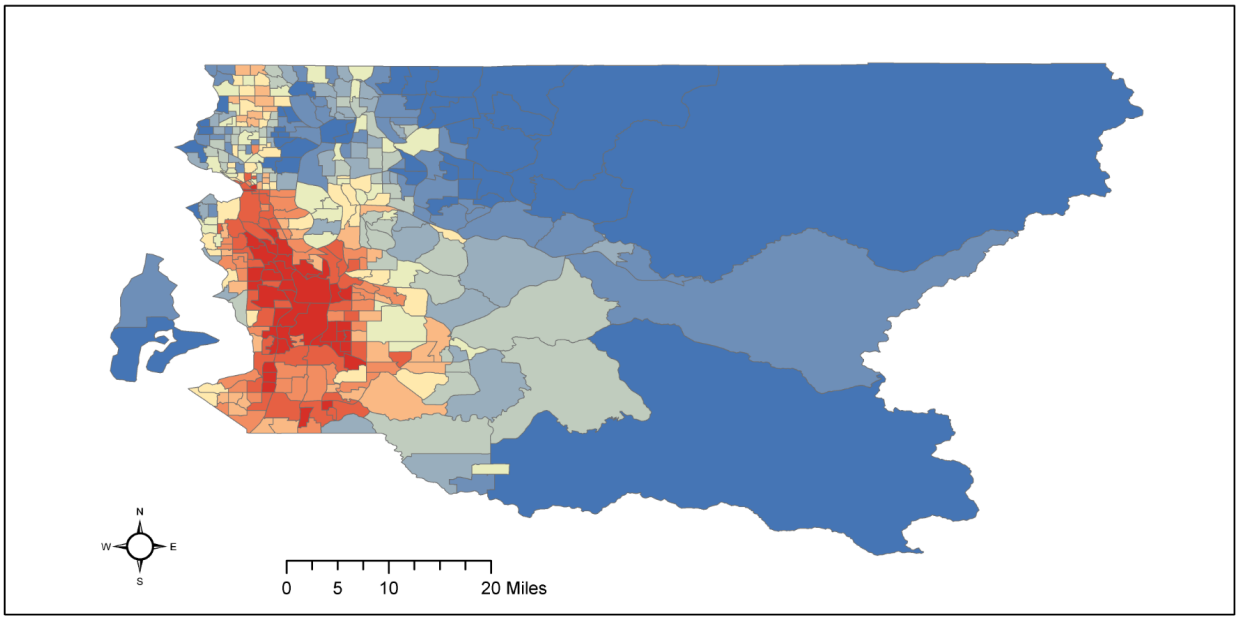
Figure 3. Legend for decile rankings used in the King County environmental health disparities map.

This means that if a census tract has a final ranking of 8, then there are 10% of census tracts in King County that are similarly impacted, 20% who are more impacted, and 70% less impacted relatively. Rankings and maps presented here can be used to measure relative environmental risk factors in communities. The ranking can also be used as a relative baseline, in order to track changes over time in environmental justice conditions in communities.

There are 397 census tracts in King County. For the final decile ranking for King County, there are 40 census tracts in each decile ranking, except for the 4th, 7th, and 10th deciles which each contain 39 King County census tracts.

Final environmental health disparities ranking

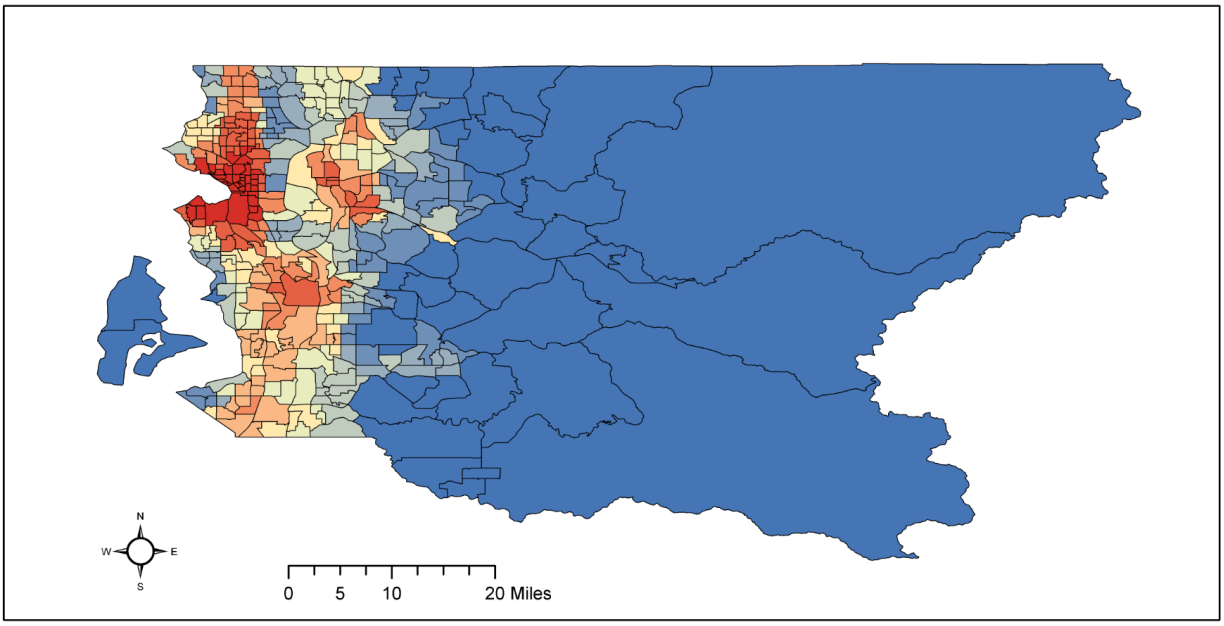
Census tracts ranked 9 or 10 are mainly clustered in the south King County region (Map 1). Particularly, most census tracts in the neighborhoods of Beacon Hill/Georgetown/South Park, SeaTac, Tukwila, and Renton are highly impacted by the cumulative EHD.



Map 1. Final environmental health disparities ranking for census tracts in King County in deciles.

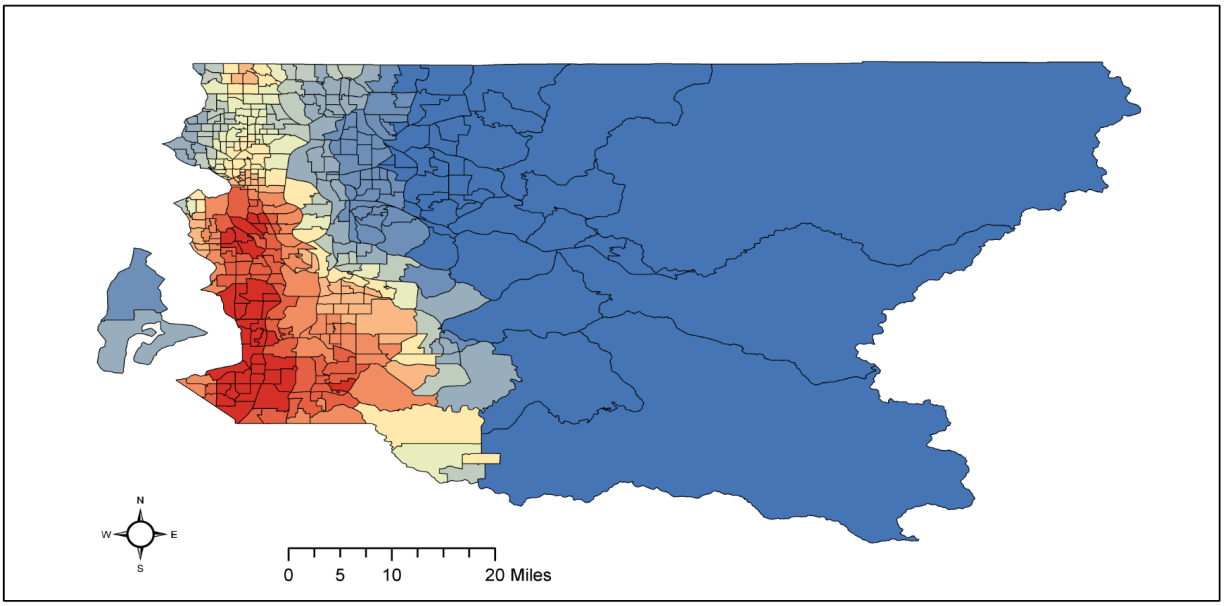
Environmental exposure

Indicators in the environmental exposure category show varying patterns of where highly impacted communities are located, primarily based on the different sources of pollution on the communities (Maps 2-7). Neighborhoods of Elliot Bay and Port of Seattle are highly impacted by diesel emission levels of NOx (Map 2).



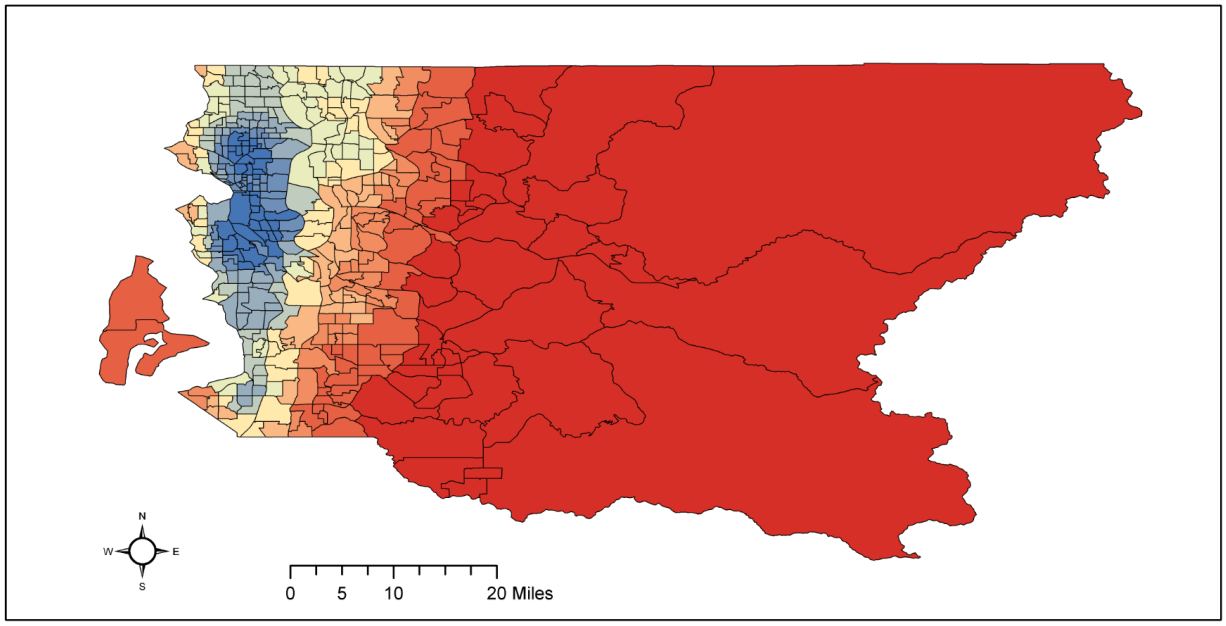
Map 2. Diesel emissions in deciles.

Census tracts in the greater Duwamish, Georgetown, Des Moines, and Federal Way are highly impacted by $PM_{2.5}$ (Map 3).



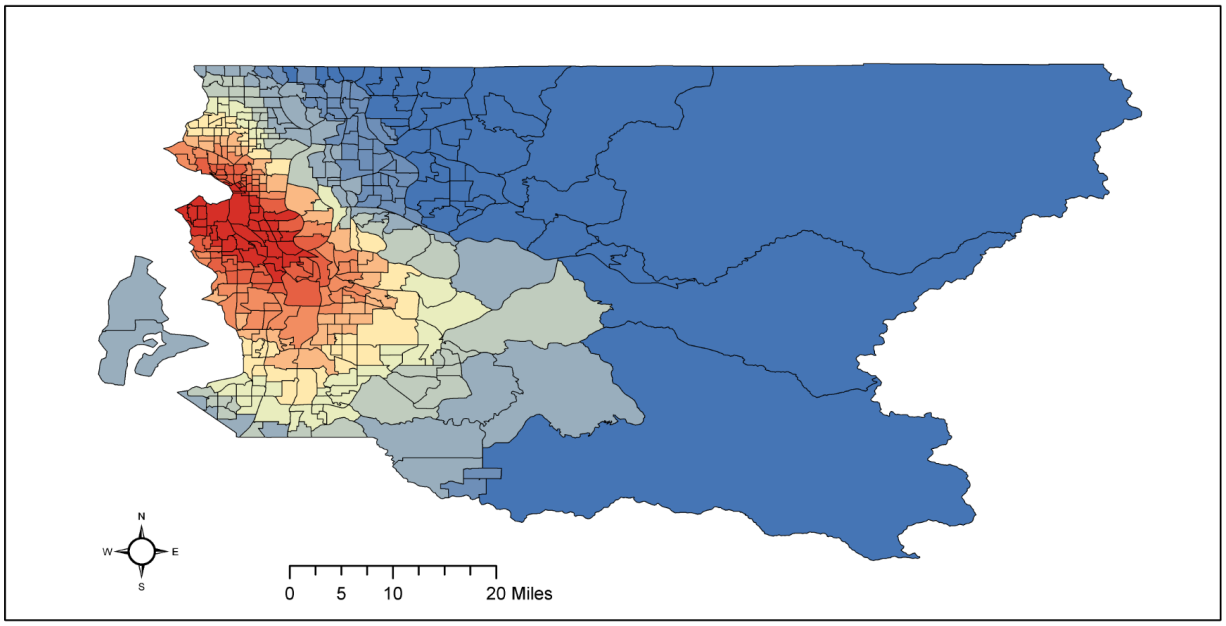
Map 3. $PM_{2.5}$ in deciles.

The distribution of the ozone indicator shows highly impacted census tracts are downwind of the urban areas and sources of emission, with highly impacted census tracts in Snoqualmie/North Bend/Skykomish, Covington/Maple Valley, and Black Diamond/Enumclaw/SE County neighborhoods (Map 4).



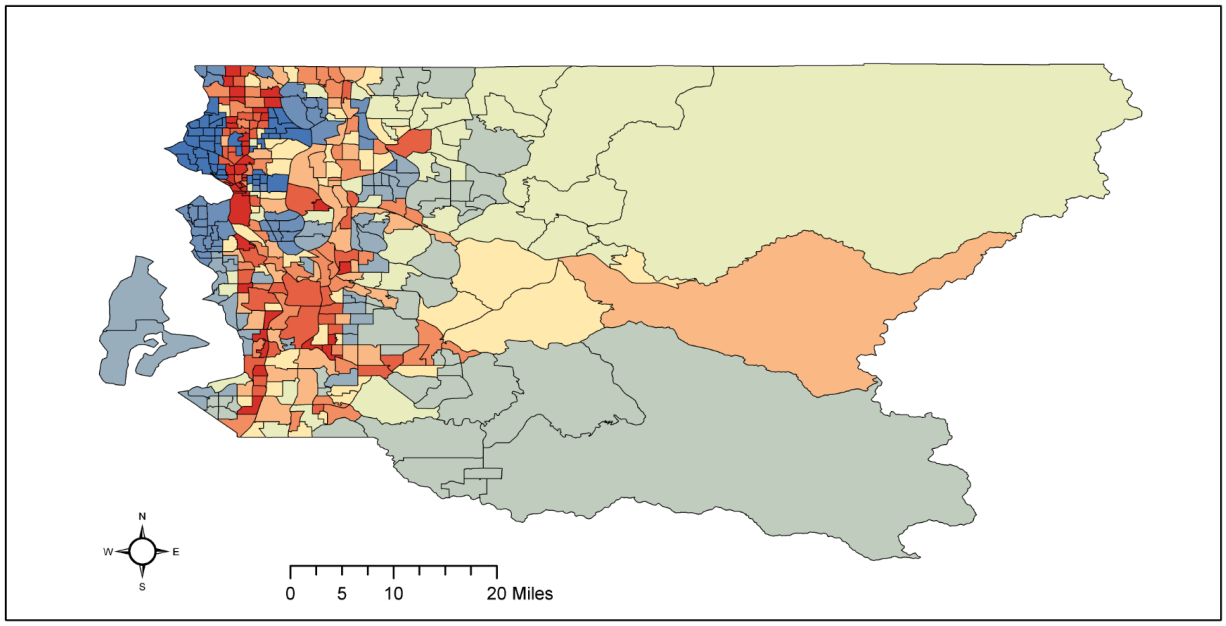
Map 4. Ozone in deciles.

Census tracts highly impacted by toxic release from facilities into air are clustered in Beacon Hill, Georgetown, South Park, and Tukwila neighborhoods (Map 5).



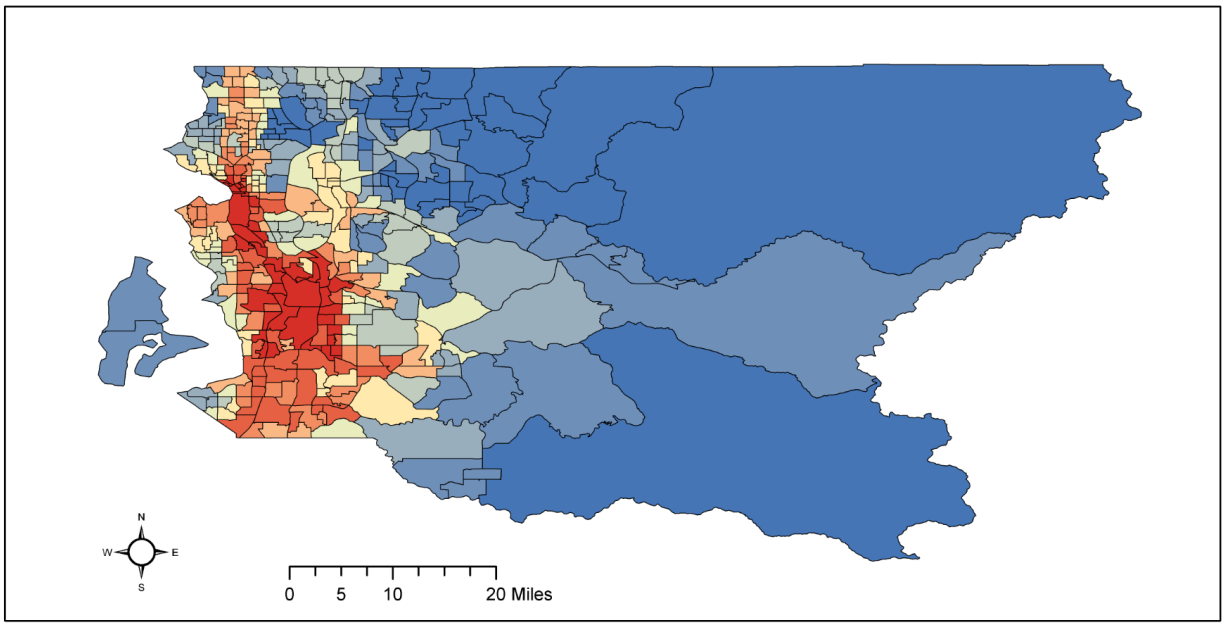
Map 5. Toxic release from facilities in deciles.

Census tracts near corridors of major freeways such as I-5 and I-405 are highly impacted by the indicator of traffic density (Map 6).



Map 6. Traffic density in deciles.

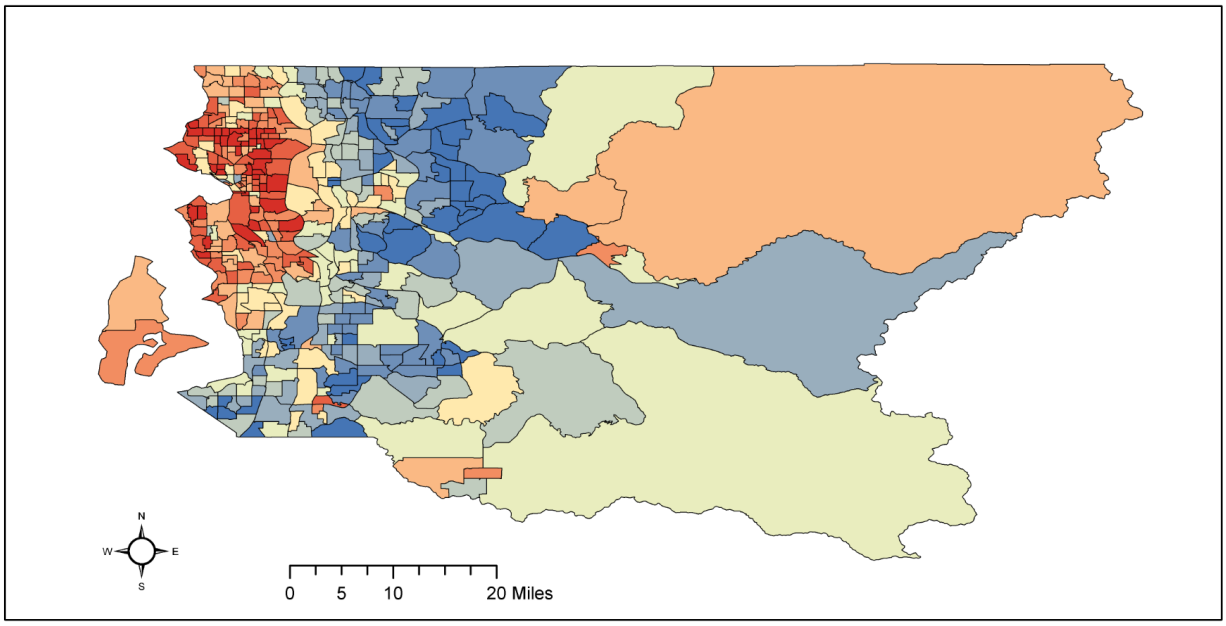
When these indicators are combined, census tracts in downtown Seattle, Beacon Hill, Georgetown, South Park, Tukwila, SeaTac, and Renton area are highly impacted by the environmental exposure category (Map 7).



Map 7. Environmental exposure category in deciles.

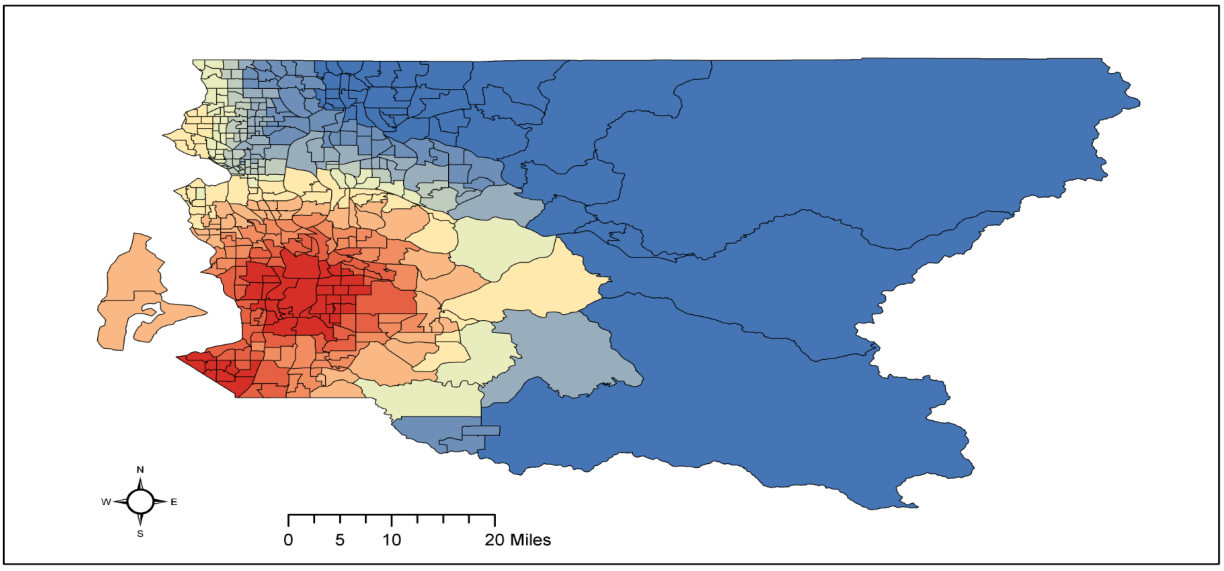
Environmental effects

The indicators in the environmental effects category highlight areas that are sources of adverse environmental quality (Maps 8-13). Neighborhoods highly impacted by lead risk and exposure are primarily located in Seattle where there is a higher prevalence of older housing, including in central Seattle, Ballard, Fremont/Green Lake, and northeast Seattle communities (Map 8).



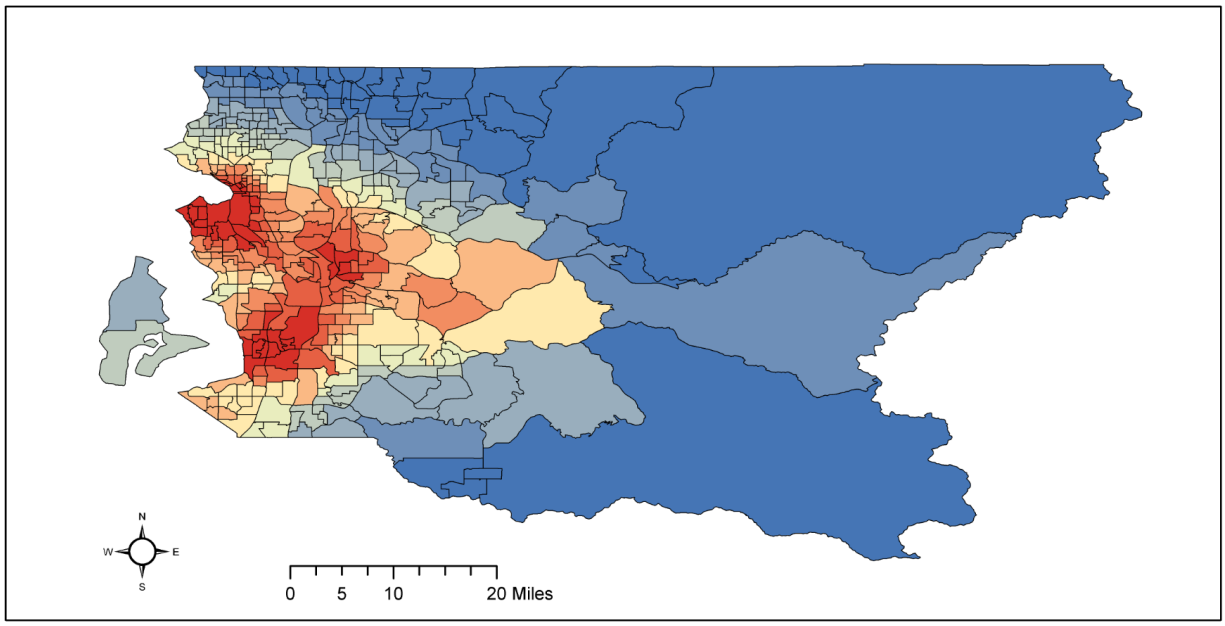
Map 8. Lead risk and exposure in deciles.

Neighborhoods of Tukwila, Kent, Renton, and Federal Way are highly impacted according to the proximity to hazardous waste TSDFs indicator (Map 9).



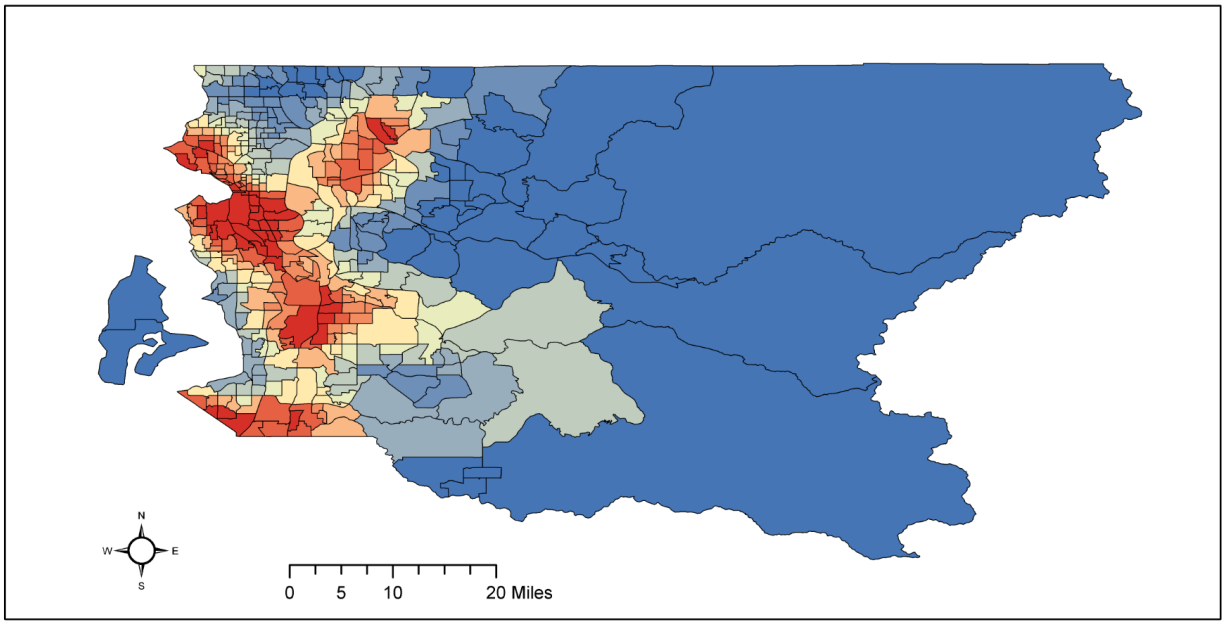
Map 9. Proximity to hazardous waste TSDFs in deciles.

Several clusters of highly impacted communities located near the Superfund sites are identified by the tool, including in West Seattle, Seattle neighborhoods along the Duwamish River, Kent, Des Moines, and Renton areas (Map 10).



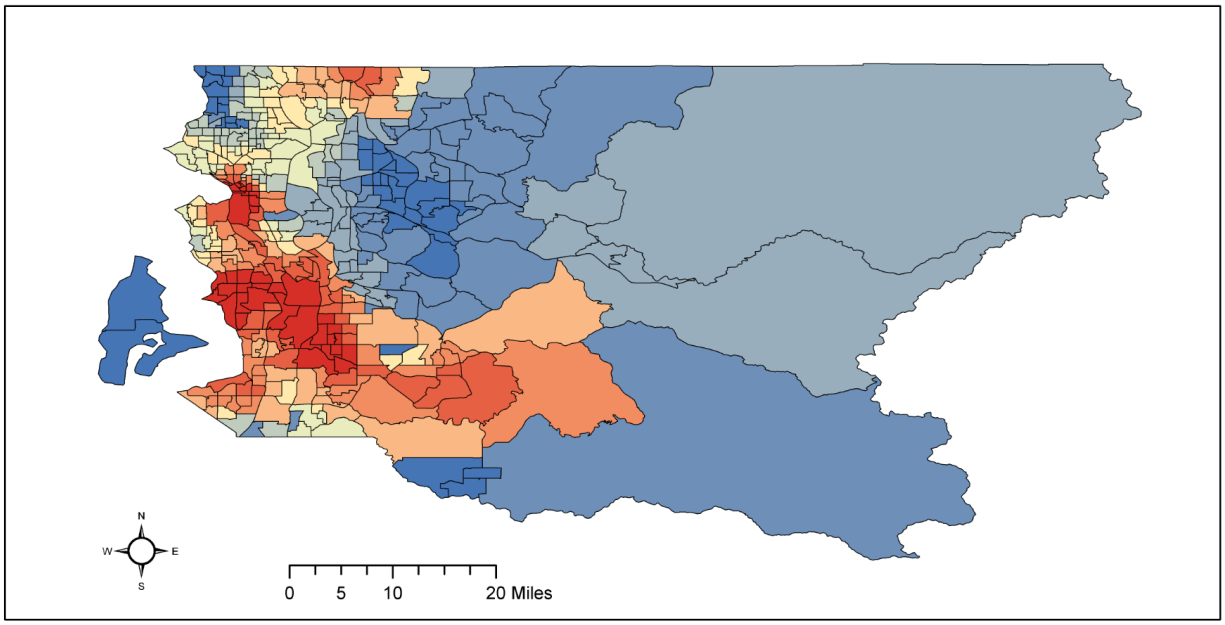
Map 10. Proximity to Superfund sites in deciles.

Census tracts around Beacon Hill, Georgetown, South Park, Kent, and Federal Way areas are highly impacted by the proximity to facilities with highly toxic substances indicator (Map 11).



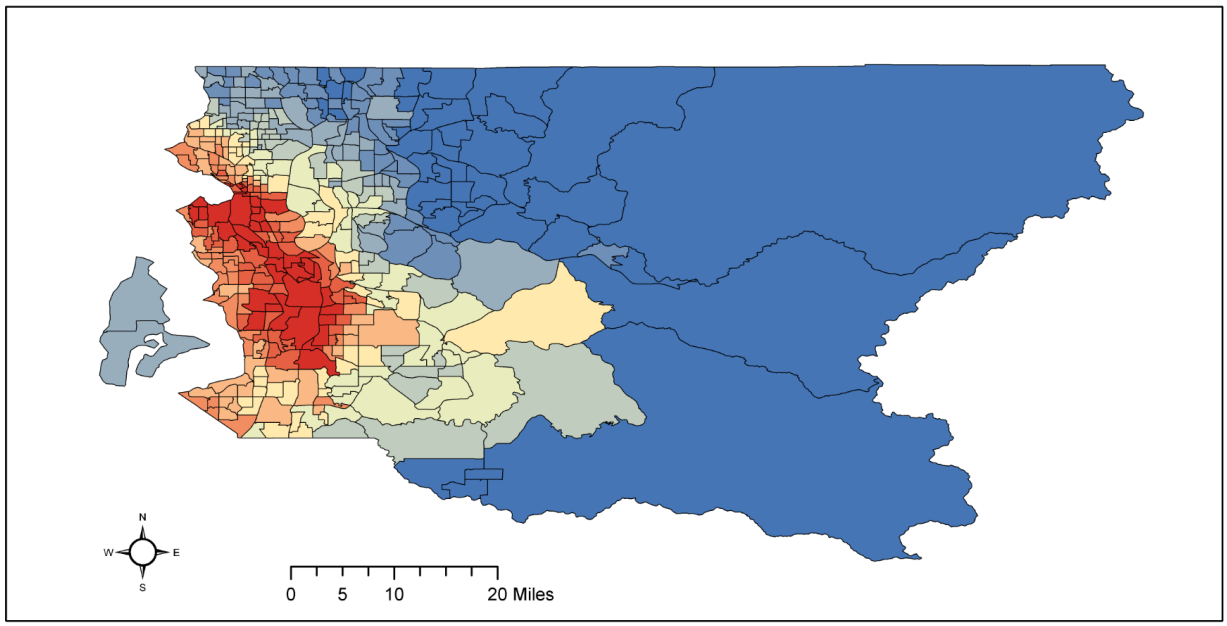
Map 11. Proximity to facilities with highly toxic substances (risk management plans) in deciles.

Neighborhoods in downtown Seattle, Burien, SeaTac, and Kent are highly impacted by wastewater discharge (Map 12).



Map 12. Wastewater discharge in deciles.

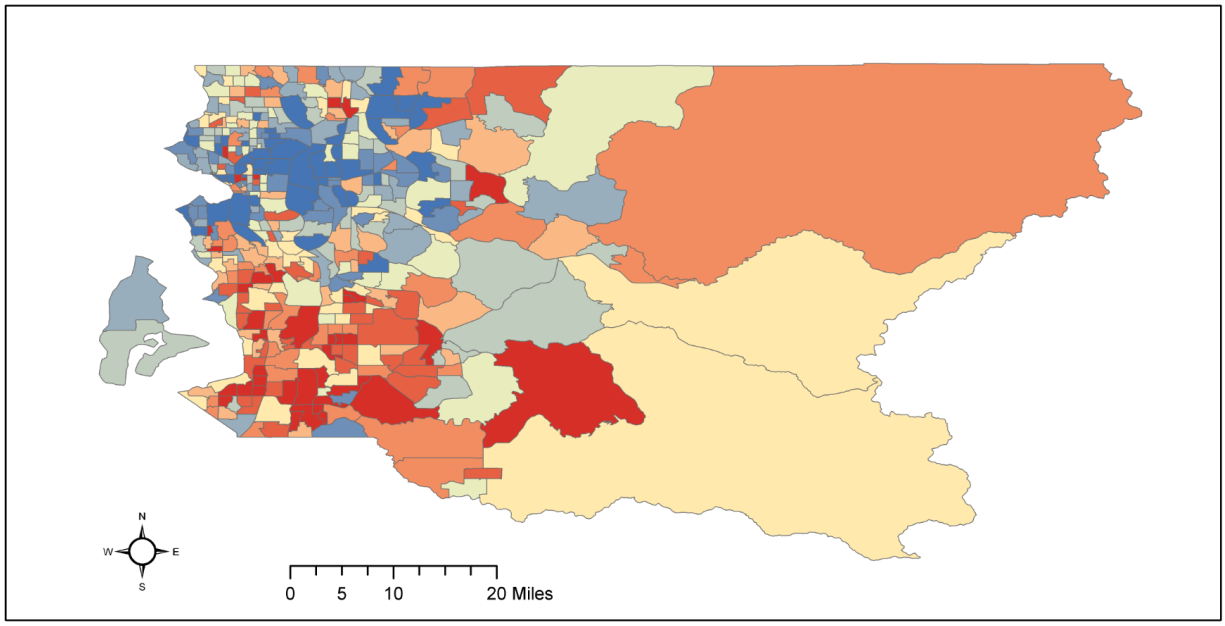
When averaged together, the map of the environmental effects category shows many south King County neighborhoods such as Beacon Hill, Georgetown, South Park, and Kent are highly impacted by these indicators combined (Map 13).



Map 13. Environmental effects in deciles.

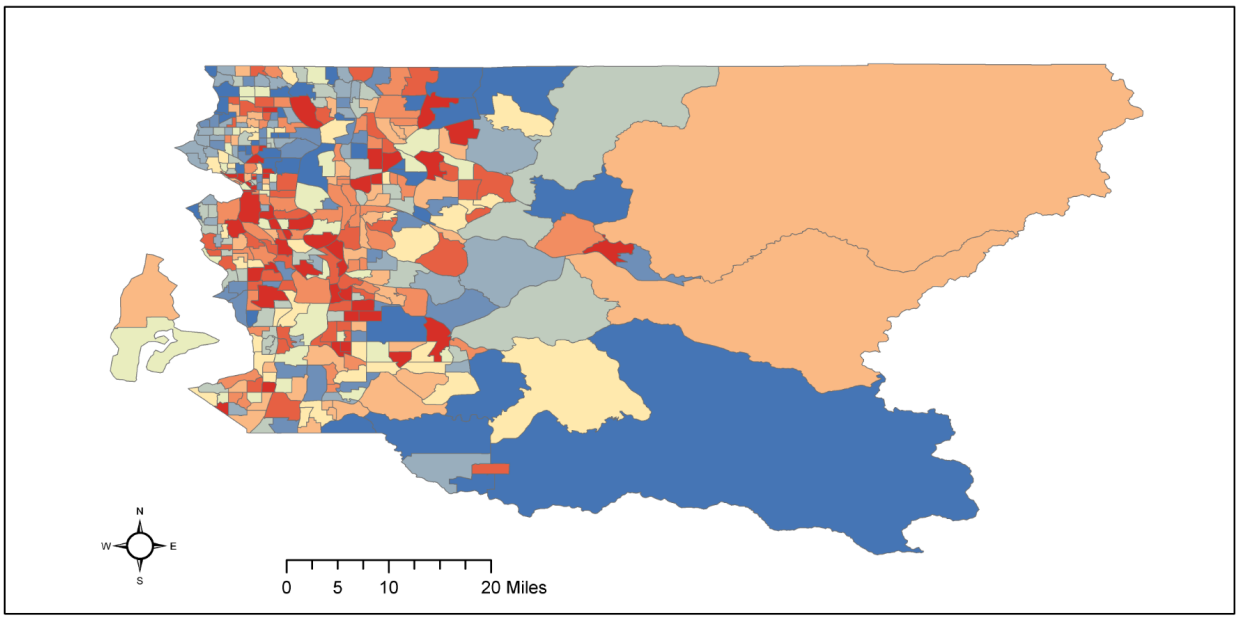
Sensitive populations

The map of cardiovascular disease indicator shows highly impacted census tracts are distributed throughout King County, predominantly in the south King County area (Map 14).



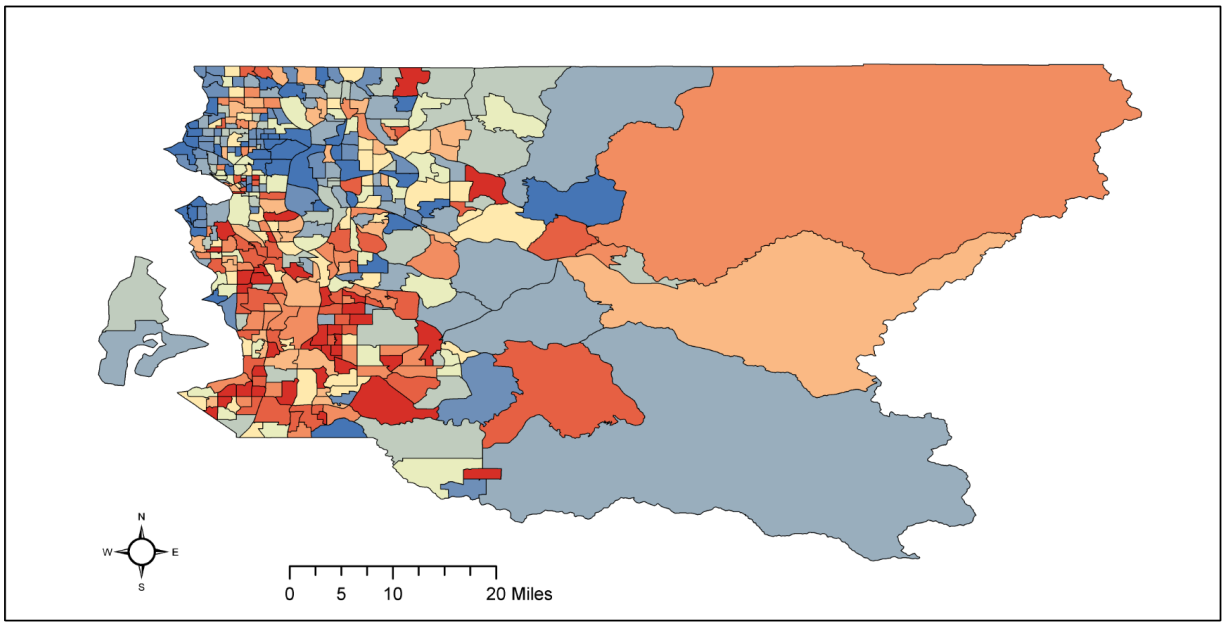
Map 14. Cardiovascular disease indicator in deciles.

For the low birth weight indicator, highly impacted census tracts were also spread throughout King County (Map 15).



Map 15. Low birth weight indicator in deciles (note this reflects the same rankings as the state decile ranking).

The sensitive population category that combines both cardiovascular disease and low birth weight indicators shows those who are at greater risk due to biological/intrinsic vulnerability. Many highly impacted census tracts are within Federal Way, Burien, and Kent (Map 16).

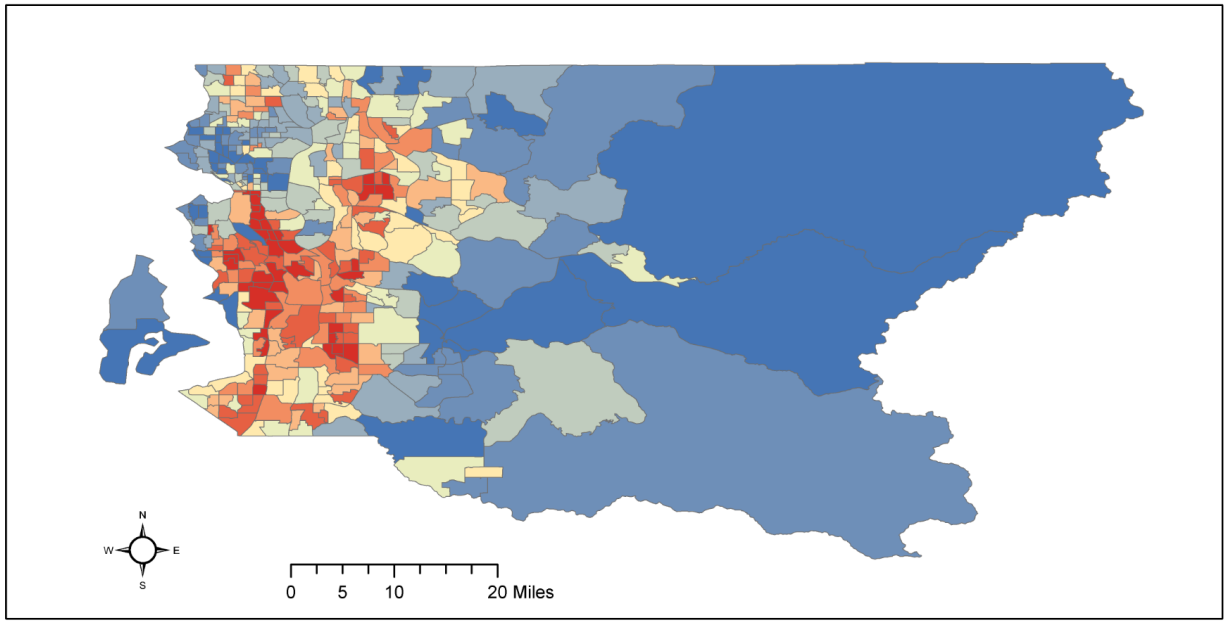


Map 16. Sensitive population in deciles.

Socioeconomic factors

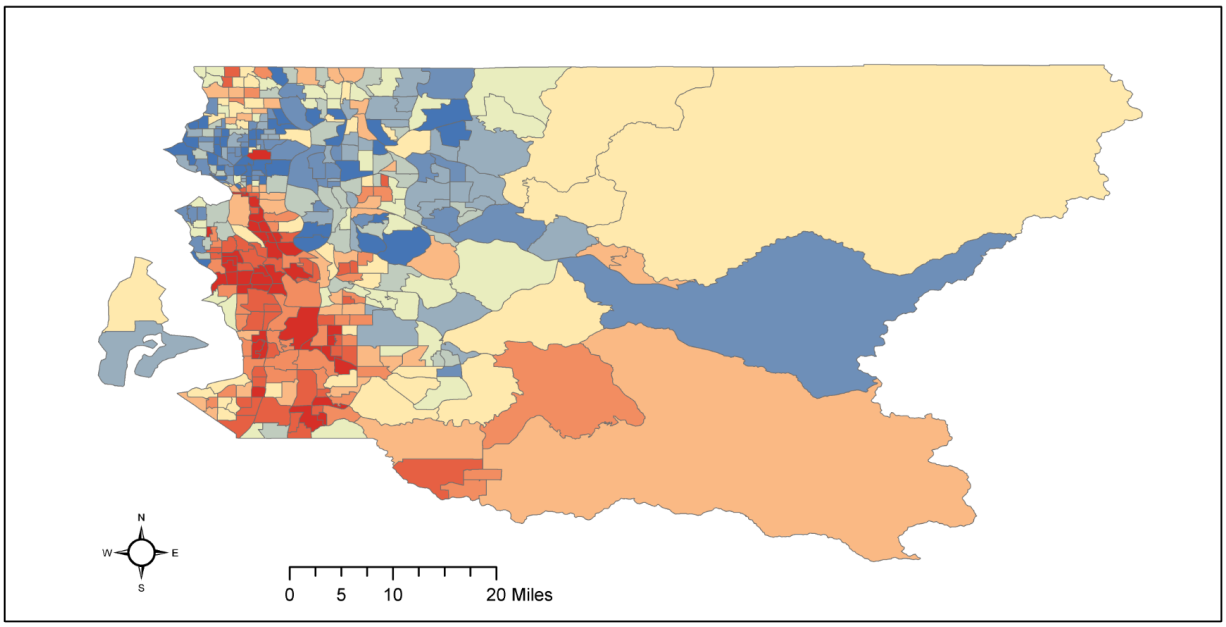
Within the socioeconomic factors category, housing burden, linguistic isolation, low educational attainment, people of color, and poverty indicators show similar patterns, with highly impacted census tracts primarily in south King County and small clusters of census tracts in other areas throughout the county (Maps 17-23).

Census tracts highly impacted by linguistic isolation were located in Beacon Hill, Georgetown, South Park, and SeaTac neighborhoods (Map 17).

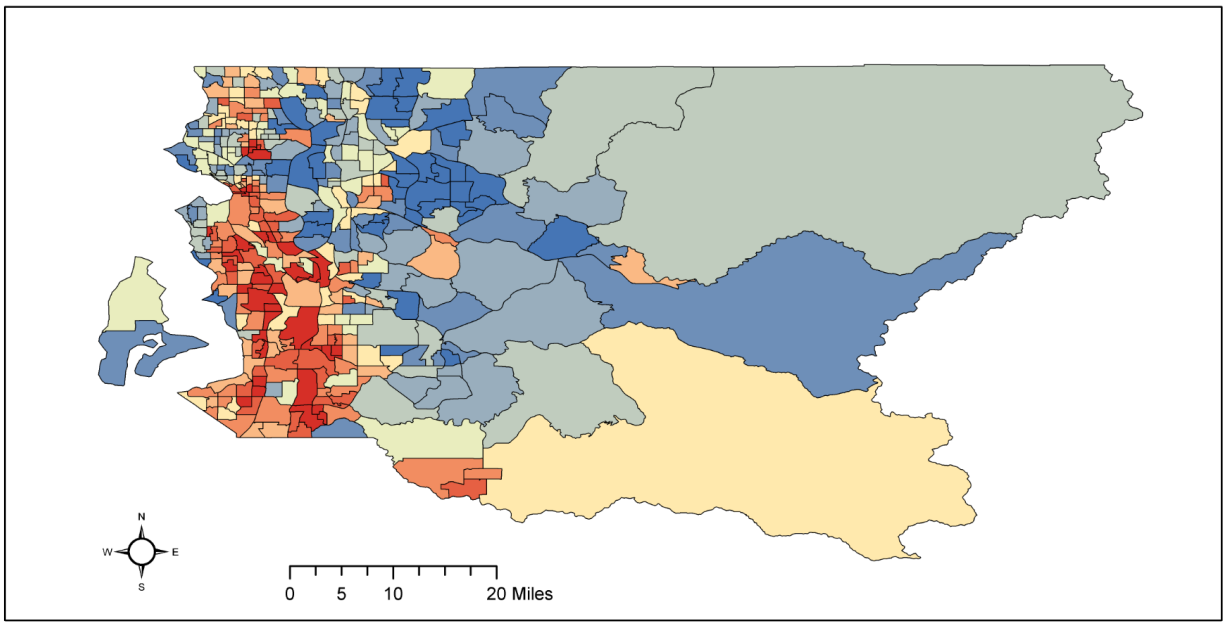


Map 17. Linguistic isolation in deciles.

Similar communities are highly impacted by low educational attainment (Map 18) and living 185% below federal poverty levels (Map 19).

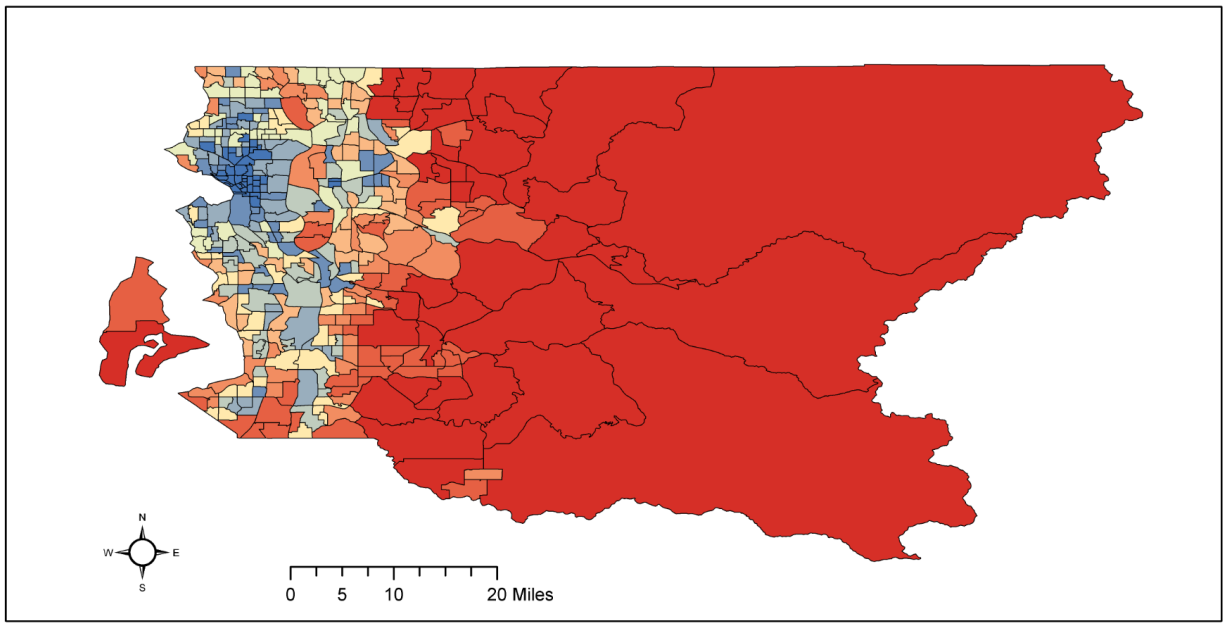


Map 18. Low educational attainment in deciles.

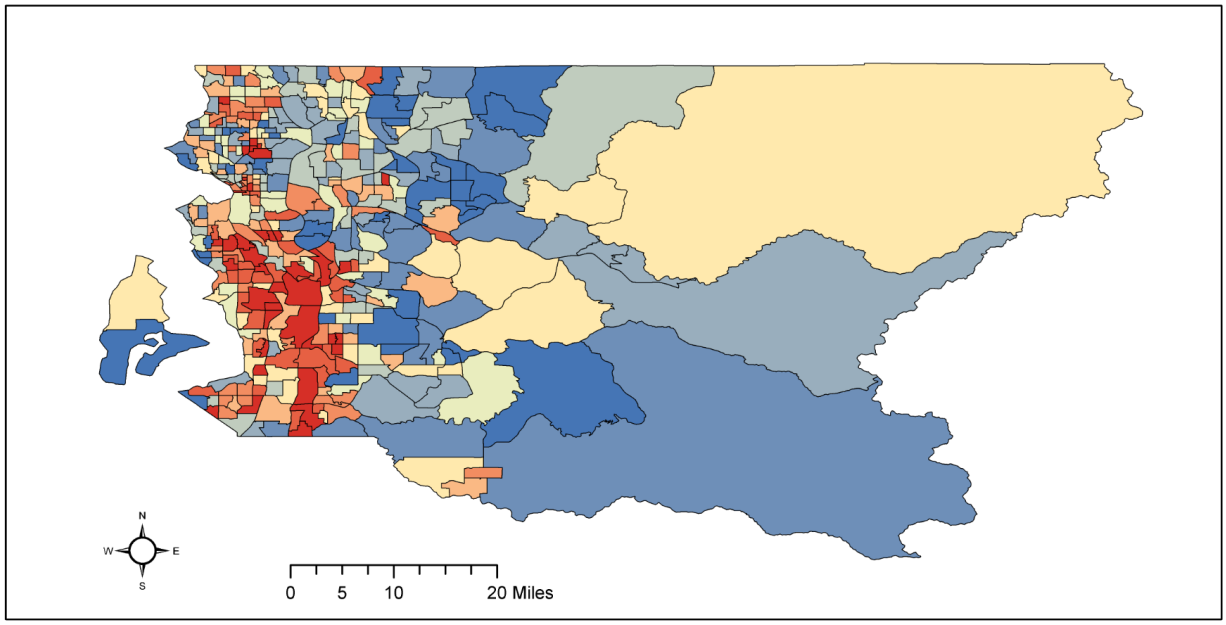


Map 19. Poverty (below 185% federal poverty level) in deciles.

The transportation expense indicator (Map 20) shows an inverse relationship to the housing burden indicator (Map 21), where census tracts with high transportation expense tend to have lower housing burden and vice versa.

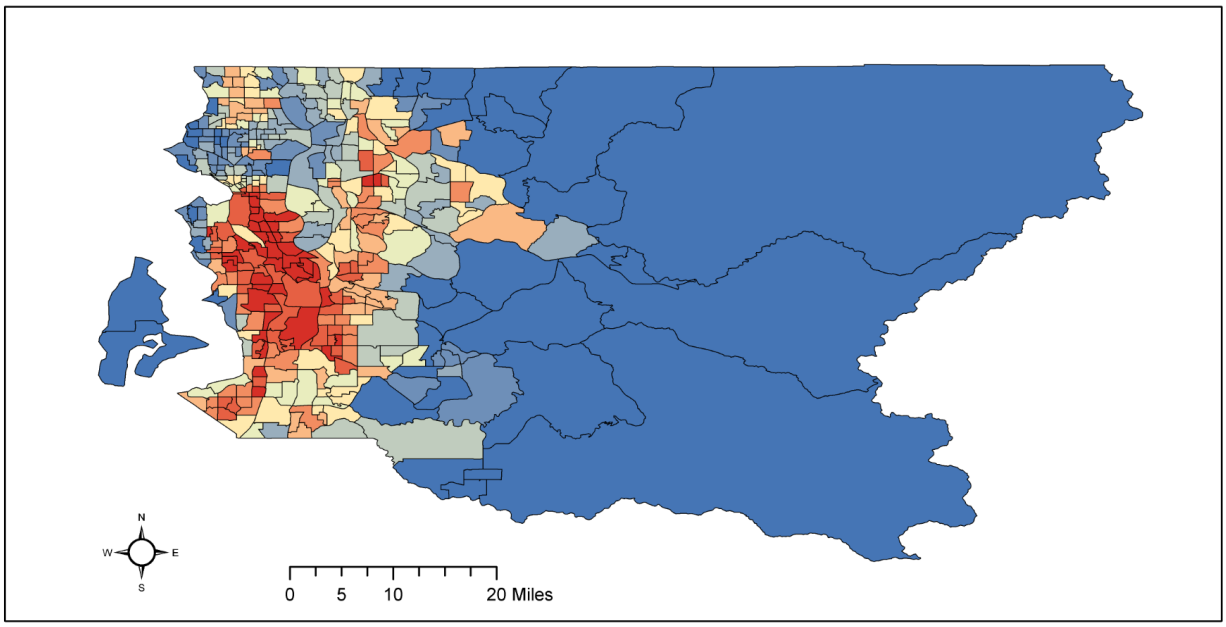


Map 20. Transportation expense in deciles.



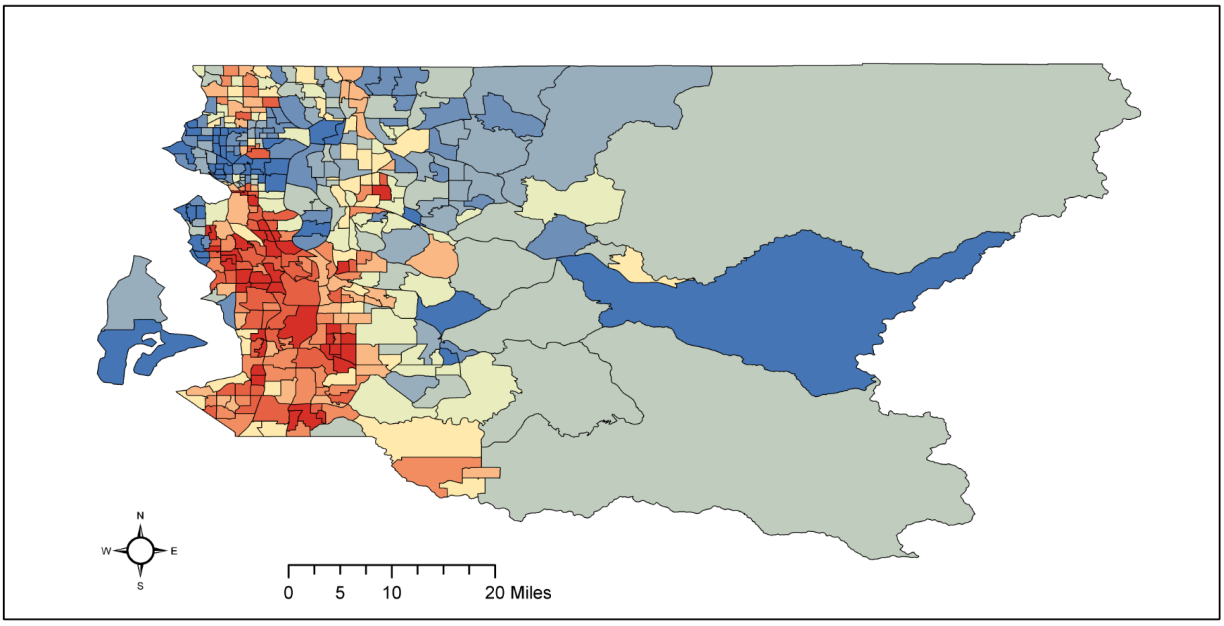
Map 21. Housing burden in deciles.

King County communities highly impacted by linguistic isolation, low educational attainment, and poverty levels also tended to be more racially/ethnically diverse (Map 22), highlighting the potential need for culturally appropriate outreach and engagement to these communities in developing solutions to environmental health disparities.



Map 22. People of color (all except non-Hispanic Whites) in deciles.

The combined ranking for the socioeconomic factors category shows highly impacted communities in King County in Beacon Hill, Georgetown, South Park, SeaTac, Kent, and Auburn (Map 23).



Map 23. Socioeconomic factors in deciles.

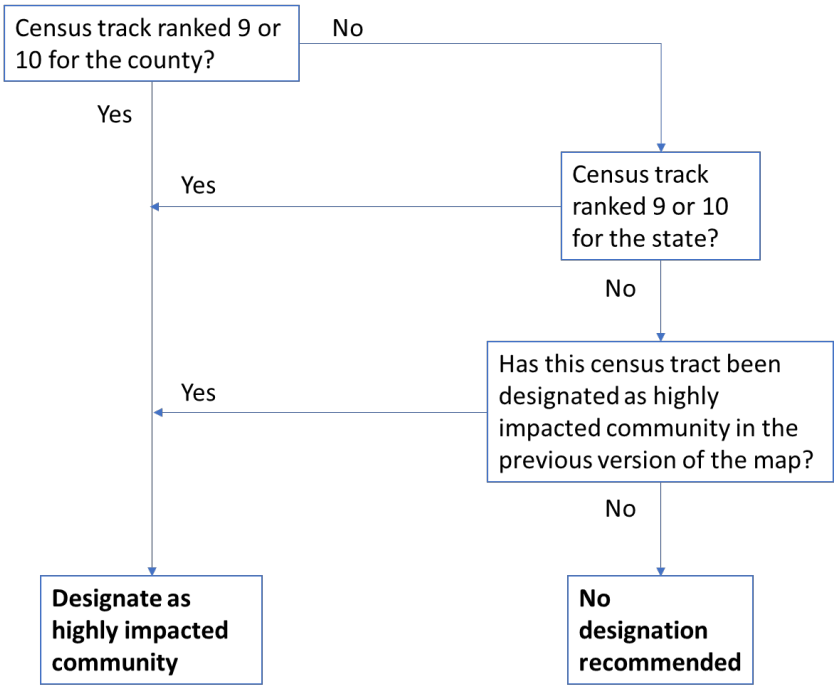
Section 4 | Next Steps

Adoption of state's definition of highly impacted or overburdened communities

To be consistent with state-level applications and the state EJTF's recommendations, King County census tracts ranked 9 or 10 within the final EHD measure should be considered highly impacted by cumulative impacts of environmental risks, or "overburdened communities." This approach is consistent with quintile scoring methods used within other equity mapping initiatives at King County.[vii] Aligning the definition of highly impacted communities with the state may allow for more synergy and opportunities for applying the county EHD map in environmental and public health programmatic work. When defining highly impacted communities, the Haz Waste Program should also give special consideration to census tracts ranked 9 or 10 in the state, even if the same census tracts have a lower EHD ranking within the King County-specific tool. This may provide more consistent approach to addressing drivers of these disparities and sources of pollution for the most overburdened communities in the state.

Note that the map should not be used alone to identify highly impacted communities. Meaningful community engagement and robust partnership with community leaders and community-based organizations are critical in understanding and addressing the drivers of disparities in order to create healthy, thriving communities.

The following flowchart can be used when designating highly impacted communities.



Updates and improvements to the map

The Haz Waste Program should update the King County EHD map routinely when data sources are updated at DOH and consider adding county-specific data to provide additional regional context of King County communities.

The state EHD map will be continuously updated, at least once every three years. The next update is scheduled for the end of 2021. The Haz Waste Program should likewise consider updating indicators for the King County EHD map to maintain alignment with state decision-making based on the updated state-level data.

The Haz Waste program should also consider including additional region-specific data, which could be important to improving the utility of the King County EHD mapping tool for local decision-making. This process should happen through an iterative process with community engagement (see below). The list below summarizes feedback and input from statewide community listening sessions, stakeholder engagements, and conversations with government agency staff regarding potential additional indicators, collected during the development of the WA state EHD map; this feedback may be relevant for revising the King County mapping tool:

- Additional environmental indicators such as ultrafine particles, noise pollution, hazardous waste specific indicators such as the location of small and medium quantity generators of hazardous waste, industrial facilities, facilities with hazardous waste permits that have been found in violation of their permits, pesticide use

(residential and commercial), airports and aircraft-related pollution, and WA Poison Center call data, drinking water quality, and surface and marine water quality.

- Additional population characteristics indicators such as asthma prevalence, access to healthcare insurance, access to healthcare, young children, people without housing, and people with disabilities.
- Additional frameworks and indicators for incorporating gentrification (e.g., displacement risk), community resilience, and community asset factors that should be protected and promoted.
- Additional indicators related to climate change and those accounting for future projections of environmental conditions (e.g., flooding risk, heat vulnerability, green and blue space).

Whenever there are proposed revisions to the tool, the Haz Waste Program should conduct listening sessions with highly impacted communities to receive feedback on the proposed updates and changes. In addition, each iteration should be accompanied by sensitivity analyses to characterize how census tract rankings may have changed. When the rankings of census tracts that were previously designated as highly impacted or overburdened are lowered during a revision, this should be carefully examined to see if the changes in ranking are truly due to improved conditions in the community. Hypothetically, if a census tract is a rank 9 in a previous version, and ranked 7 in the update, a comparison of rankings in the previous and updated for individual indicators, category of indicators, and the final EHD score may help explain the reason for the change in overall EHD ranking. If raw values decrease (e.g., lower concentrations of diesel emission or lower unemployment rates), this may represent improved conditions in the community over time. If changes to raw/absolute values are not observed, the Haz Waste Program should consider grandfathering those census tracts ranked 9 or 10 in the previous version of the map into the definition of highly impacted communities.

Development and ongoing improvements in a publicly available data platform

All indicators in the King County EHD mapping tool and its composite scores should be made available to other King County stakeholders by hosting the tool and data on a publicly accessible dashboard. Following the recommendations of the EJTF and feedback from communities across Washington State, any public platform for the King County EHD map should include the following elements, when possible:

- Ability to toggle back and forth between raw/absolute values and the relative rankings.

- Ability to track changes over time as updated versions of the maps are developed.
- Ability for users (such as program staff, partner agency staff, community members, or academics) to add their own data to overlay onto the map (e.g., CDC's social vulnerability index) in addition to specific layers from the Haz Waste Program (e.g., waste collection events/sites, sites where implementation of safer alternatives was carried out, etc.).
- Ability for users to select specific geography or census tracts and see the rankings and indicator values in a convenient way.
- Ability for users to print a selected census tract or geography with indicators or layers picked by the user.

Section 5 | Recommendations

The Haz Waste Program is well-positioned to integrate this EHD map into their community-engagement, decision-making, planning, evaluation, and other work processes through their equity and social justice initiatives, including their Racial Equity Strategic Plan (Figure 4).

Figure 4. Suggested applications for the King County environmental health disparities map.

Ensure meaningful community engagement as part of program planning

The EHD map can be used to identify disparities reduction strategies and community-driven solutions with highly impacted communities, and to guide out community outreach strategies for the Haz Waste Program.

In order to effectively work towards environmental justice, the Haz Waste the Program should first consider defining and operationalizing a definition of meaningful community engagement, consistent with recommendations from the WA EJTF and the White House Environmental Justice Advisory Council.

The White House Environmental Justice Advisory Council defines meaningful community engagement as *"potentially affected populations have an opportunity to participate in decisions that will affect their health or environment, that the population's contributions can influence the agency's decisions, that the viewpoints of all participants involved will be*

considered in the decision-making process, and that the agency will seek out and facilitate the involvement of the population potentially affected, including consultation with Tribal and indigenous communities and by providing culturally appropriate information, access for people with disabilities, and language access for persons with Limited English Proficiency (LEP), considering issue of access raised by location, transportation, and other factors affecting participation, and by making available technical assistance to build community-based capacity for participating."[viii]

The EJTF report in October 2020 lists recommendations for improving and increasing meaningful community engagement.[ix] Three of the recommendations are highlighted here.

- *Recommendation 17: Agencies evaluate new and existing services and programs for community engagement using a systematic process to determine outreach goals. These evaluations weigh the goals of the service or program, potential for its impact on the public, its importance to the community/ies being impacted, and the makeup of the impacted community.*
- *Recommendation 23: When an agency's program or service has potential to impact Tribal and/or Indigenous people or their resources, the agency includes those groups in their community engagement work, using tailored approaches based on the needs of the Tribe. Note that community engagement is distinct from and not a substitute for formal government-to-government or cultural resource consultation.*
- *Recommendation 24: Agencies conduct compliance reviews of existing laws and policies that guide community engagement, and where gaps exist, ensure compliance for the following laws in agency service and program budgets: Title VI of the Civil Rights Act, prohibiting discrimination based on race, color, or national origin and requiring meaningful access to people with limited English proficiency; Executive Order 05-03 requiring Plain Talk when communicating with the public; Executive Order 13166, requiring meaningful access to agency programs and services for people with limited English proficiency.*

The Haz Waste Program should also continue to improve on ways to integrate meaningful engagement from King County communities. One example of meaningful community engagement in the Haz Waste Program is the Residential Services team's "How to make a safer cleaner & how to buy a safer cleaner" campaign. The Residential Services team partnered with community organizations and leaders for community-driven strategies and solutions to increase environmental health literacy and address exposures to hazardous cleaning chemicals in homes. The EHD map can aid in similar place-based activities to identify ways to reduce the sources of pollution in the communities.

In addition, the Haz Waste Program can use the EHD map to better understand the pollution burden and population characteristics of the communities when developing outreach strategies, consistent with EJTF Recommendation 19, included below.

- *When planning outreach activities, agencies use screening tools that integrate spatial, demographic, and health disparities data to understand the nature and needs of the people who may be impacted by agency decisions. The Task Force's recommended use of the Environmental Health Disparities map to build the demographic and environmental context to guide and inform place-based activities is a key example.*

In coordination with existing efforts to engage communities and apply environmental justice principles, the Haz Waste Program should support community conversations to ground truth the map and identify additional areas for improvement. For example, when the Residential Services team hosts community listening sessions to understand how community groups interact with hazardous products and wastes, feedback from the conversations can inform the development of additional indicators for this map. The Haz Waste Program should continue to financially support community leaders' time to organize and convene community members in highly impacted areas, support childcare during the duration of the meeting, and provide culturally relevant materials and food. The Program should continue to support community leaders and their capacity to partner with the Haz Waste Program to reduce exposures to hazardous materials and eliminate disparities.

Performance evaluation and prioritization of resource allocation to guide agency activities

This tool can be used to incorporate information on equity and environmental health disparities as routine practice for programs and projects. Retrospectively, this map can assist in evaluating the distribution and effectiveness of Haz Waste Program activities, and to track the reduction of pollution burden in communities from these actions. In particular, such evaluations could determine which communities benefited most from programmatic initiatives, including allowing for examination of whether Haz Waste Program funds and services are being equitably distributed across King County. For example, the Program could track how vouchers were distributed for the program to convert perchloroethylene (PERC) dry cleaners to professional wet cleaning or track the outreach and education activities conducted by the Residential Services team.

This map can also be used when allocating or prioritizing resources for the Haz Waste Program. For example, the EHD map can be used to prioritize field visits for the Business Services Program to highly impacted neighborhoods. The team can use either cumulative indicators based on final EHD ranking, or individual indicators such as poverty or people of color, to choose businesses for technical assistance services or programs to implement safer alternatives to hazardous products currently in use.

Incorporate performance goals and metrics to reduce inequities in hazardous waste exposures

Setting goals to reduce and eliminate environmental health disparities and tracking progress towards those goals will be critical in achieving equity and social justice. The Haz Waste Program should consider developing metrics to monitor both absolute values of the pollution burden (for example, changes to the number of hazardous waste facilities) and relative values (for example, ranking changes for the proximity to hazardous waste TSDFs indicator) in order to ensure the drivers of environmental health disparities are addressed. In addition, additional analyses should be performed to determine the changes in health outcomes, such as life expectancy at birth or prevalence of asthma or cardiovascular disease, to be compared and associated with environmental conditions.

In creating goals and metrics to improve equity and eliminate environmental health disparities, there is a strong need to harmonize metrics for equity action across other partner agencies. There are separate efforts across different regional and local agencies such as the City of Tacoma, City of Lynnwood, Port of Seattle, Public Health-Seattle King County (PHSKC), and Puget Sound Regional Council (PSRC) to develop standard ways to track disparities and equities in each respective jurisdiction. For example, an agency may be focused on housing or residential displacement while other agencies are designing tools to evaluate disparities in transportation services. These regional efforts result in alternative maps and perspectives on the relevant environmental justice issues that different communities face. As ongoing policy efforts aim to incorporate information from such maps - including the recently passed HEAL Act which will require many Washington state agencies to consider environmental justice in decision-making processes - there is an urgent need for developing standardized methods for assessing disparities that compare, contrast, and harmonize different mapping tools across jurisdictional boundaries and is centered around communities overburdened by existing disparities.

The Haz Waste Program staff should consider participating in existing work groups or lead a task force for adopting EHD maps and similar environmental justice tools, including using the tool for the Results-Based Accountability Framework.

In addition to these recommendations, the Haz Waste Program should consider applying the state EJTF's multiple recommendations on applications and model policies for using EHD maps in agencies.

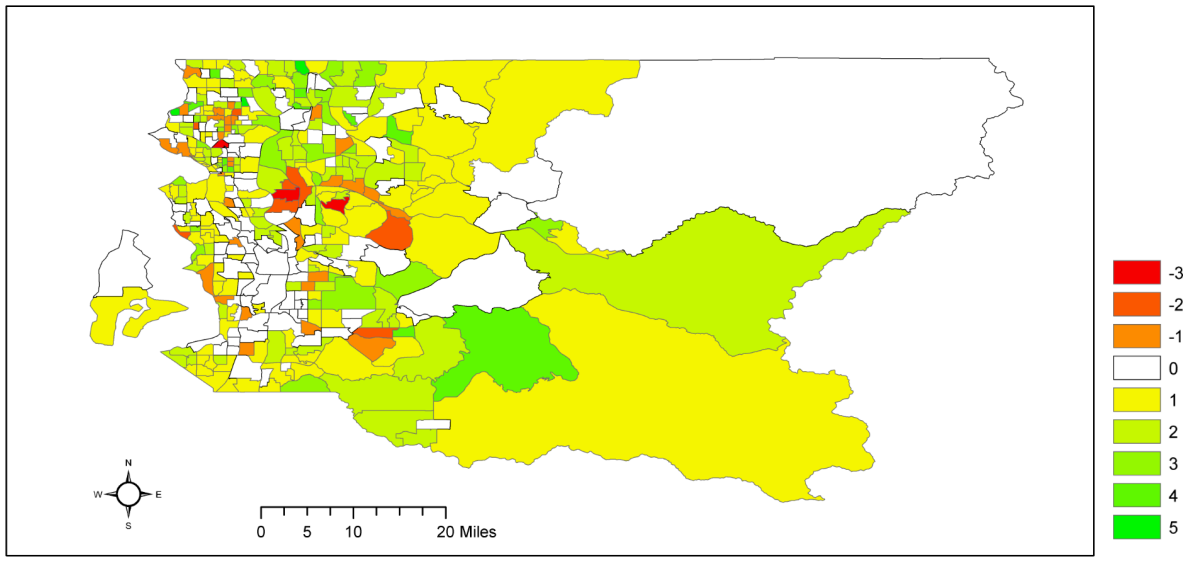
Appendix

Differences between statewide and King County rankings

This section shows differences in statewide EHD rankings compared with the county EHD rankings through maps and histograms. The formula *Statewide ranking minus County ranking* was used for all. For example, Map A1 shows the differences in final EHD rankings range from -3 to 5. The distribution of census tracts is shown in Figure A1. The maps and histograms of indicators in the EHD map and the differences in rankings. A mapping demo page is also included to compare the rankings between statewide decile and King County EHD rankings:
https://uw.maps.arcgis.com/apps/MapSeries/index.html?appid=ebcb89a18d0c4b129e93bd97862944cd

Difference in final environmental health disparities ranking and categories

Overall EHD score



Map A 1. Difference of final EHD rankings between state and county.

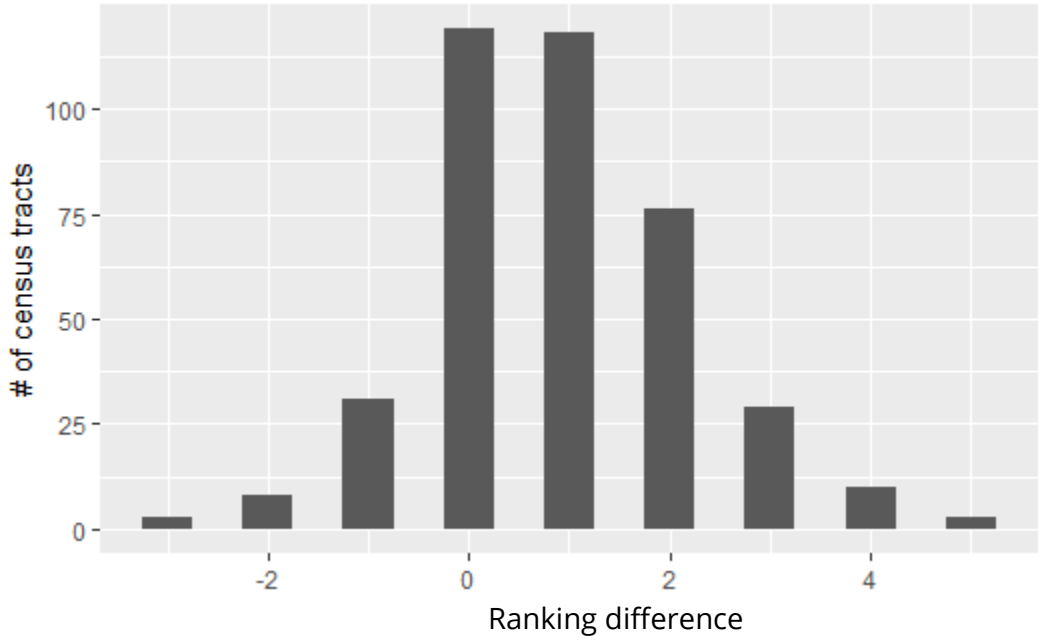
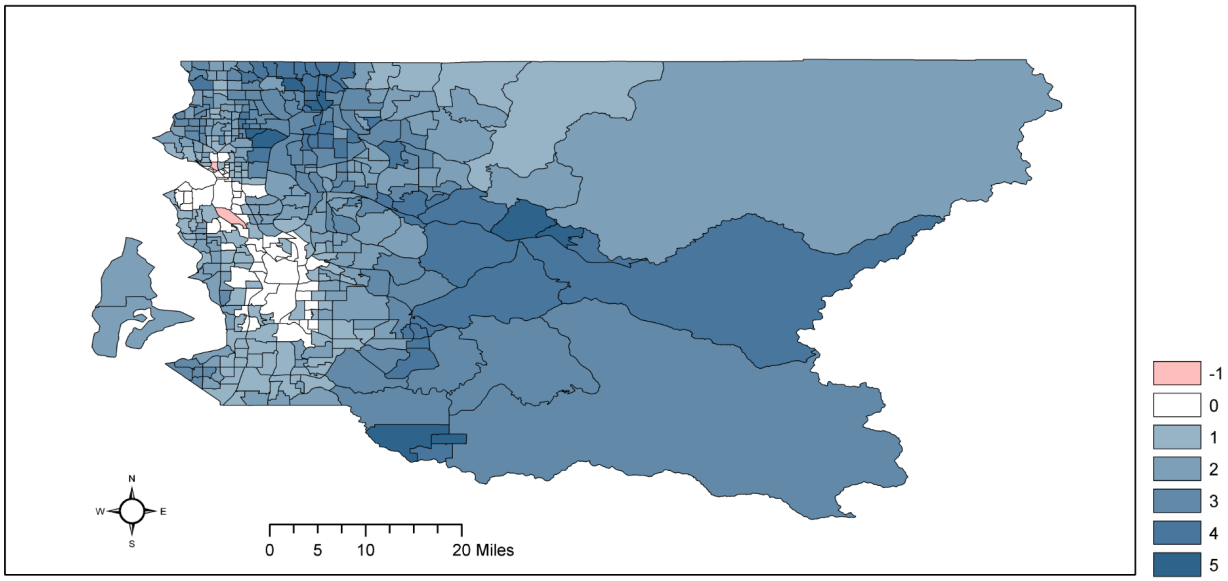


Figure A 1. Histogram of the ranking differences for all King County census tracts: final EHD ranking.

Environmental exposure category



Map A 2. Difference of environmental exposure ranking between state and county.

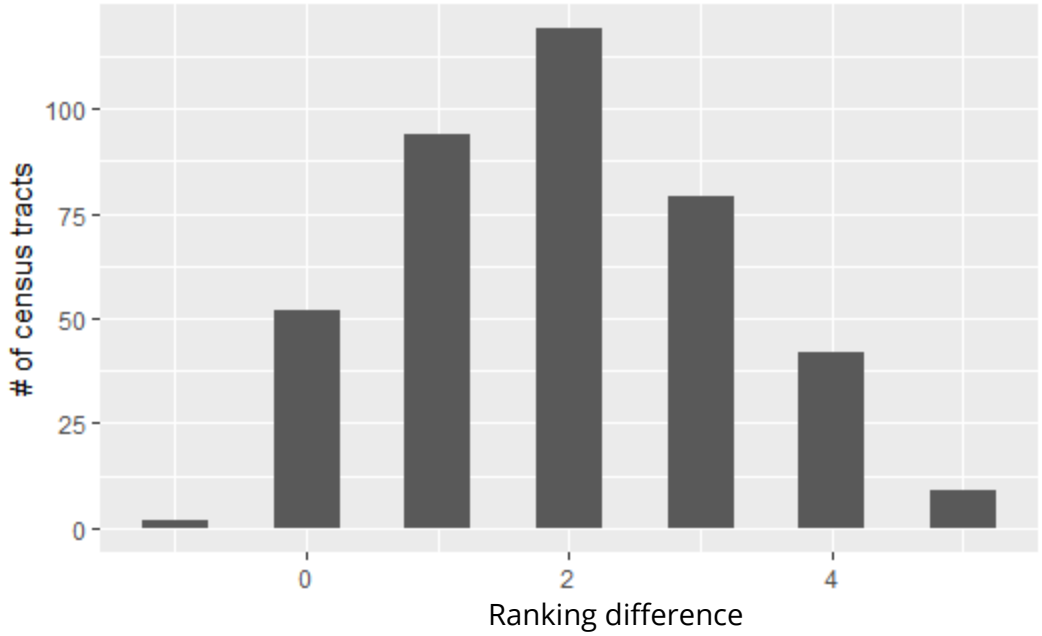
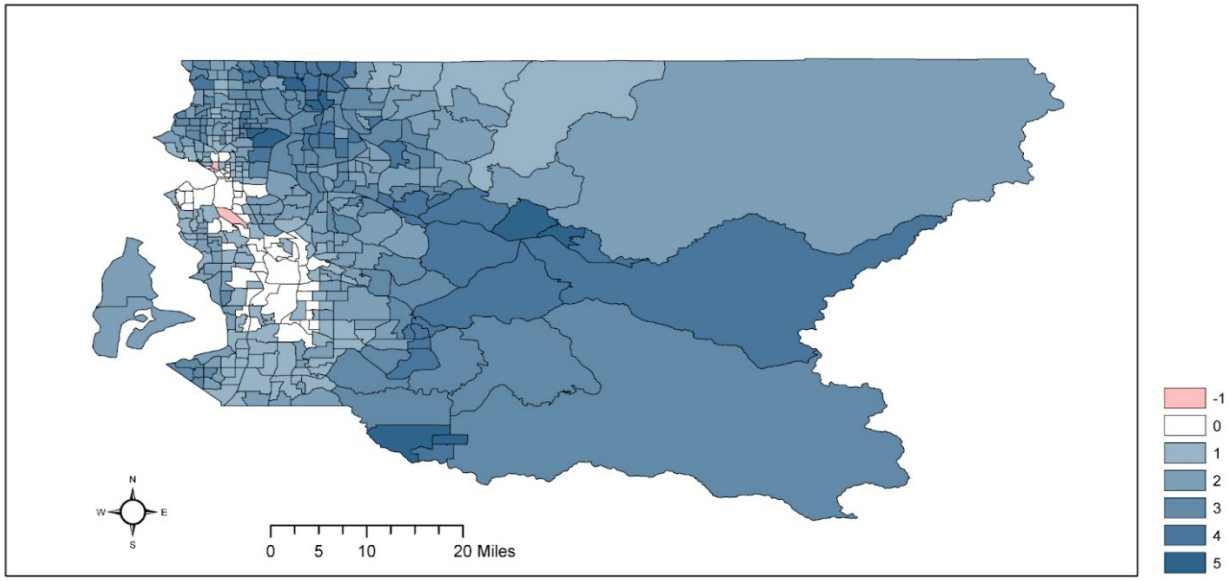


Figure A 2. Histogram of the ranking differences for all King County census tracts: environmental exposure category.

Environmental effects category



Map A 3. Difference of environmental effects ranking between state and county.

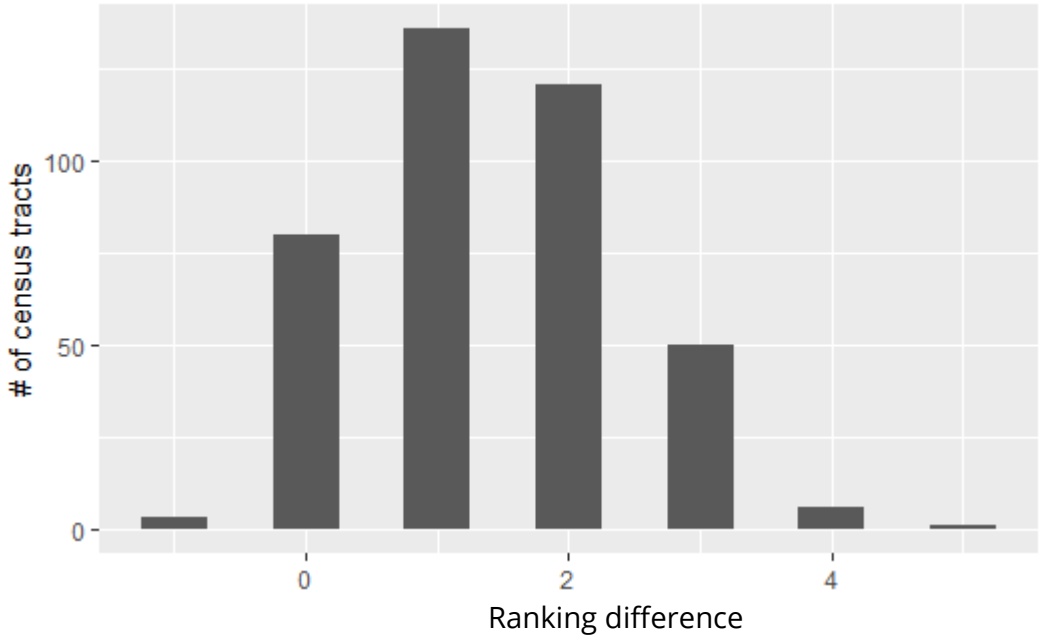
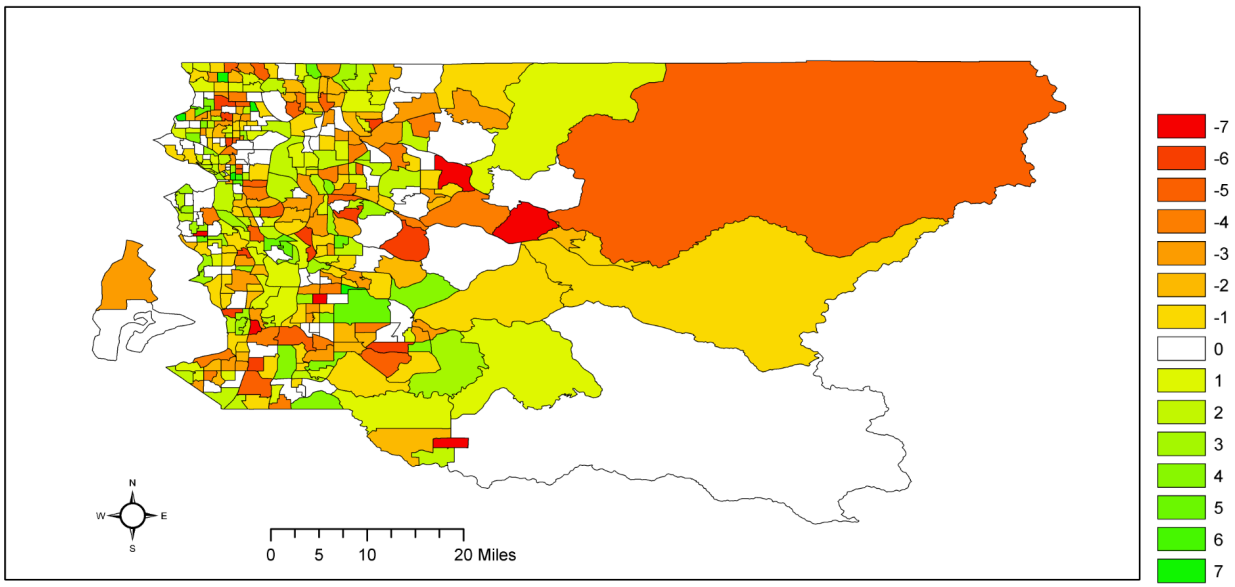


Figure A 3. Histogram of the ranking differences for all King County census tracts: environmental effects category.

Sensitive population category



Map A 4. Difference of sensitive population ranking between state and county.

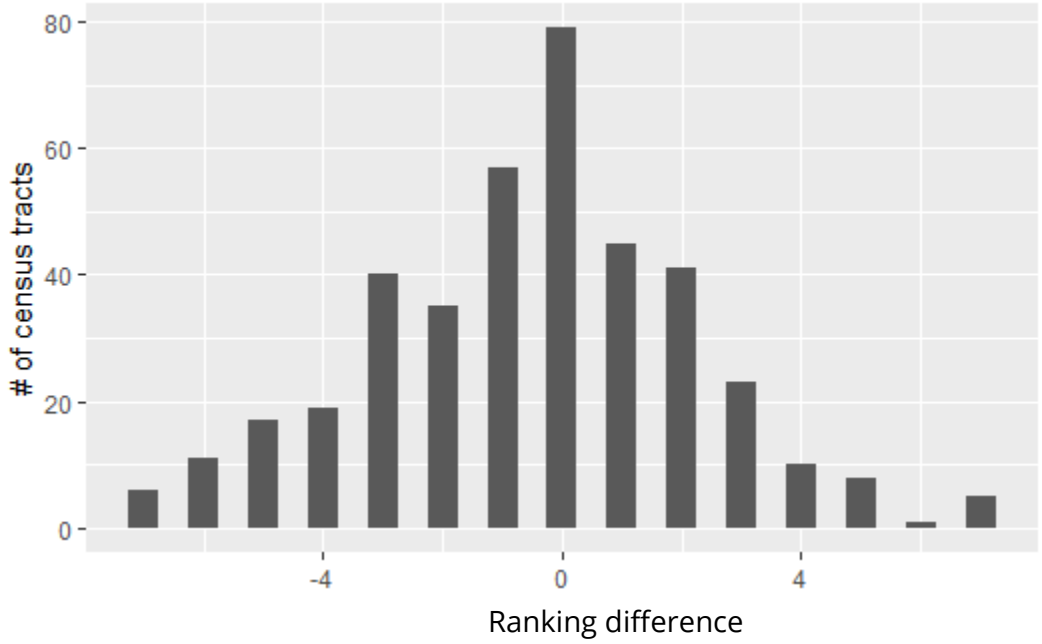
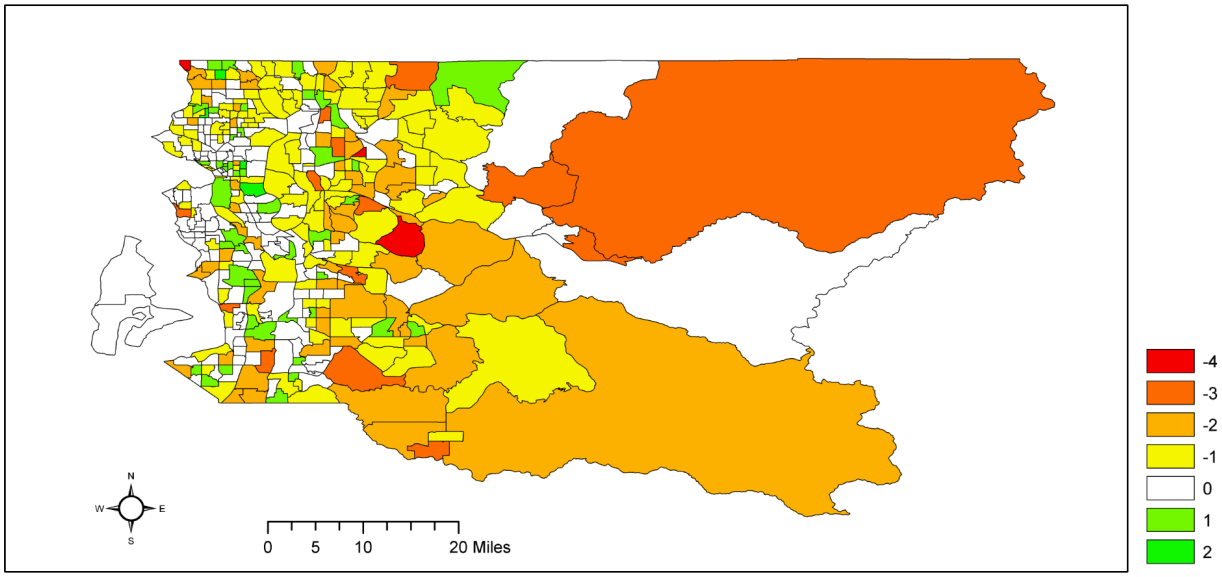


Figure A 4. Histogram of the ranking differences for all King County census tracts: sensitive populations category.

Socioeconomic factors category



Map A 5. Difference of socioeconomic factors ranking between state and county.

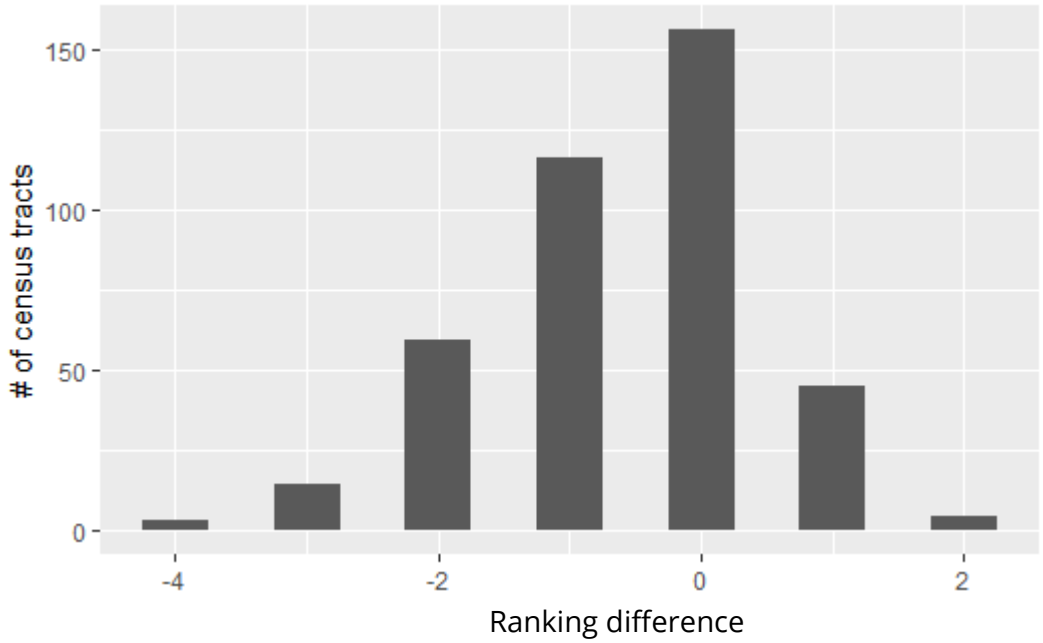
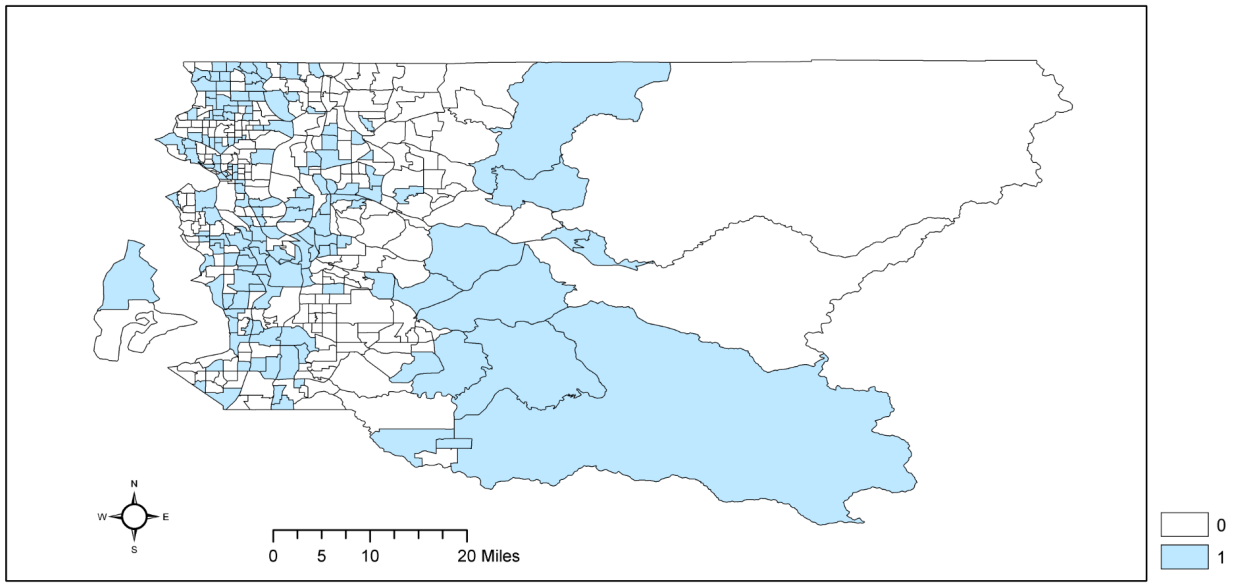


Figure A 5. Histogram of the ranking differences for all King County census tracts: socioeconomic factors category.

Individual indicator difference

Environmental effects



Map A 6. Difference of proximity to lead risk and exposure indicator ranking between state and county.

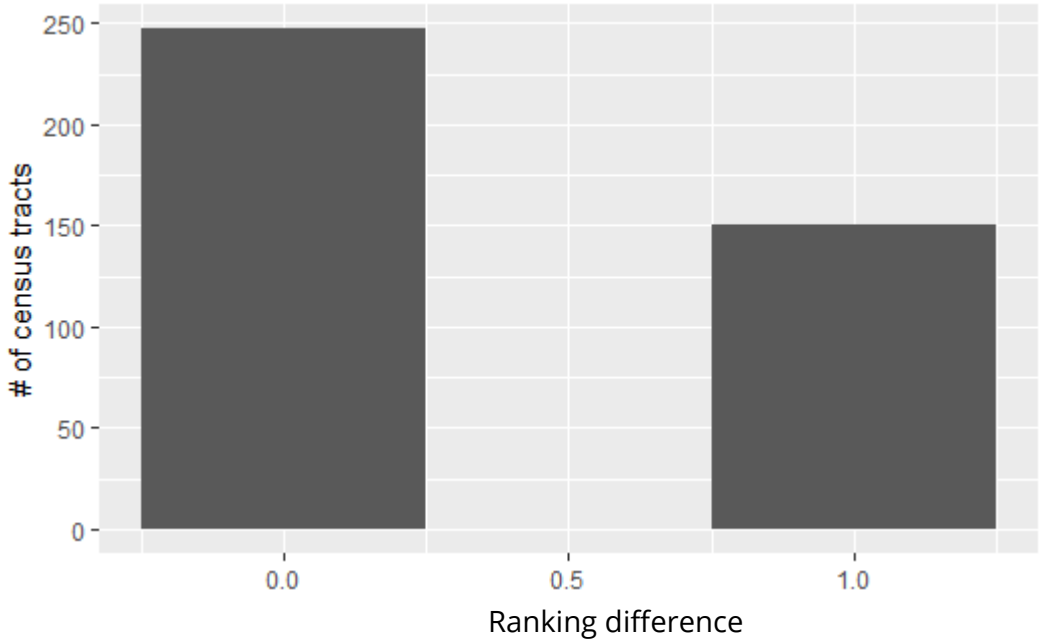
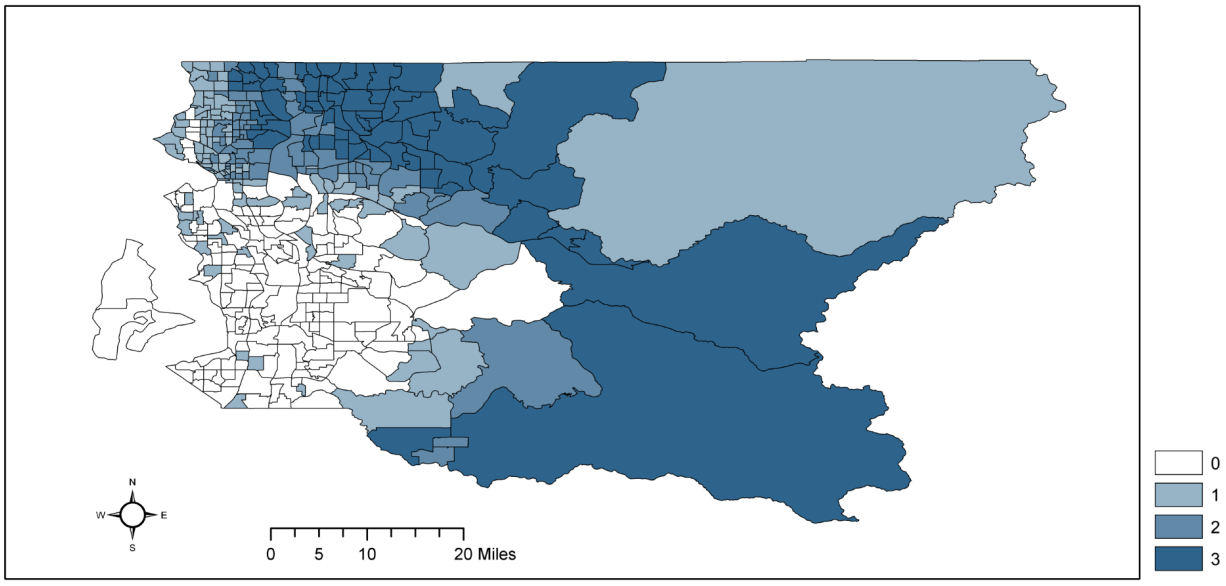


Figure A 6. Histogram of the ranking differences for all King County census tracts: lead risk and exposure indicator.



Map A 7. Difference of proximity to hazardous waste TSDFs indicator ranking between state and county.

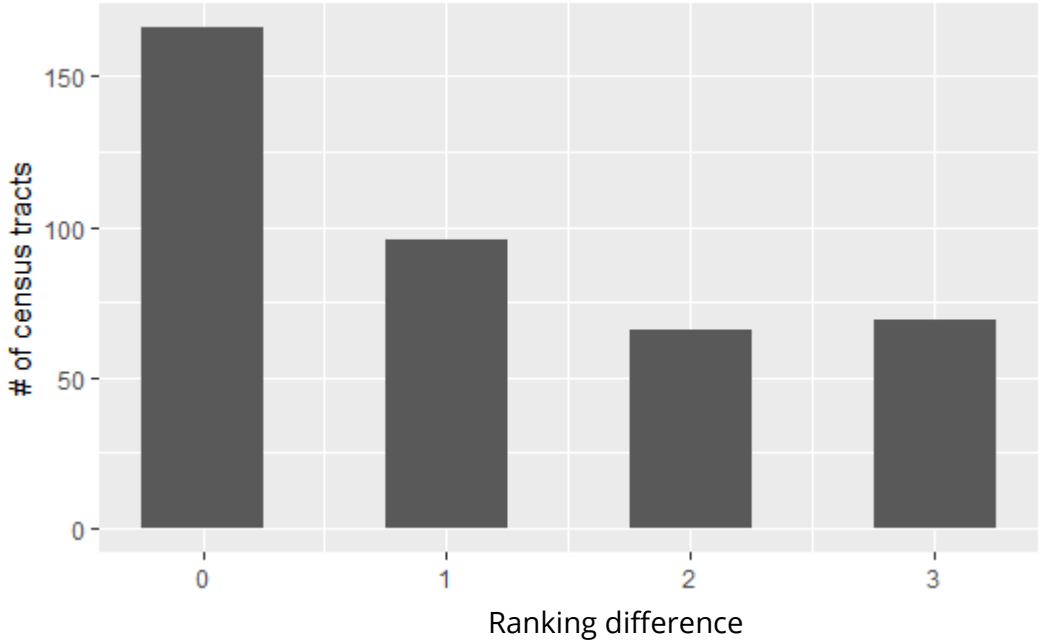
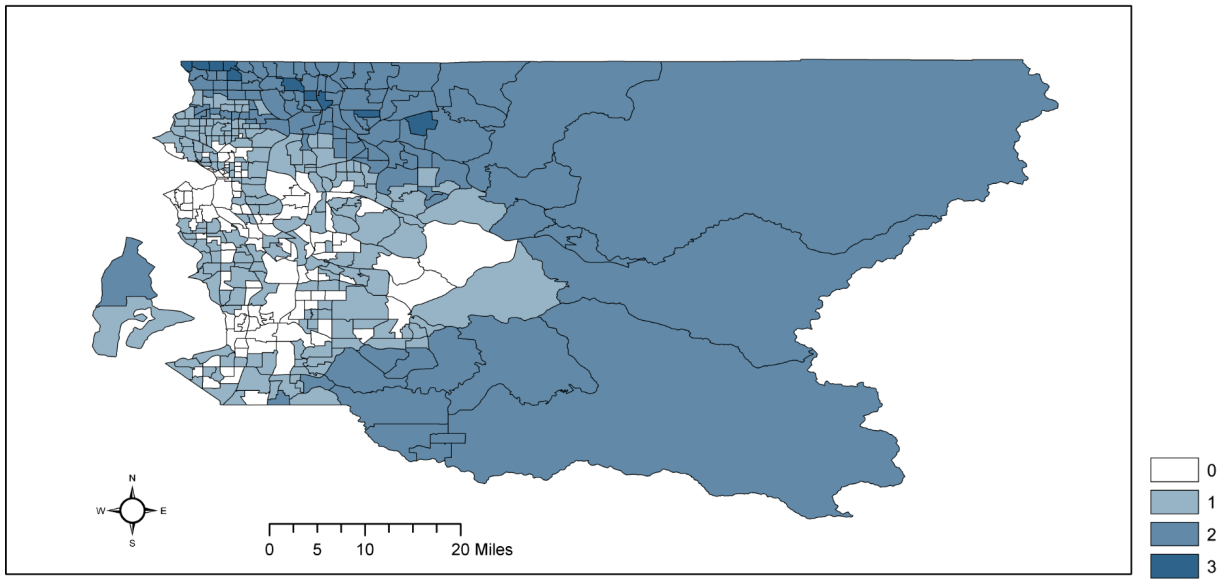


Figure A 7. Histogram of the ranking differences for all King County census tracts: proximity to hazardous waste TSDFs indicator.



Map A 8. Difference of proximity to Superfund sites indicator ranking between state and county.

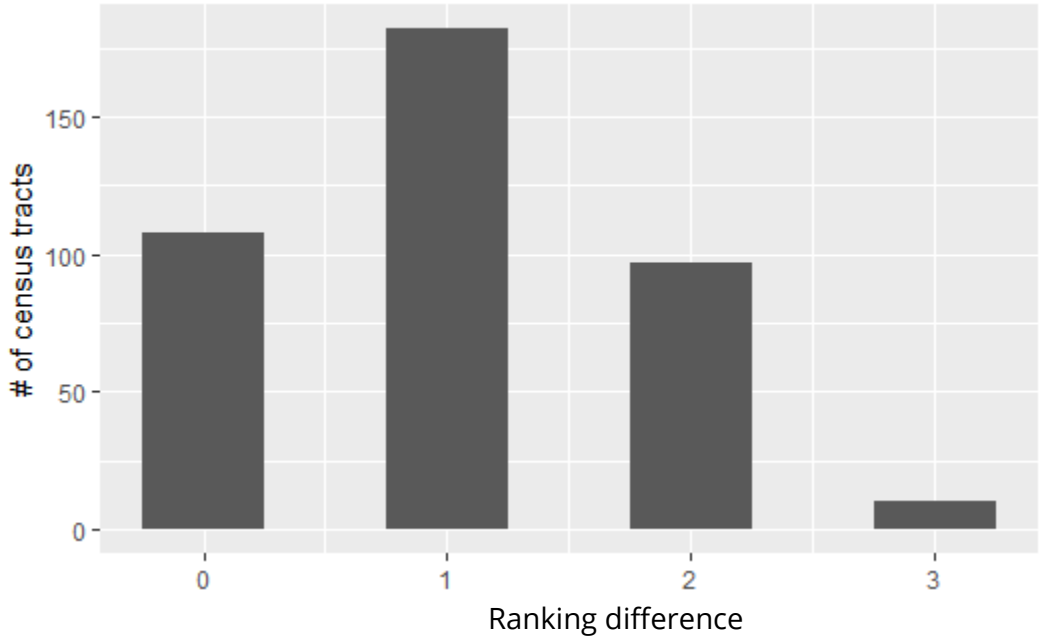
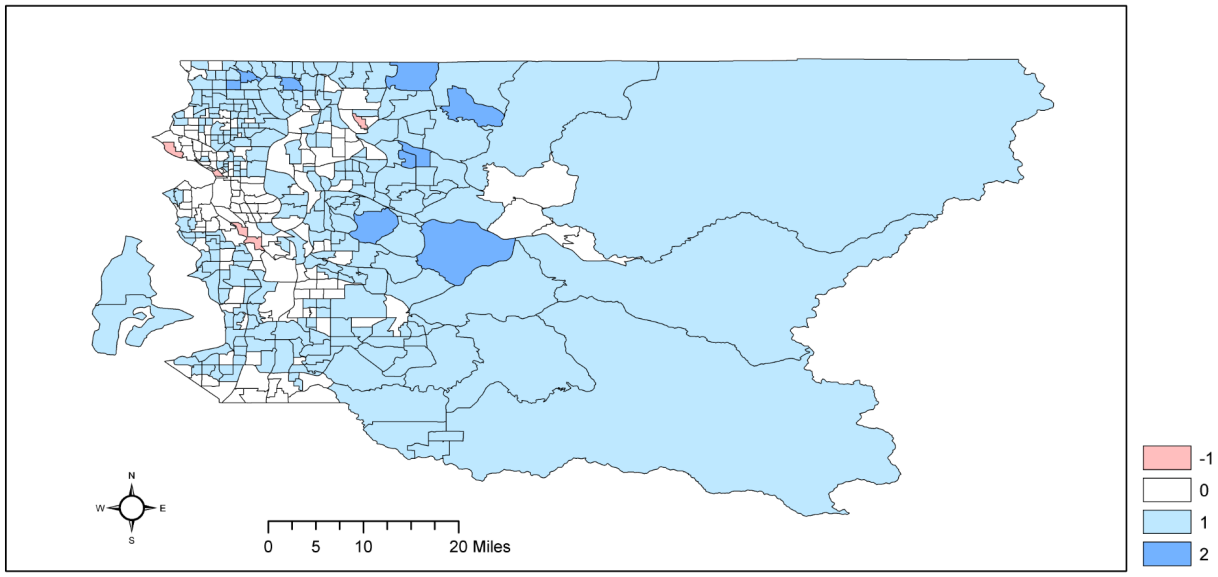


Figure A 8. Histogram of the ranking differences for all King County census tracts: proximity to Superfund sites indicator.



Map A 9. Difference of proximity to highly toxic substances (risk management plans) indicator ranking between state and county.

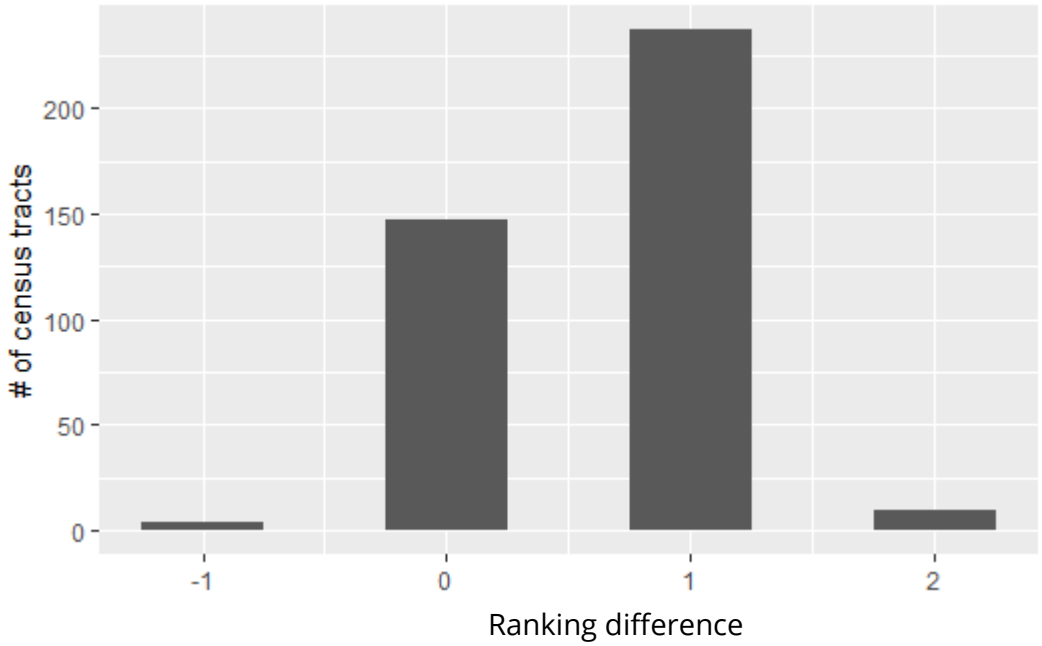
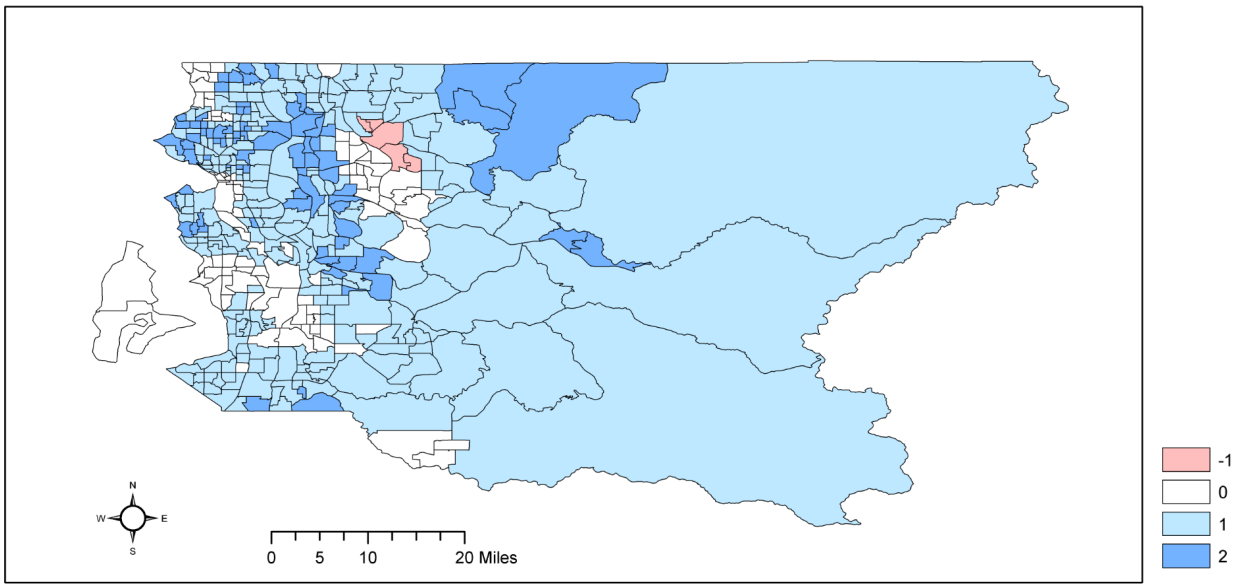


Figure A 9. Histogram of the ranking differences for all King County census tracts: proximity to facilities with highly toxic substances (risk management plans) indicator.



Map A 10. Difference of proximity to wastewater discharge indicator ranking between state and county.

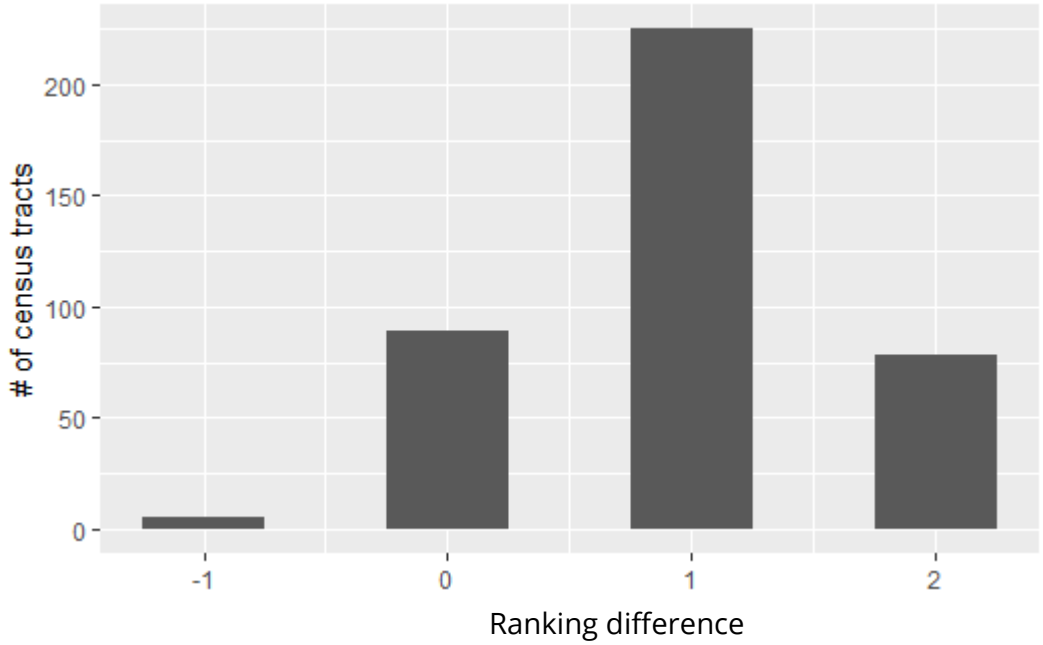
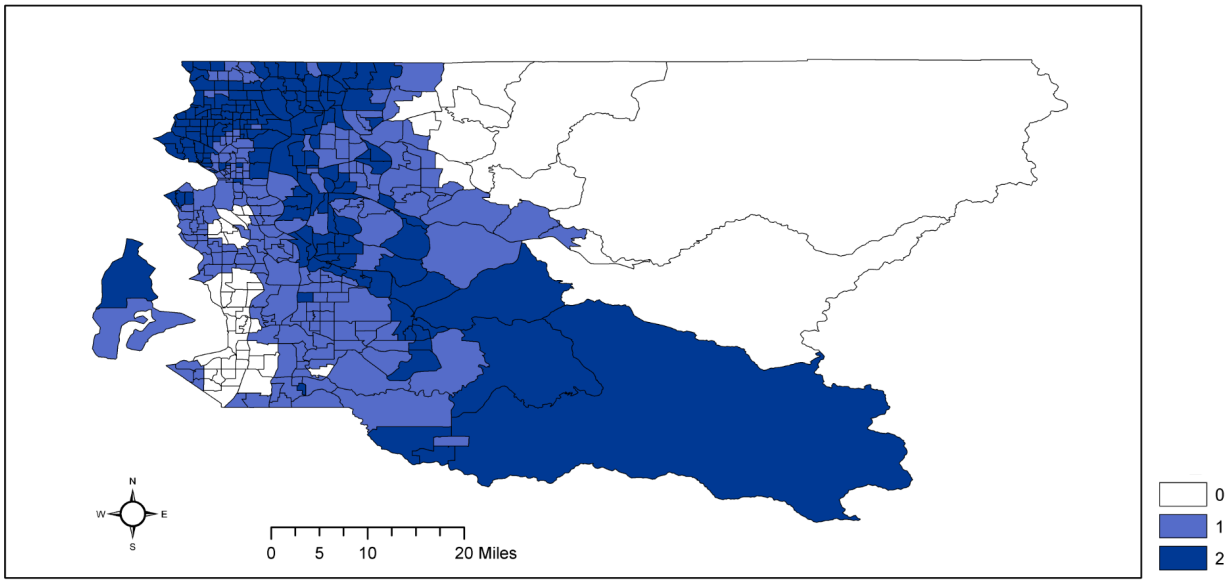


Figure A 10. Histogram of the ranking differences for all King County census tracts: wastewater discharge indicator.



Map A 11. Difference of $PM_{2.5}$ indicator ranking between state and county.

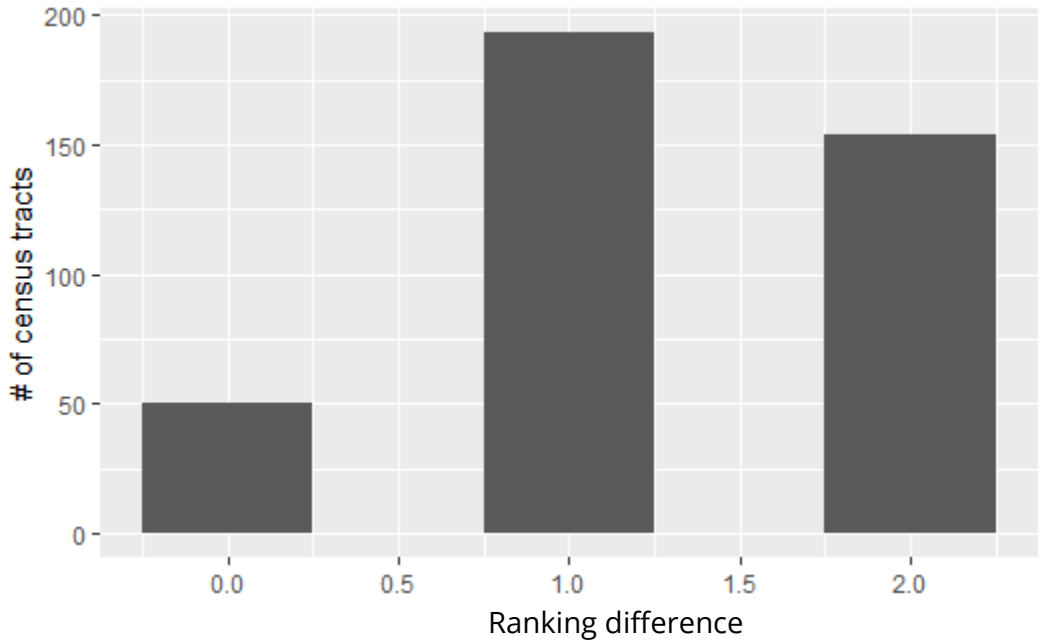
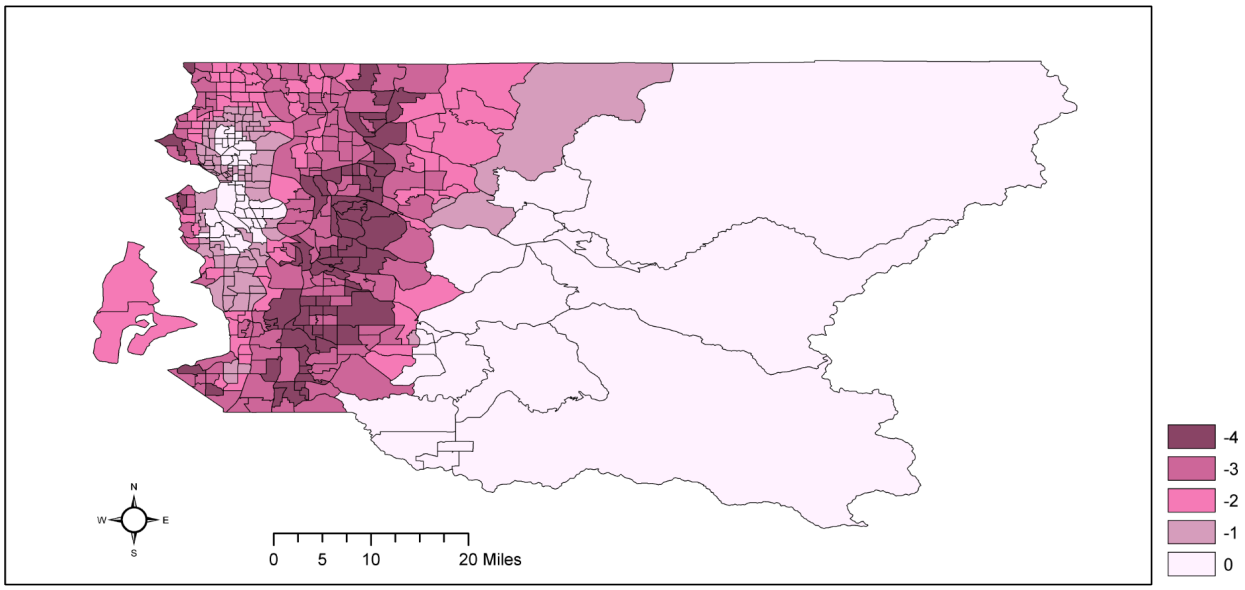


Figure A 11. Histogram of the ranking differences for all King County census tracts: $PM_{2.5}$ indicator.



Map A 12. Difference of ozone indicator ranking between state and county.

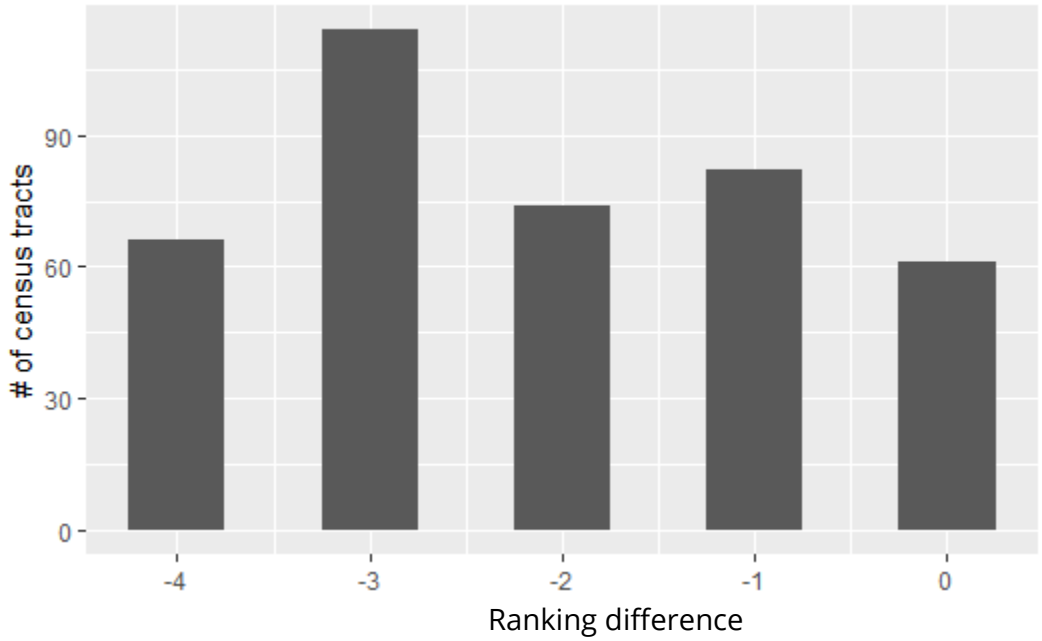
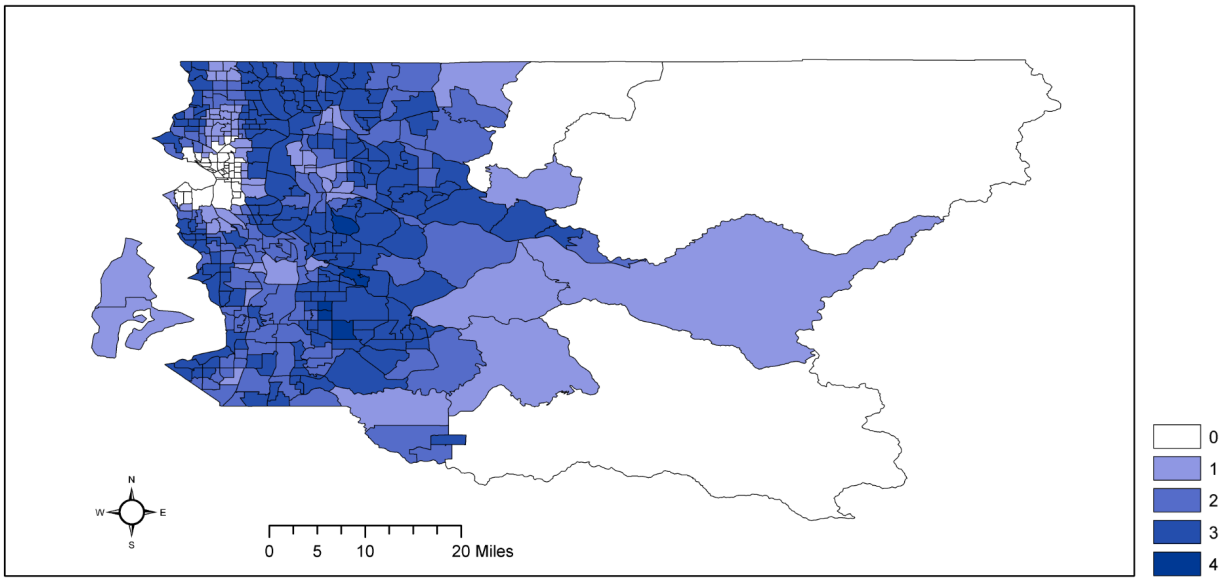


Figure A 12. Histogram of the ranking differences for all King County census tracts: ozone indicator.



Map A 13. Difference of diesel emission indicator ranking between state and county.

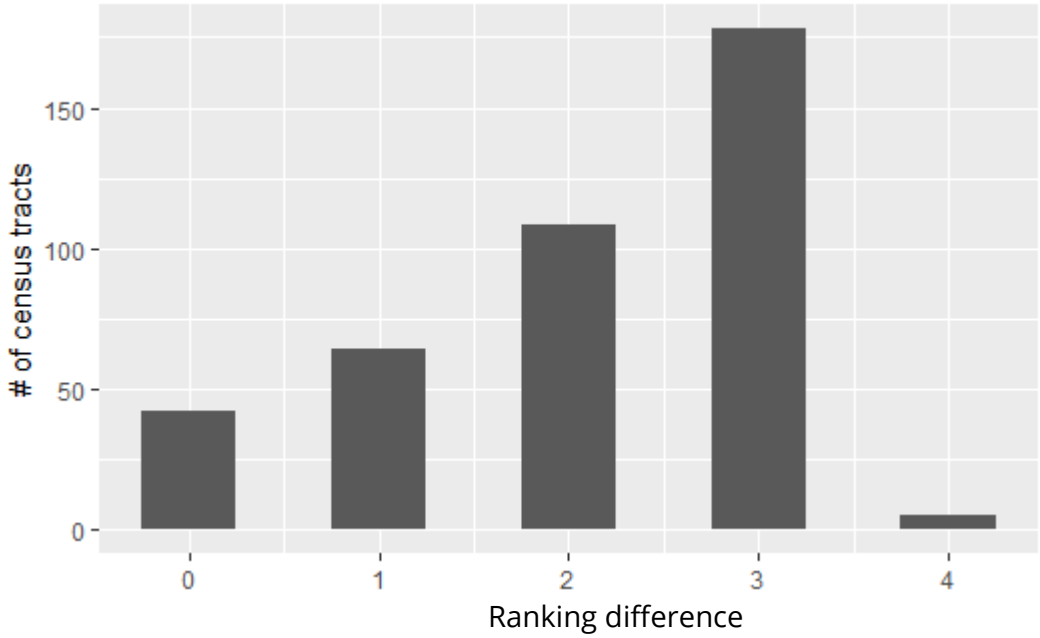
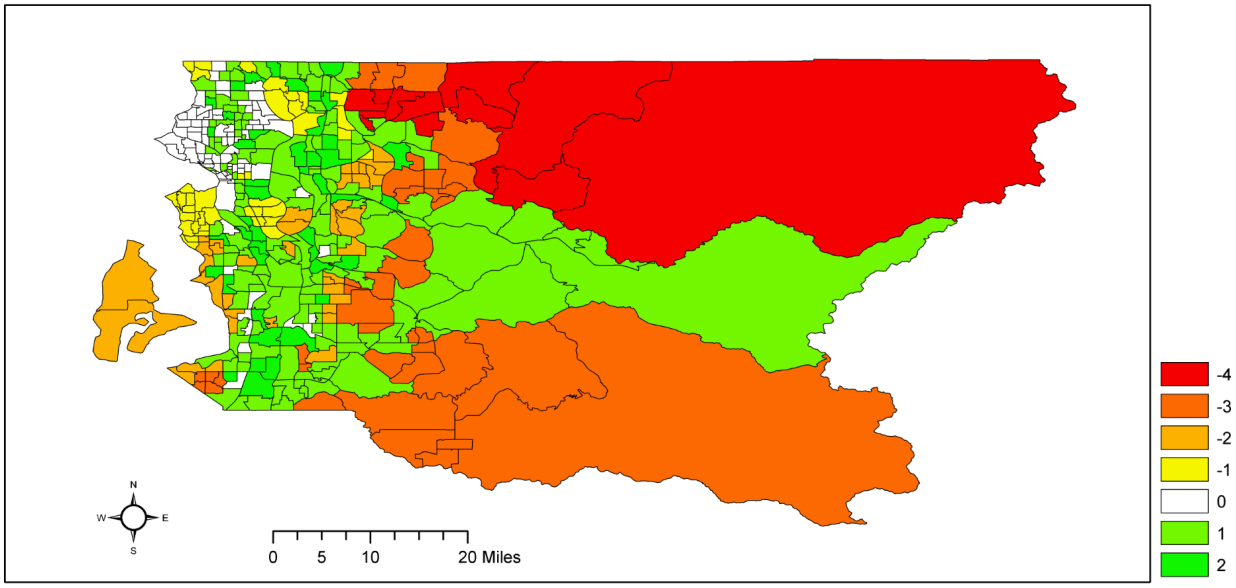


Figure A 13. Histogram of the ranking differences for all King County census tracts: diesel emission indicator.



Map A 14. Difference of traffic density indicator ranking between state and county.

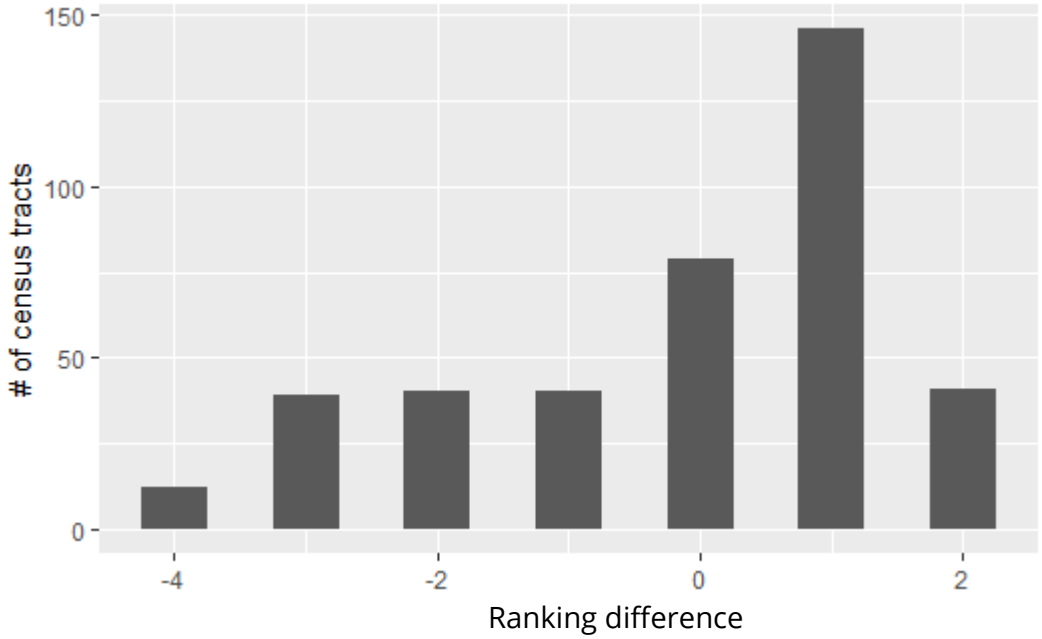
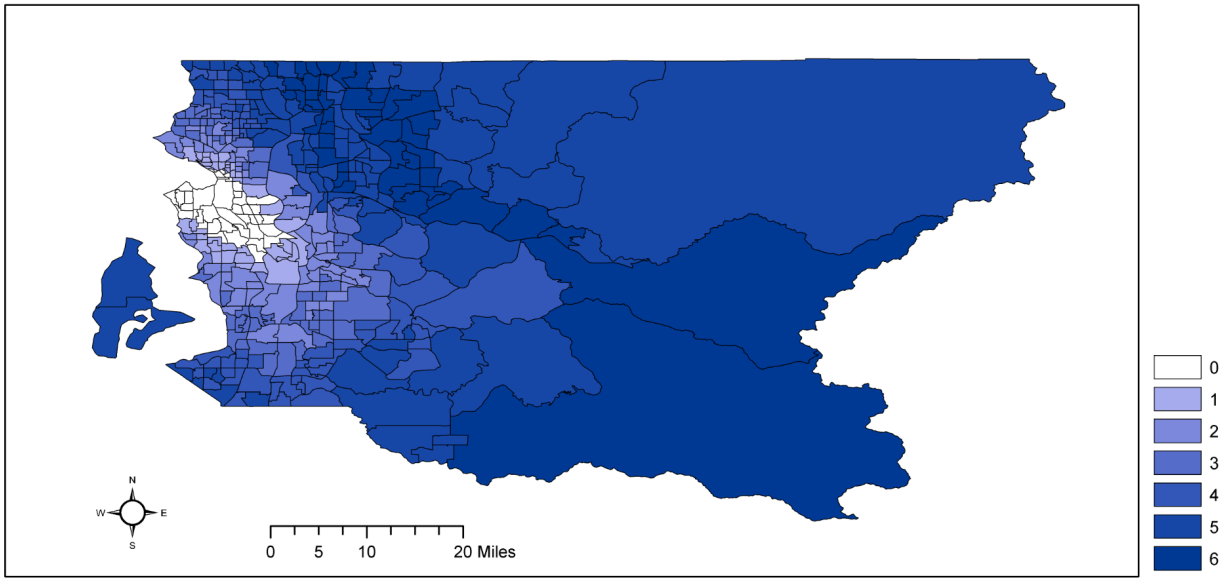


Figure A 14. Histogram of the ranking differences for all King County census tracts: traffic density indicator.



Map A 15. Difference of toxic release from facilities indicator ranking between state and county.

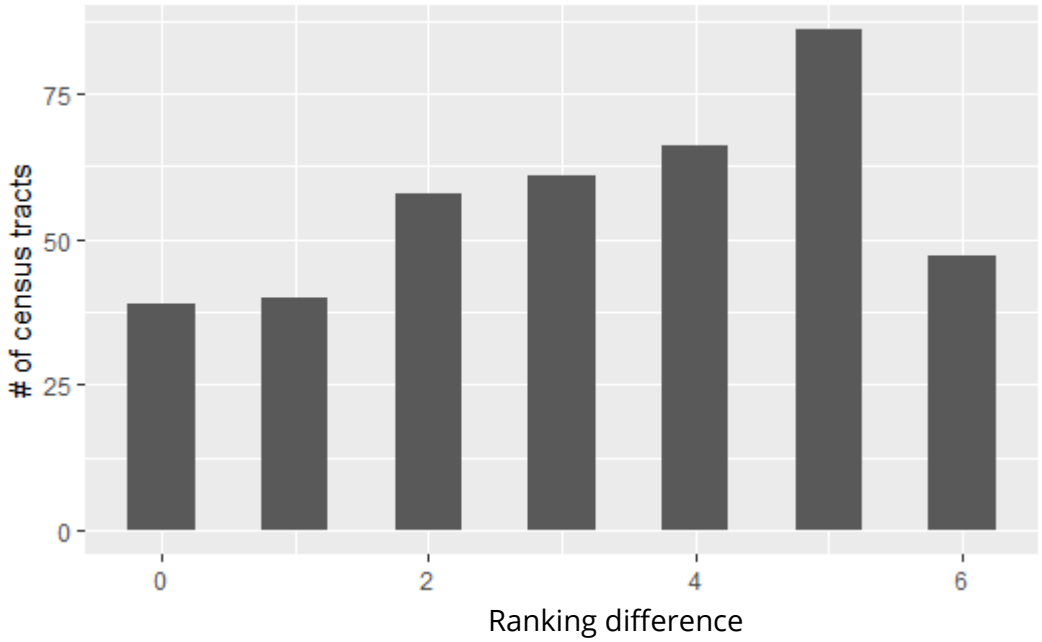
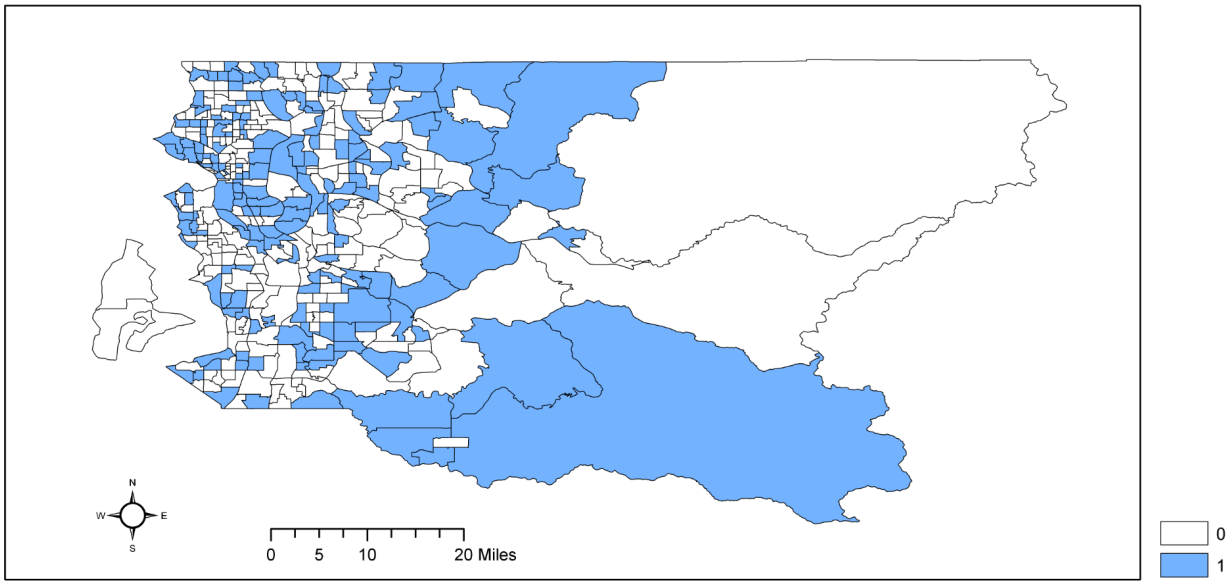


Figure A 15. Histogram of the ranking differences for all King County census tracts: toxic release from facilities indicator.

Socioeconomic factors



Map A 16. Difference of housing burden indicator ranking between state and county.

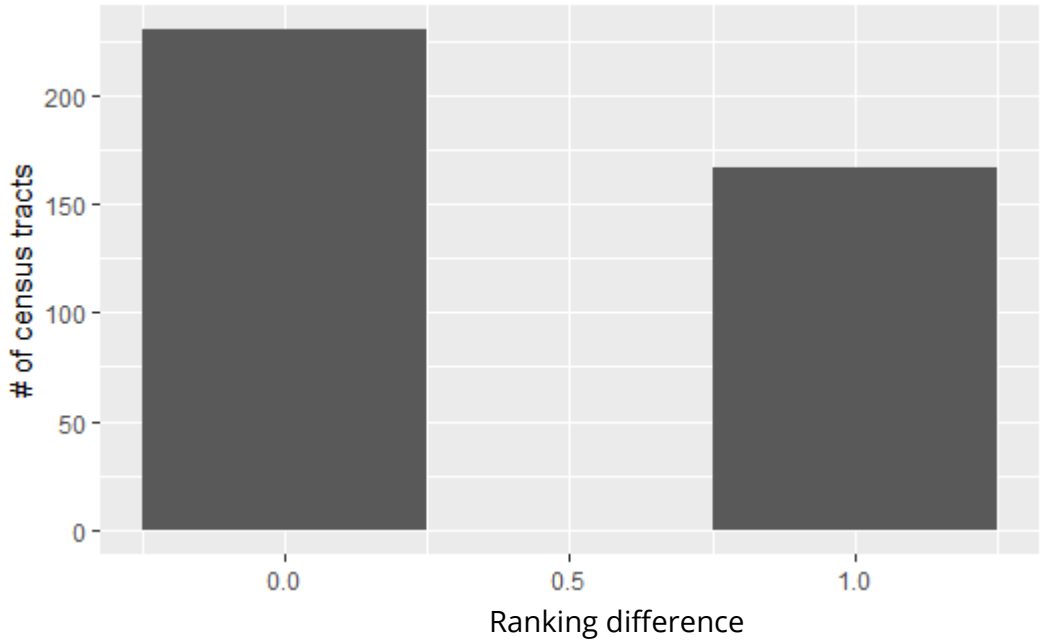
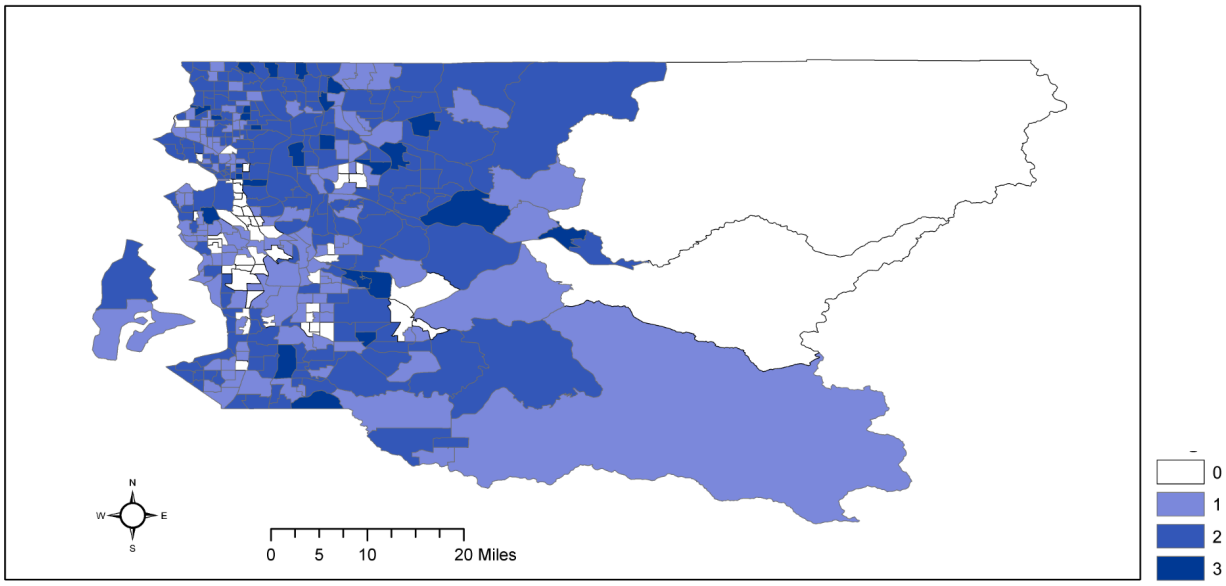


Figure A 16. Histogram of the ranking differences for all King County census tracts: housing burden indicator.



Map A 17. Difference of linguistic isolation indicator ranking between state and county.

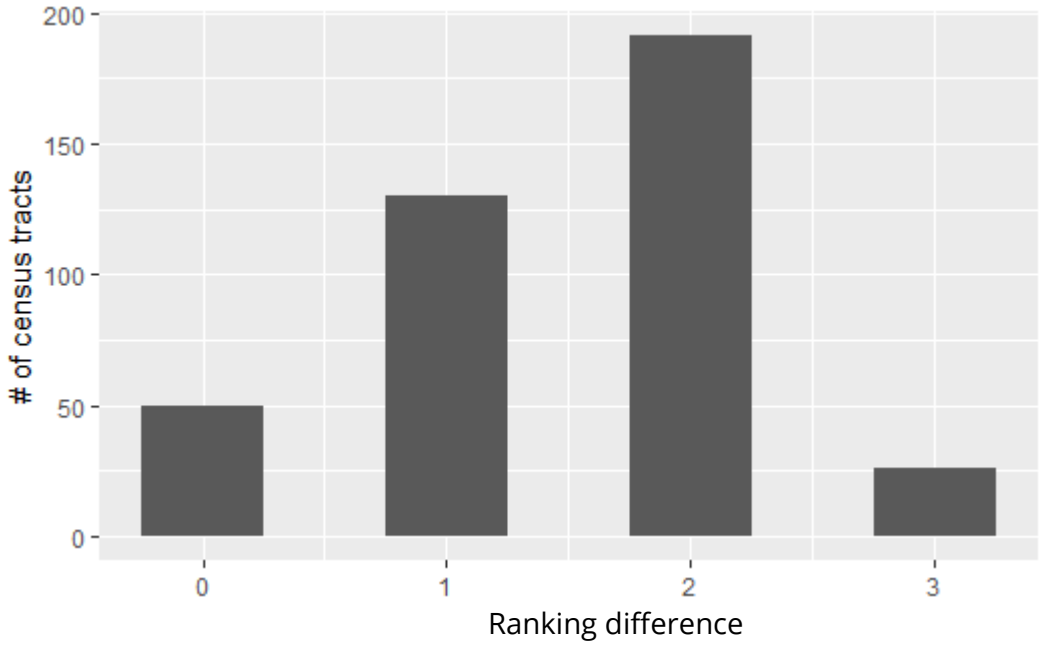
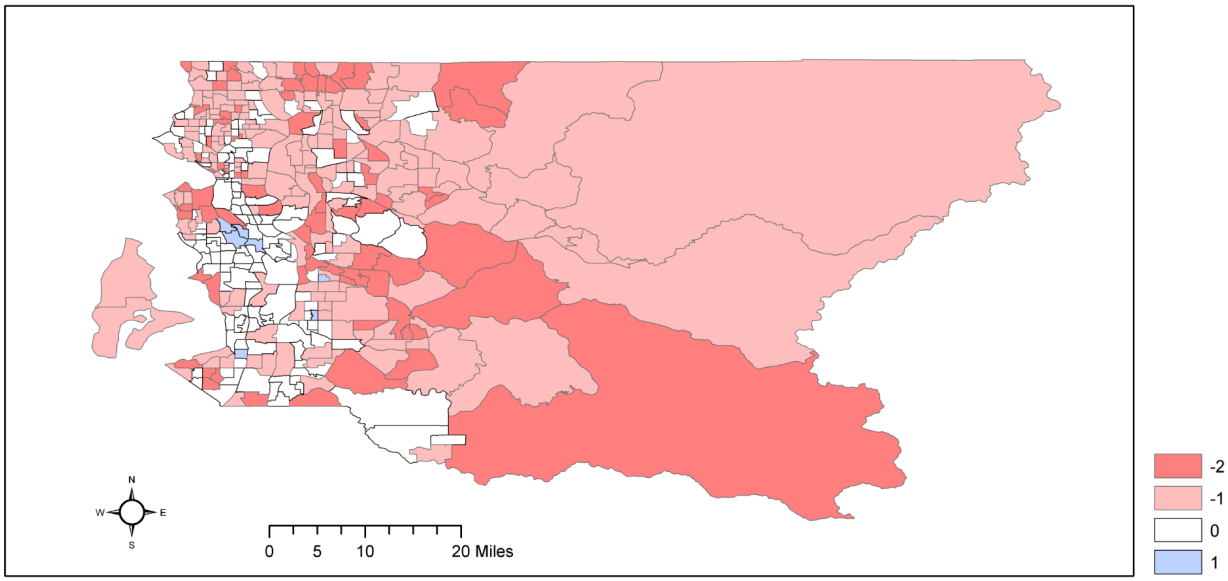


Figure A 17. Histogram of the ranking differences for all King County census tracts: linguistic isolation indicator.



Map A 18. Difference of low educational attainment discharge indicator ranking between state and county.

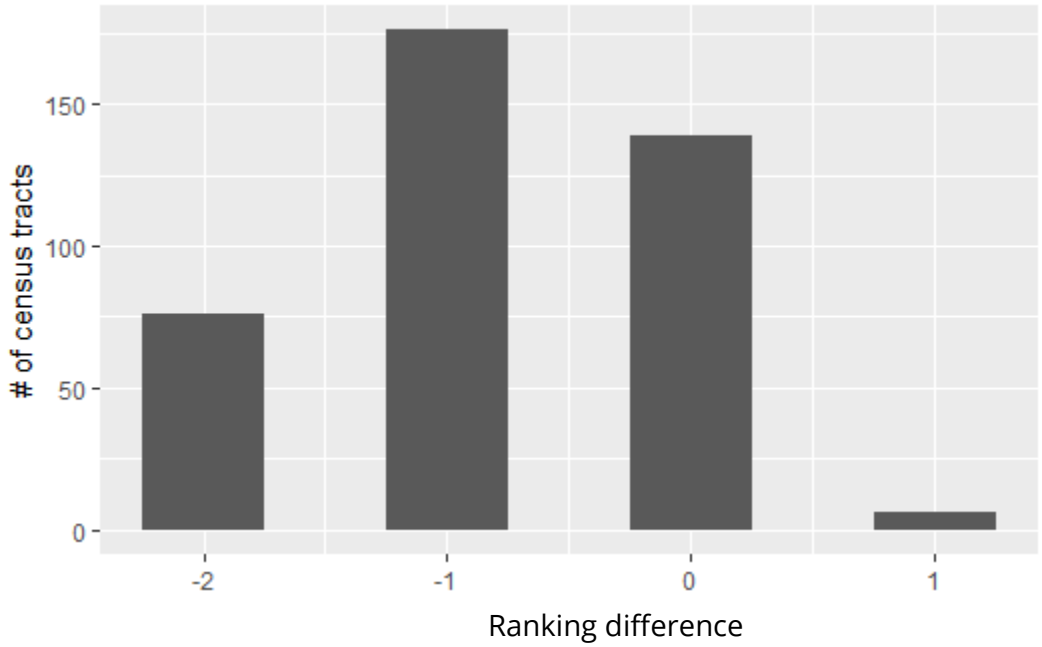
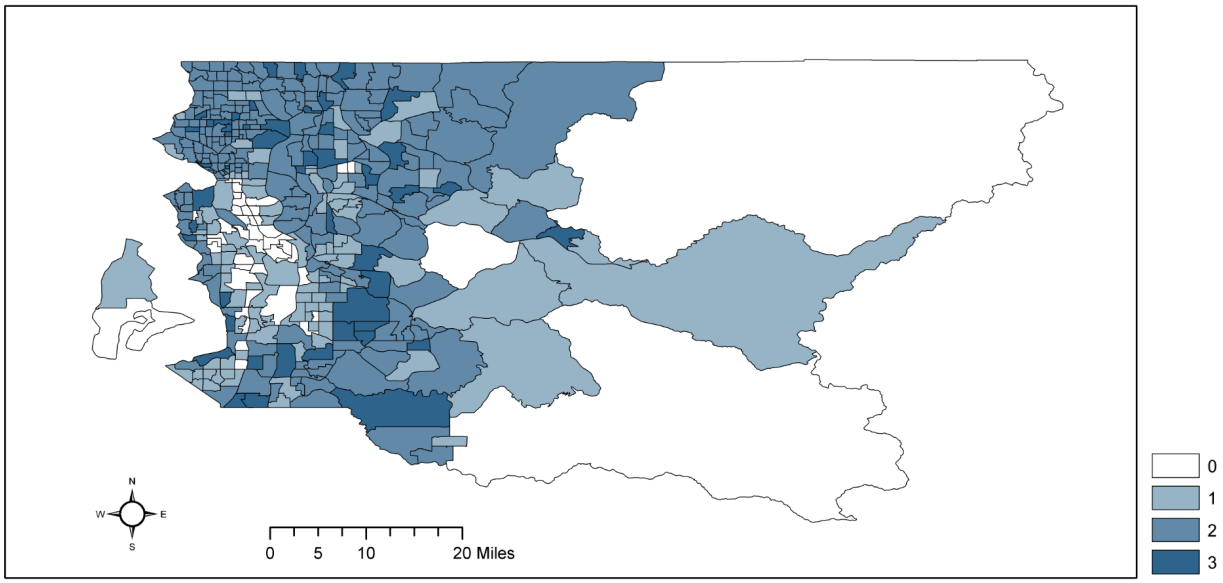


Figure A 18. Histogram of the ranking differences for all King County census tracts: low educational attainment indicator.



Map A 19. Difference of people of color indicator ranking between state and county.

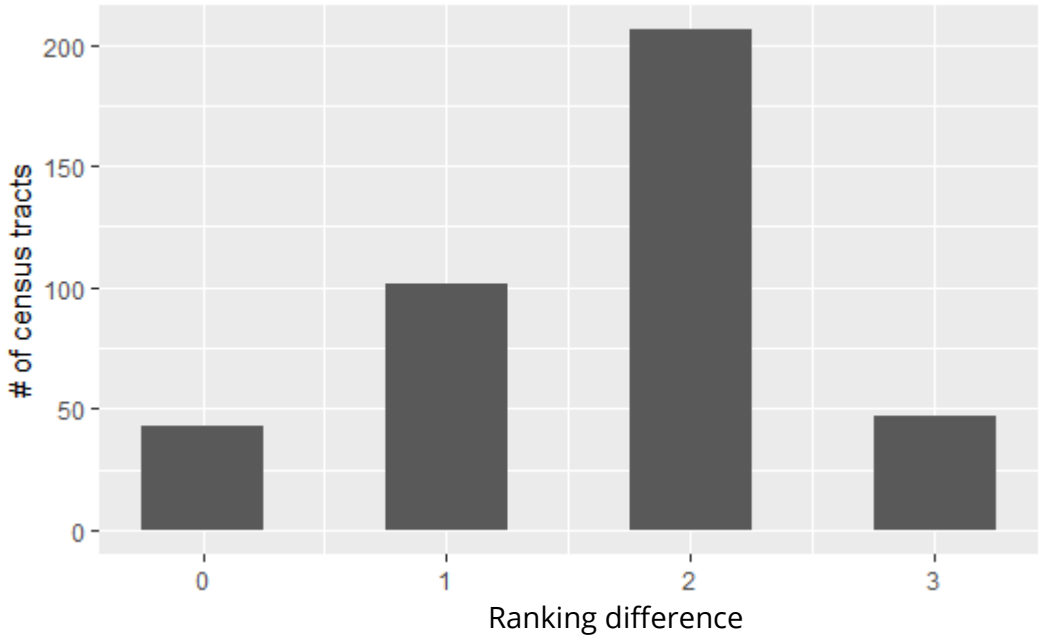
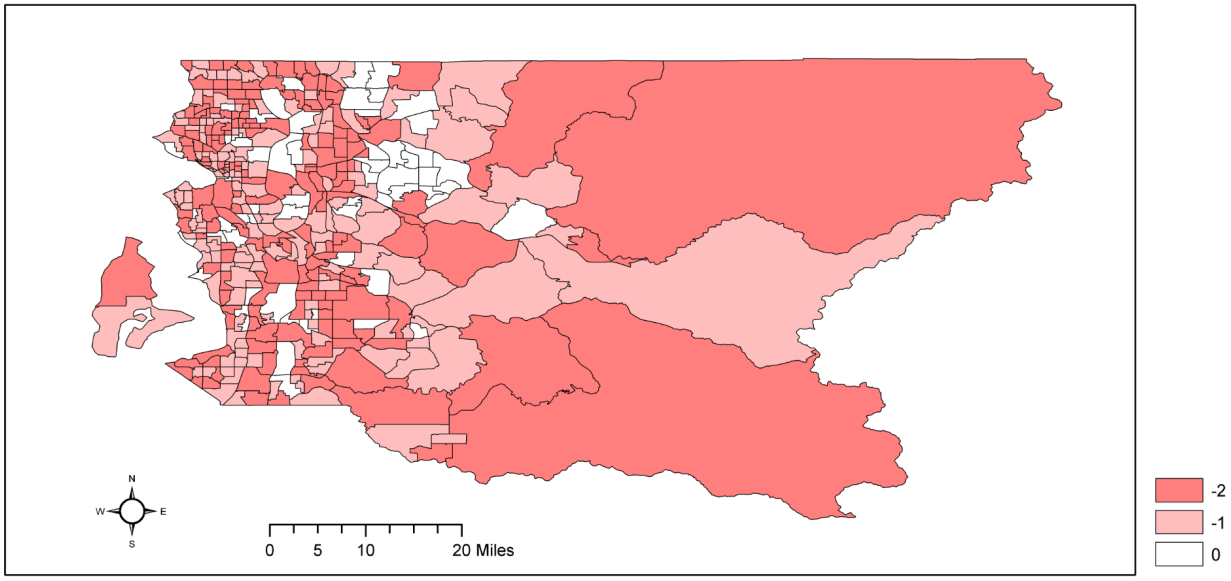


Figure A 19. Histogram of the ranking differences for all King County census tracts: people of color indicator.



Map A 20. Difference of poverty (below 185% federal poverty level) indicator ranking between state and county.

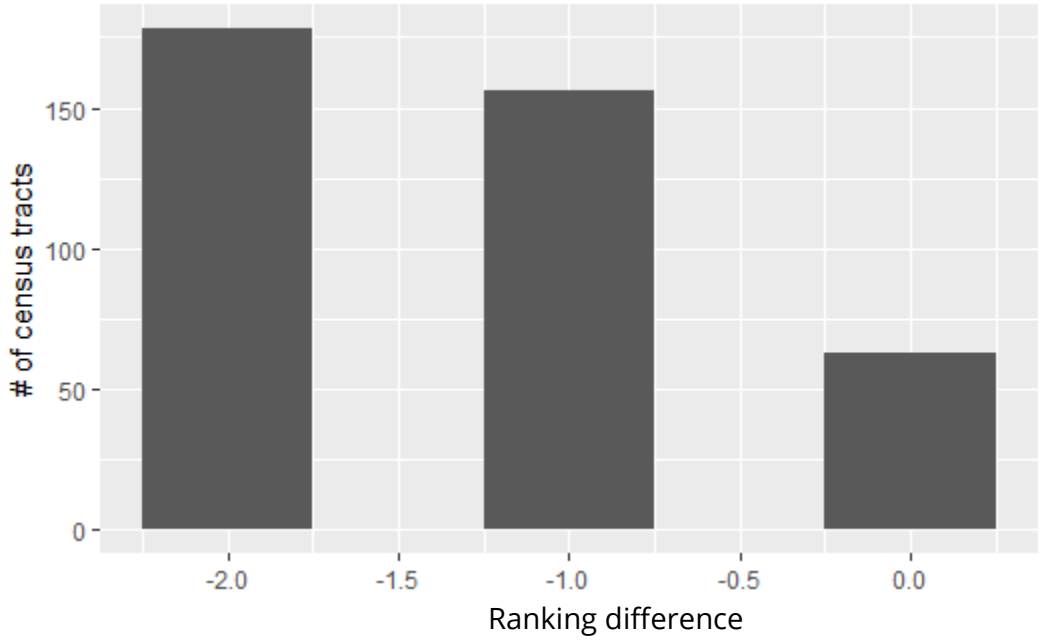
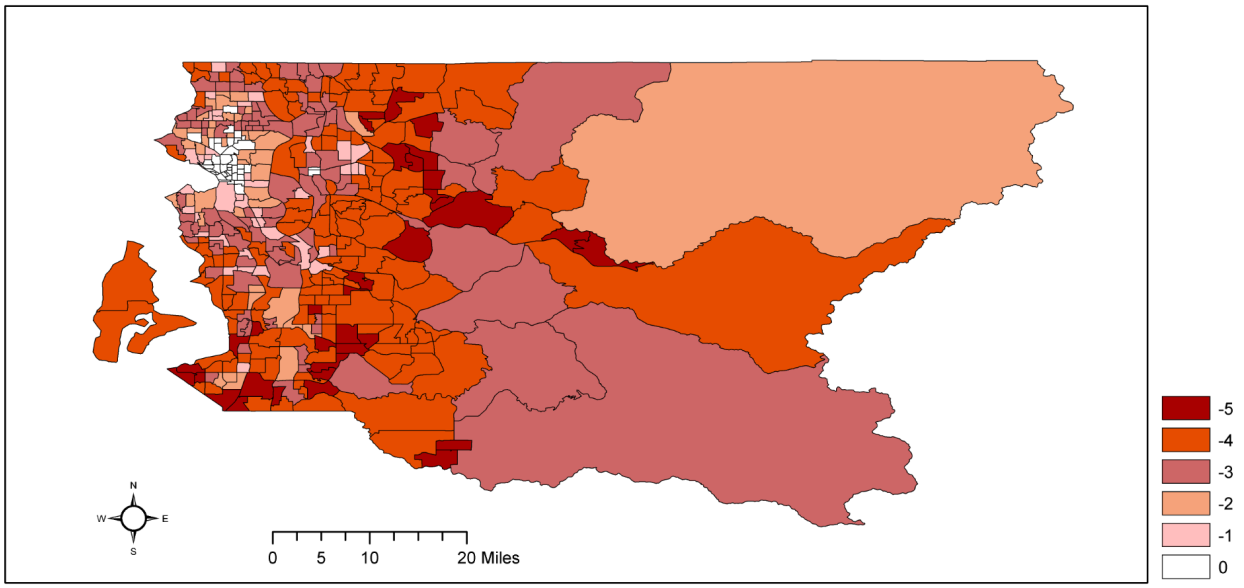


Figure A 20. Histogram of the ranking differences for all King County census tracts: poverty (below 185% federal poverty level) indicator.



Map A 21. Difference of transportation expense indicator ranking between state and county.

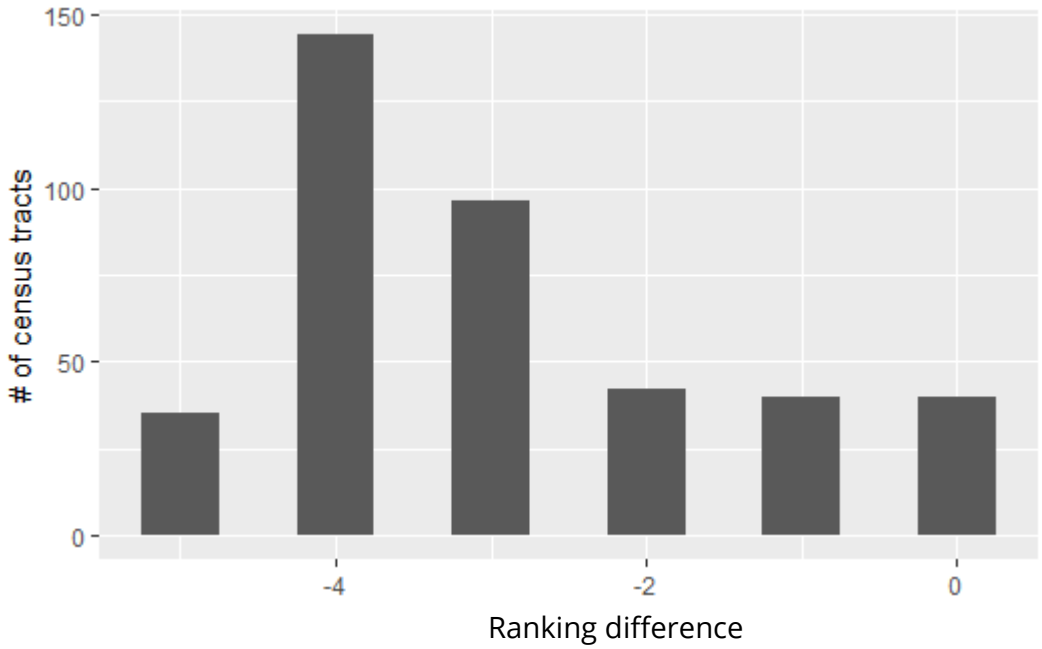
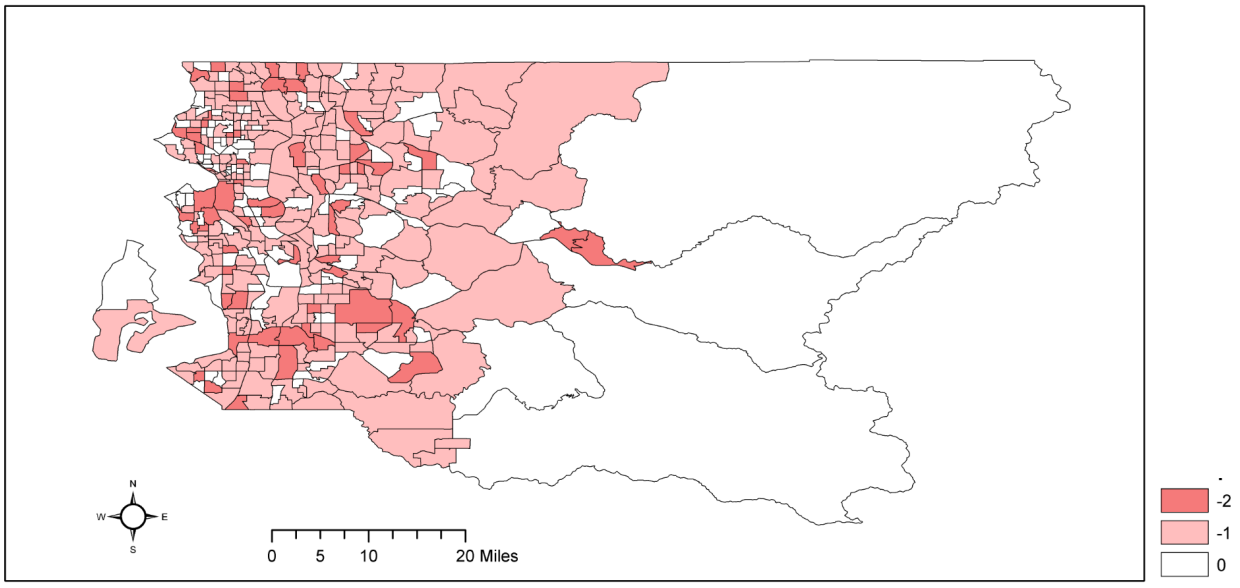


Figure A 21. Histogram of the ranking differences for all King County census tracts: transportation expense indicator.



Map A 22. Difference of unemployment indicator ranking between state and county.

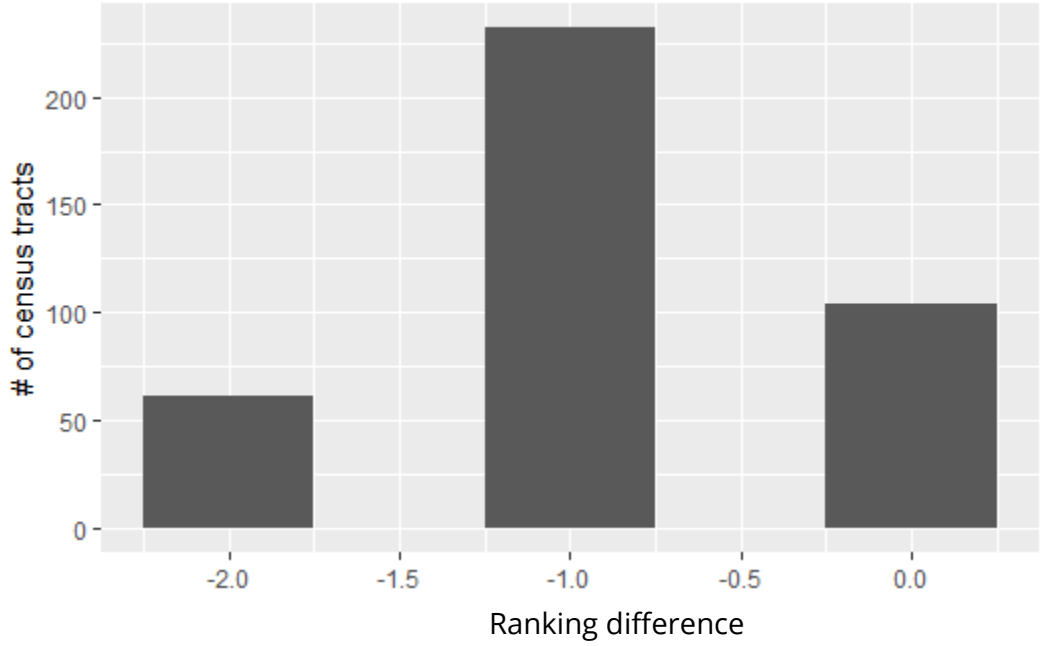
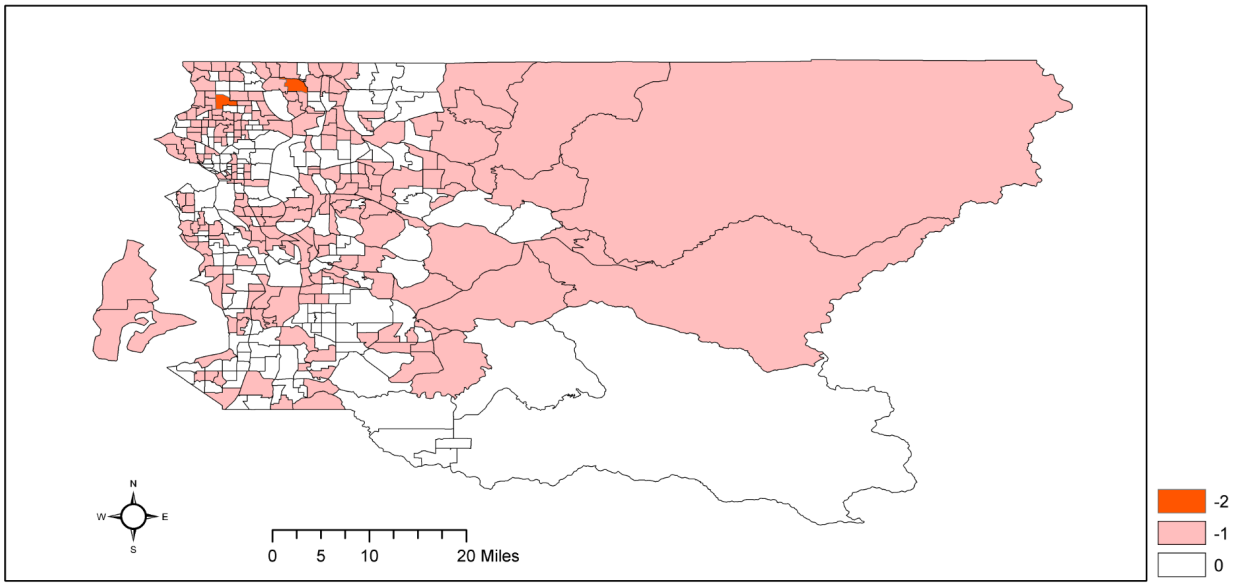


Figure A 22. Histogram of the ranking differences for all King County census tracts: unemployment indicator.

Sensitive population



Map A 23. Difference in cardiovascular disease indicator ranking between state and county.

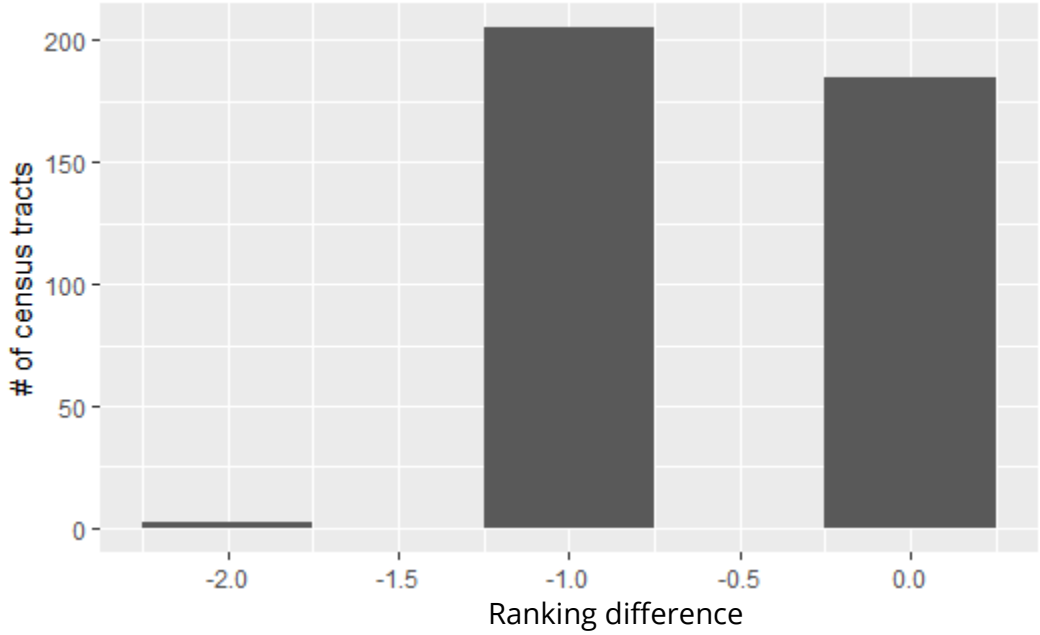


Figure A 23. Histogram of the ranking differences for all King County census tracts: cardiovascular disease indicator.

Additional Information

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The University of Washington occupies the traditional land of the Coast Salish peoples. Without them, we would not have access to this working, teaching, and learning environment. We honor and acknowledge the original caretakers of this land, who are still here.

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