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10/13/25

Relationship Between Nitrate and Cancer in Wisconsin

Background.

This report examines spatial relationships between the concentration of nitrates taken from groundwater wells and the rates of cancer for census tracts in Wisconsin. According to the National Cancer Institute there is evidence for gastric cancers arising from consuming water or vegetables containing excess amounts of nitrates concentrating in the water system from nitrogen rich pollutants such as fertilizers, septic, and feed lot runoffs, though there is not a consensus on its link to cancer as the EPA have still not classified nitrates as carcinogenic.

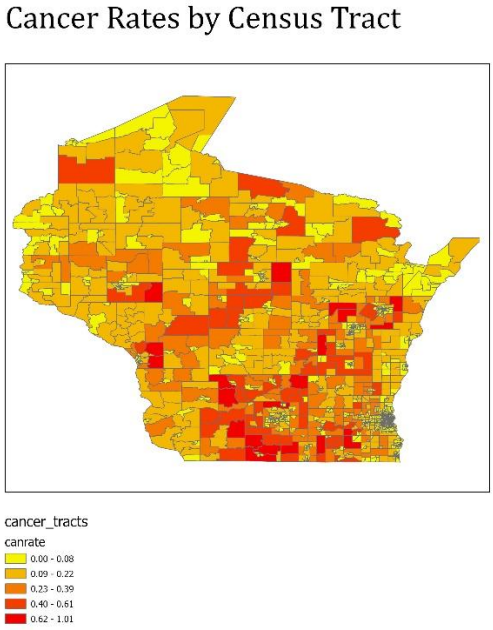

Figure 1. Cancer rates throughout Wisconsin Census Tracts

Methods.

To analyze the nitrates and cancer within the scope of this report we examined a random point survey of groundwater wells holding values for nitrate concentration found. Running inverse distance weighting interpolation on these points we acquire a raster of the state with predicted nitrate concentration values shown below. (Figure 2a.) Using this raster with Zonal Statistics alongside the census tract polygons we create a raster which has an averaged valued for the extent of each polygon. With this

we join the averaged nitrate value to the layer containing the cancer rates, which is done by converting the raster to point vectors necessary for spatial joins. With this layer we run linear regression analysis to create a map of residuals. (Figure 2b.)

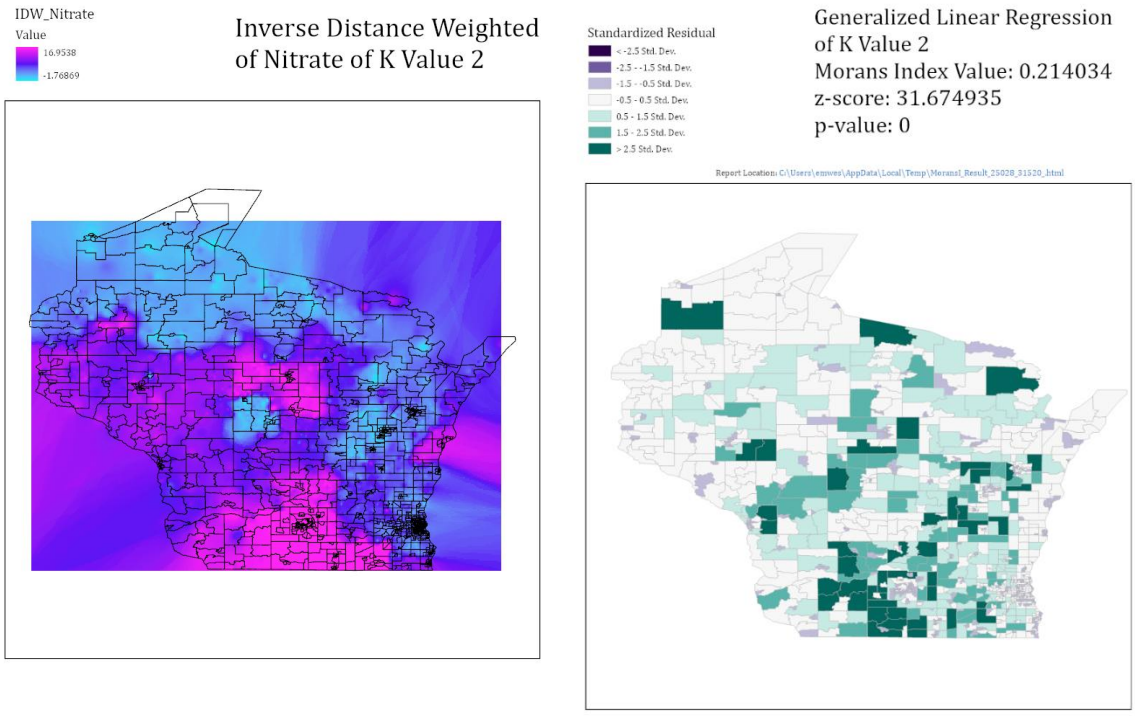

Figure 2. a. (left) The IDW of Nitrate estimated throughout Wisconsin. Pink refers to higher concentrations. b. (right) The map of standardized residuals from linear regression. Darker green shows higher deviations from the expected cancer rate.

We run Global Morans 1 spatial autocorrelation on the residuals to test model fit. By making the value of k dynamic in our IDW model we are able to change resulting averages of nitrate concentrations, with higher values of k resulting in a Voronoi diagram-like raster around each well measurement point (Figure 3a) and thereby exaggerating any outlier concentration values.

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Results and Analysis.

Results at different k values remain similar in their significance, compared below in the example Figure 3 to Figure 2b, with the resulting residuals, Morans Value, z-score, and p-value being near identical.

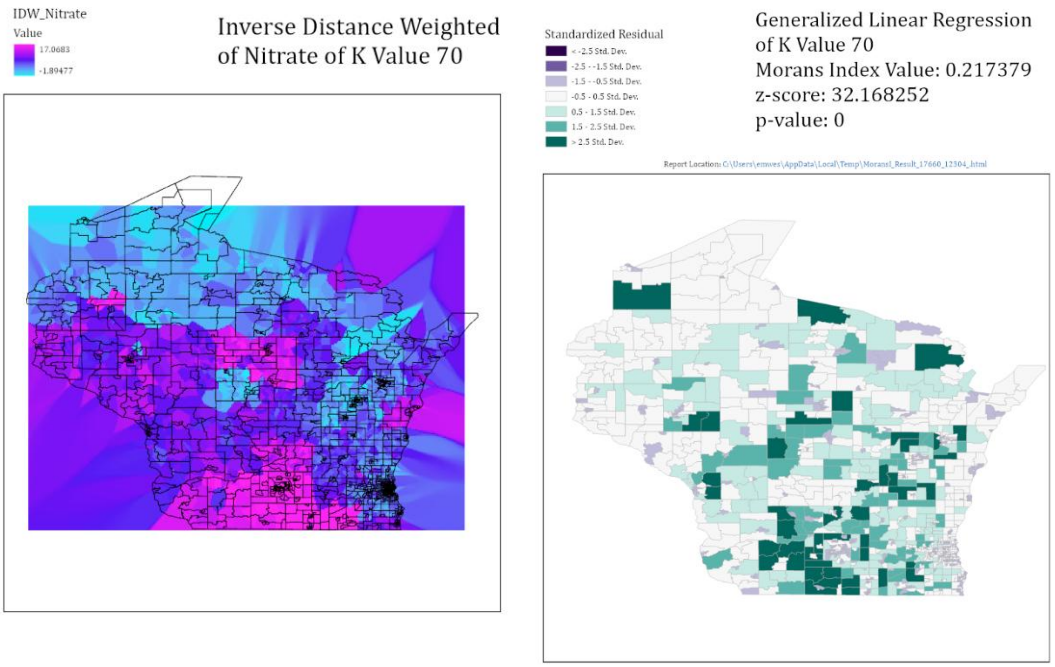

Figure 3. The IDW and Linear Regression map for a high k value (k = 70)

The spatial autocorrelation of the resulting residuals shows statistical significance for clustering which indicates, as explained by the ESRI documentation on linear regression analysis, there are key variables which are not included in the model and thereby cannot draw conclusions about the relationship. We can hypothesize this is from the scale and resolution of these tests; carcinogens are numerous and difficult to isolate while also having varying situations for a subject to experience harmful exposure i.e. lifestyle and living conditions modifying their risk. As the research suggests there is a link to gastric based cancers specifically, cancer rates could be constrained to remove potential noise from the model.

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References

National Cancer Institute. (April 2025) *Cancer Trends Progress Report*. National Institute of Health. https://progressreport.cancer.gov/prevention/chemical_exposures/nitrate

Environmental Systems Research Institute. (May 2025) *Regression analysis basics*. https://pro.arcgis.com/en/pro-app/3.4/tool-reference/spatial-statistics/regression-analysis-basics.htm