Benzene Exposure, Leukemia, and Non-Hodgkin's Lymphoma in a Spatial Context

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Abstract

This research looks at various environmental benzene sources: tobacco smoke, plastic industries, petroleum industries, and benzene-related chemicals released in industries and its known association with leukemia and Non-Hodgkin lymphoma in geospatial context. It uses geospatial analytics to understand relationships between the environment and leukemia & non-Hodgkin Lymphoma. Our hypothesis is that the greater the number of high environmental benzene sources, the higher incidence rate for each cancer. We found two factors, specifically plastic industries and benzene-related chemicals with statistically significant relationships with leukemia and non-Hodgkin lymphoma incidence rates.

Introduction/Aims

Benzene, a classified carcinogen by IARC, NTP, and EPA, is known to cause leukemia [1]. It is widely used in industries and is among the top 20 chemicals in production volume in the United States due to its role as a starting chemical for plastics and dyes. Cigarette smoke is responsible for over 50% of benzene exposure. Many studies have been done on industry workers with frequent, direct exposure to benzene. However, there are not many studies focusing on benzene exposure through the environment for the common population. Non-Hodgkin Lymphoma has been suspected to be linked to benzene, but it is not widely established [2]. This study looks to find data-driven evidences of a geospatial relationship between benzene exposure from the environment and incidence rates on the county level for leukemia and non-Hodgkin lymphoma.

Methods & Results

Leukemia & Non-Hodgkin Lymphoma

- Source: Cancer Control Planet (SEER and NPCR-SS) dataset
- No data from Kansas, Minnesota, and Nevada due to state legislation
- Plot incidence rates by quantile
- 2011-2015 Average
- Leukemia Incidence Rates (Figure 1)
- Non-Hodgkin Lymphoma Incidence Rates (Figure 2)

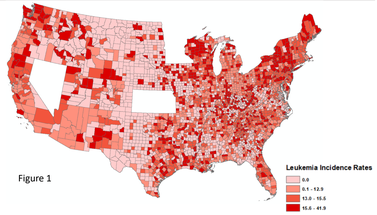

Figure 1

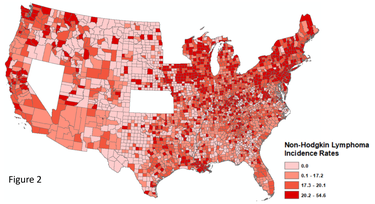

Figure 2

http://cancercontrolplanet.cancer.gov/.

Individual Benzene Sources: Separate each variable data by quantiles (Q1-Q4) -Isolate Q1 and Q4 -Use T-test to find difference in average incidence rates of Q1 set and Q4 set for leukemia and lymphoma

Smoking Mean Rates in 2012:

- Source: Behavioral Risk Factor Surveillance System (https://www.cdc.gov/brfss)
- Smoking Rates separated by quantile (Figure 3)
- Result (Leukemia):
  - Mean of Q1 set = 9.773224
  - Mean of Q4 set = 8.129667
  - T = 4.1661, df = 1392.2
  - P-value = 3.289e-05

Result (NHL):
Mean of Q1 set = 13.81270
Mean of Q4 set = 12.91635
T = 1.8424, df = 1421
P-value = 0.06563

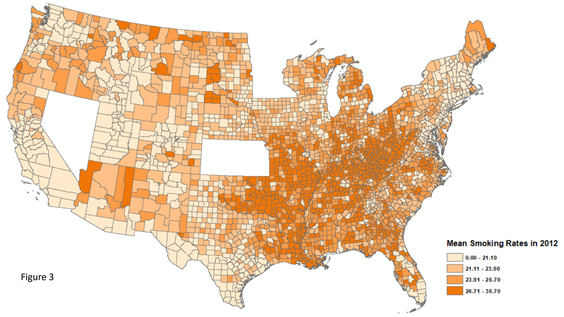

Figure 3

Smoking Average Annual Rate of Change from 1996-2012

- Source: Behavioral Risk Factor Surveillance System (https://www.cdc.gov/brfss)
- Rate of change separated by quantile (Figure 4)
- Result (Leukemia):
  - Mean of Q1 set = 11.391746
  - Mean of Q4 set = 5.734291
  - T = 14.466, df = 1100.4
  - P-value = <2.2e-16

Result(NHL):
Mean of Q1 set= 16.177537
Mean of Q4 set = 9.325853
T= 13.738, df = 1050.9
P-value = <2.2e-16

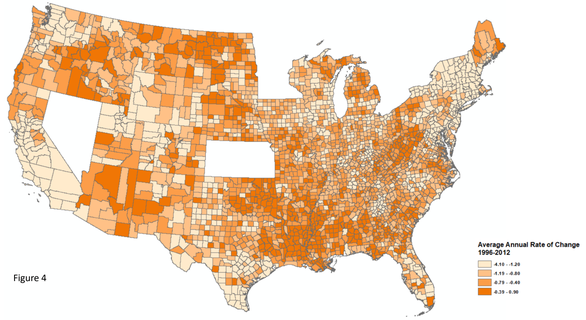

Figure 4

40 Benzene-Related Chemicals

- Source: Toxic Release Inventory – 2017 (https://iaspub.epa.gov/triexplorer/tri_release.geography)
- Amount of chemical disposed separated by quantile (Figure 7)
- Result (Leukemia):
  - Mean of Q1 set = 8.501968
  - Mean of Q4 set = 12.631373
  - **T = -8.9295**, df = 126.15
  - **P-value = 4.293e-15**

Result (NHL):
Mean of Q1 set = 12.8571
Mean of Q4 set = 17.8598
T = -9.1428, df = 128.25
P-value = 1.169e-15

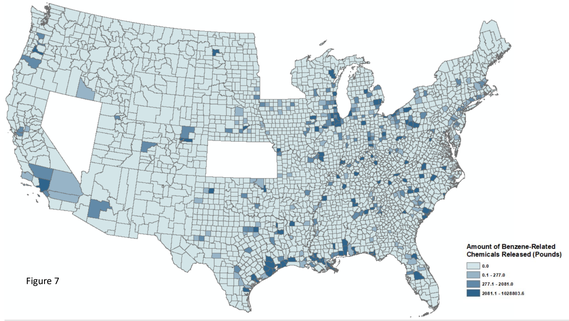

Figure 7

Petroleum Industry

- Source: Toxic Release Inventory – 2017 (https://iaspub.epa.gov/triexplorer/tri_release.geography)
- Amount of chemical disposed separated by quantile (Figure 5)
- Result (Leukemia):
  - Mean of Q1 set = 8.906174
  - Mean of Q4 set = 11.02
  - T = -.062908, df = 2886
  - P-value = 0.5293

Result (NHL):
Mean of Q1 set = 13.37232
Mean of Q4 set = 11.88
T = 0.36315, df = 2886
P-value = 0.7165

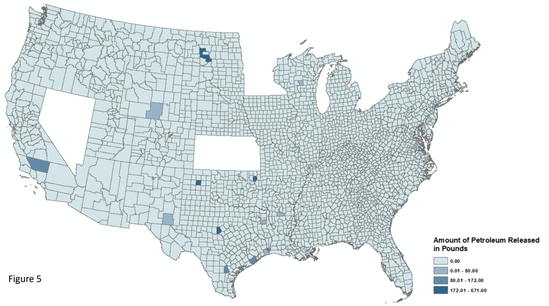

Figure 5

Plastic Industry

- Toxic Release Inventory – 2017 (https://iaspub.epa.gov/triexplorer/tri_release.geography)
- Amount of chemical disposed separated by quantile (Figure 6)
- Result (Leukemia):
  - Mean of Q1 set = 8.649372
  - Mean of Q4 set = 12.0211
  - **T = -5.2636**, df = 99.306
  - **P-value = 8.174e-07**

Result (NHL):
Mean of Q1 set = 13.04462
Mean of Q4 set = 16.88111
T = -5.2758, df = 101.27
P-value = 7.537e-07

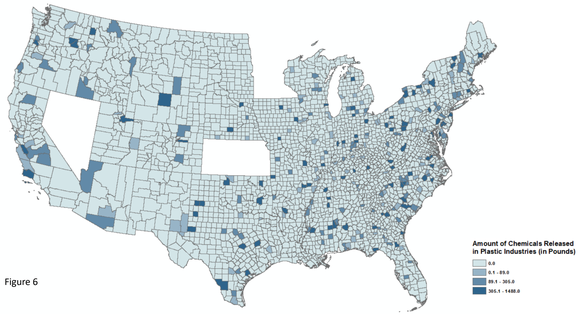

Figure 6

Conclusion and Discussions

From our results, we found two environmental benzene sources that had statistically significant p-values. ***Plastic's*** and ***Benzene-Related Chemicals'*** Q1 and Q4 data sets showed noticeable differences in the means of incidence rates for both leukemia and Non-Hodgkin Lymphoma. Others, such as smoking and the petroleum industry did not support our hypothesis. This work demonstrates the potential use of environmental factors in geospatial analytics for cancer epidemiology. Future work includes expanding to multiple cancer types, other environmental sources, and social & economic factors.

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