Lead Exposure and Health Equity

Background

While the Massachusetts commonwealth has made substantial gains in mitigating the harmful effects of lead exposure through public health intervention over the past 45 years, lead exposure remains a significant health risk for children across Massachusetts. The "Healthy People 2020" goal includes the elimination of blood lead levels (BLLs) > 10µg/dL[1]. Children under five years of age are particularly vulnerable to lead poisoning.

The primary source of lead pollution is lead paint in homes. Children who live in pre-1979 housing (the law banning the use of lead paint was passed in 1978) are more likely to be exposed to lead[2]. Moreover, studies have reported, socioeconomic and racial status are also related to a child's risk level for lead poisoning [3]. Children living at or below the poverty line are at a significantly elevated risk of lead exposure. While age of housing, poverty, and educational attainment of parents play a strong role across much of the state, racial make-up has seen to be independently associated with elevated BLLs in central regions and within urban areas of MA [4].With these indicators, this analysis will compare the prevalence of high BLLs and health equity.

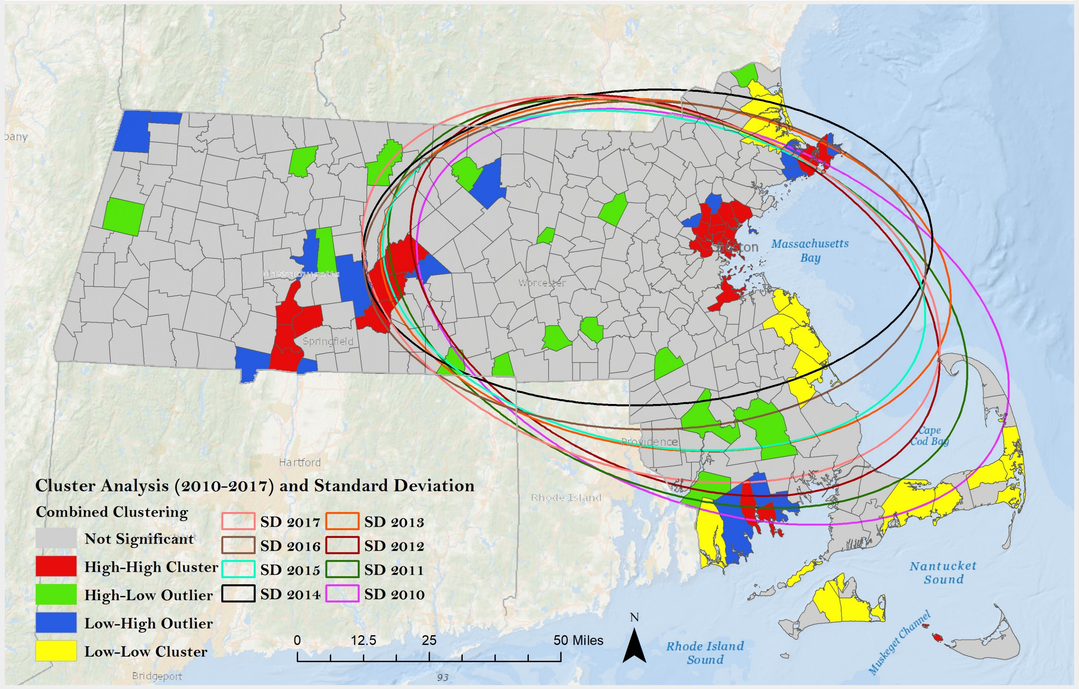
This project aims to answer the following question:

- Which communities are affected most by lead exposure over the last eight years? Are there any clustering present in high BLLs communities?
- Which communities are highly vulnerable for lead exposure in Massachusetts?
- Are the higher clustering high BLLs communities in/near the lead exposure vulnerable (low health equity) communities?

Methodology

To answer the first spatial question, a space time analysis was done to show the clustering of high child BLLs in MA. The annual children (<age 4) BLLs prevalence data (> 5µg/dL) per town from Massachusetts Department of Public Health from the year of 2010-2017 was used for the analysis. First, a bivariate clustering using Moran's I was conducted to show whether the high BLLs towns are spatially correlated, whether there are clustering present and whether clustering are statistically significant or not. Local Moran's I generated the bivariate LISA (BiLISA) cluster map for high BLLs towns of each year (2010-2017). Then the standard deviational ellipse tool were used to check if the high BLLs distribution is elongated with particular orientation. After that, all the high-high clustering were numbered as 1 and with the help of field calculator all the high clusters were added from 2010-2017 to create the hotspot map for the high clusters of all the past eight years.

Clustering of High BLLs from 2010-2017



In order to compare the high BLLs with health equity, a vulnerability analysis was done. The percentage of - houses built before 1978, population (> 25 years) not graduated from high school, children (< 5 years) under poverty level, renter occupancy, and non-white population were used as the health equity variables. The variables were then reclassified from 1-4 with higher percentages indicating higher values for all five factors. Finally, with the "weighted overlay" tool a "lead exposure vulnerability" map was created. The weights were determined by using AHP priority calculator.

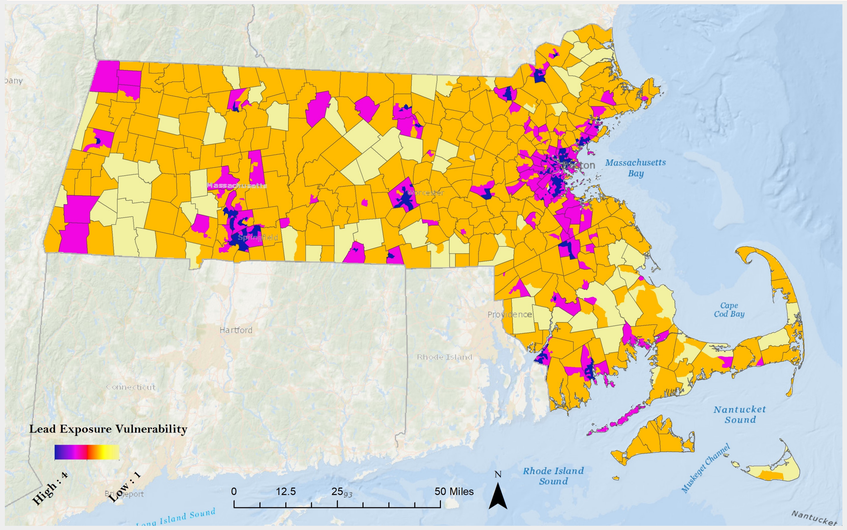
Table 1: Lead Exposure Vulnerability Weights

Risk Factors	Weight
Housing year	36%,
Child under poverty	21%
Non-white population	19%
Education attainment	12%
Renter occupancy	12%

Result and Discussion

The clustering map indicates that there are areas with significantly higher clustering of high BLLs from year 2010-2017. Table 2 shows the value of Moran's I, and except for 2014, 2015 and 2017 the Moran's I are more inclined to perfect clustering. However, all the map clustering are significant as the p value is less than 0.0001. There are areas (greater Boston, Lynn, Saugus, Gloucester, Springfield, Ware, Hardwick particularly) where clustering is significantly higher than other areas which were shown by high-high cluster. The SD for 2010-2017 shows that the high BLLs distribution have a particular orientation as there were many overlapping of ellipses; the clustering was distributed more in eastern MA that western.

Vulnerability



The highest vulnerable communities from the vulnerability map matches with most of the high-high clustering communities. It matches with greater Boston, areas near Lynn, near New Bedford with the combined clustering and single year's high-high cluster. However, there are some high vulnerable areas which are not colocated with high clustering areas. Hardwick, Ware, and Palmar are not vulnerable, when there are high clustering present on those areas. Again greater Worchester shows high vulnerability where there is no combined or a single year clustering on that areas. This result could be due to various factors; non-white population and renter occupancy could be a factor as the high-high clustering areas not colocated with high percentage of these two factors.

One of the key limitations of this project is that there is no public access to lead incidence data and very limited lead exposure data. The pre-1978 housing data could be another limitation of this analysis as there is no information of de-leading, where more than 10% of housing stock has been reported to de-leaded which are no longer threats to lead exposure[4]. More public health intervention should be targeted on the vulnerable areas to mitigate the health equity as the project showed there are clear pattern of high clustering of high BLLs in vulnerable areas.

Table 2: Global Moran's I

2010	2014
Moran's I: 0.698 p-value: 0.000	Moran's I: 0.447 p-value: 0.000
2011	**2015**
Moran's I: 0.547 p-value: 0.000	Moran's I: 0.406 p-value: 0.000
2012	**2016**
Moran's I: 0.555 p-value: 0.000	Moran's I: 0.540 p-value: 0.000
2013	**2017**
Moran's I: 0.653 p-value: 0.000	Moran's I: 0.449 p-value: 0.000

Tufts UNIVERSITY

Cartographer: Hur E Zannat

UEP 294 Advanced GIS | Fall 2018

Projecion: NAD_1983_StatePlane_Mssachusetts _Mainland_FIPS_2001 (Meters)

Sources and References:

MassGIS, Mass Department of Public Health , American Fact Finder, Census Tract Massachusetts State Level Data.

Refferences:

[1] Centers for Disease Control and Prevention. (October 23, 2015). Childhood blood lead levels- United States, 2007-2012. Morbidity and Mortality Weekly Report (MMWR), 62 (54), 76-80.

[2] Centers for Disease Control and Prevention: Childhood Lead Poisoning Prevention Program Geographical Information System Workgroup. (December 2004).

[3] Carrel, M., Zahrieh, D., Young, S. G., Oleson, J., Ryckman, K. K., Wels, B.,Saftlas, A. (2017). High prevalence of elevated blood lead levels in both rural and urban Iowa newborns: Spatial patterns and area-level covariates. *PLOS ONE*. doi.org/10.1371/journal.pone.0177930

[4] Massachusetts Department of Public Health: Data Brief, Childhood Lead Exposure in Massachusetts 2016.