Preliminary Multi-Factor Risk Mapping for Potential Lead (Pb) Exposure

As became an acute and critical concern in Flint, MI beginning in 2014, one principal potential source of childhood lead (Pb) exposure in the U.S. is through municipal drinking water infrastructure. Other principal potential sources of Pb exposure that warrant evaluation result from exposures to remnants/residuals of leaded house paints and residual soil contamination from the historical addition of lead into gasoline.

With respect to house paint, the use of lead in interior house paints was banned in 1978, but the housing stock in many locations is considerably older than this date. In general, 70% of the homes constructed before 1960, and > 85% of home constructed before 1940s were painted with lead-containing paints. The flaking, chipping and peeling of this paint can be an ongoing and significant source of Pb exposure for children in un-remediated houses.

With respect to lead in fuel, tetraethyl lead was added to gasoline beginning in the 1920s, was banned from use in automotive fuels in 1976 and has recently (2021) been removed entirely from aviation fuels. Automotive emissions resulted historically in direct exposures to Pb via breathing exhaust residuals – an exposure route of significant impact in urban environments with high traffic density – as well as enduring contemporary exposures from contaminated soils and urban dust that have retained leaded particulates.

Demographically, the potential for Pb exposure is therefore overall elevated for individuals and families who live in urban areas (higher residual contamination in soils) and older homes (higher potential for residual contamination from historical house paints). The potential for elevated risk of exposure to Pb increases further as a function of socio-economic status (SES) due to poor(er) housing quality in lower income neighborhoods; lack of families' time and $$ to maintain and/or completely remove old residual interior house paint; lack of access (or restricted access) to play areas for children that are clean and/or have been remediated; and impacts of poverty on childrens' nutritional status (both in terms of consistency of nutrition and quality of nutrition).

In addition, while not linked directly to SES, there may be an association in some regions of the U.S. between SES and English language literacy that may result in additional potential for Pb exposure if public programs and/or PSAs regarding strategies for protecting children from Pb are not able to be accessed and/or acted upon.

As public health engineers, we are focused on evaluating and understanding the spatio-demographics of contaminant exposures and exposure risks. As example, we may be collecting

or evaluating spatio-demographic data to help identify neighborhoods in which additional services should be provided or in which services that should be available to everyone are not being accessed. With the public availability of ArcGIS and American Community Survey (ACS) census data, we have a suite of tools for creating preliminary screening maps to help identify areas or neighborhoods in which community health interventions should be offered or in which we may have a role to play in confirming that available services are accessible and available.

The multi-factor risk map we're developing here for Pb exposure focuses on three risk factors:

- **Housing stock**, and specifically, identifying neighborhoods with a significant percentage of older (pre-1940s) housing stock;
- **Elevated poverty**, and specifically, neighborhood-scale concentrated poverty (i.e., > 40% of a neighborhood identified as living below the poverty line; and
- **Linguistic isolation**, and specifically, an elevated percentage of a community identifying as non-English speaking or of limited English proficiency. [For this factor, we note overall that linguistic isolation may increase risks across many focus areas of personal safety, including interaction with law enforcement, prevention-related actions around personal behaviors and natural disaster preparedness and response.]

American Community Survey (ACS) data are available through US Census and provide demographically-relevant data on the aggregate scale of census tracts (approx. 4000 people per census tract). ACS data are collected monthly and aggregated yearly to provide a more nuanced understanding of higher-level U.S. Census data (which are collected every 10 years). Approximately 3.5 million ACS surveys are conducted annually, representing approximately 1% of the U.S. population. These data are well suited for baseline or preliminary risk assessments on the scale of urban neighborhoods.

For the preliminary Pb exposure assessment we are conducting, we will want to access and map the following data layers:
- ACS Housing Units by Year Built (Boundaries)
- ACS Poverty Status Variables (Centroids)
- ACS English Ability and Linguistic Isolation Variables (Boundaries)

To build a multi-factor screening-level exposure risk map:
1. Login to ArcGIS through the UMaine portal and click on Map
2. Identify a city of interest and navigate your map view to a scale that highlights census tracts. You can use Shift + Alt + cursor to zoom in quickly to city-level scale.

3. Preview available basemaps to find a base layer that is useful but not cluttered. I tend to use Topographic (the default) or Light Gray Canvas to begin with.

4. Under Layers, click 'Add Layer'

5. Under 'Add Layer', click 'My Content' and select 'Living Atlas'

6. Under 'Living Atlas', search for map layers applying the data layer names from above. For each layer, once found, click 'Add to Map'. We'll arrange the layers next. There are an infinite number of ways to overlay map layers to allow you to visualize multiple factors simultaneously. Consider this exercise as one possible strategy.

7. Click on Save and name your map (example: Baseline Risk Map_Pb Exposure_Miami).

8. Open map in Map Viewer Classic and click on **ACS Housing Units by Year Built**; click on Perform Analysis > Analyze Patterns > Find Hot Spots. Within Hot Spots, identify the layer to be analyzed (in this case: ACS Housing Units by Year Built) and select Find Clusters of High and Low by [in this case: Housing Units Built 1939 or Earlier]. Provide a name for the new Results Layer you are creating and click 'Run Analysis'.

9. For presentation of this newly created Layer, I find it works well to highlight census tracts by outline. To highlight by outline, click on Change Style and click on the Counts and Amounts option (offered here as a default). Within Counts and Amounts you will see options for changing data classification (number of bins, how bin breaks are selected); symbol presentation and legend attributes (amongst other options). For this exercise, I have selected 4 bins and am highlighting only the highest range (1.5 – 3) and presenting the symbology by outline (red) with no color fill. Click SAVE/OK.

10. For the **Poverty Index**, I've chosen to present the data by relative (percent) frequency; using only 2 bins (0-40) and (>40 – 100) with the breakpoint defined by the US Census definition or categorization of *Concentrated Poverty*. The **poverty threshold** as defined by the US Census represents the federal government estimate of the point below which a household of a defined size has *pre-tax cash income insufficient to meet minimal food and other basic needs*.

11. Within the **Poverty Index** layer, click on Change Style and click on the Counts and Amounts option (offered here as a default). Within Counts and Amounts you will see options for changing data classification (number of bins, how bin breaks are selected); symbol presentation and legend attributes (amongst other options). For this exercise, I have selected 2 bins, defined the breakpoint between bins at the 40% breakpoint and am presenting the results in a light blue/gray. This presentation style allows clarity between categories, highlights a breakpoint with broader demographic significance and presents the symbology in a way that allows combining with other data categories. You may find that for the city you're looking at, you want additional disaggregation of the data for spatial analysis; you can adjust the number of bins (click Change Style > Style Option > Classify Data to access the bin breaks) as needed to help you think usefully

about spatial differentiation with respect to the question you're interested in understanding. Remember to click SAVE/OK.

12. For the **Prevalence of Non-Native English Speakers**, I've chosen to present the data by a sliding color scale with richest color intensity corresponding to highest prevalence of non-native English speakers).

13. Within the **Prevalence of Non-English Speakers** layer, click on Change Style and click on the Counts and Amounts option (offered here as a default). Within Counts and Amounts you will see options for changing data classification (number of bins, how bin breaks are selected); symbol presentation and legend attributes (amongst other options). For this exercise, I've selected a color ramp in the blue-green color range, adjusted breakpoints to create a clear distinction of significantly low English speaking neighborhood and have selected a color ramp that allows this layer to be visible behind the **Poverty Index** layer. Click SAVE/OK.

14. Using the three dots to the left of the layer name, drag/re-arrange the three layers if necessary to confirm that all three factors are visible: the red outline (high census tract density of housing stock built pre-1940); the blue dots (relative poverty rate within census tract); and the sliding color scale (indicating relative percent frequency of non-English speakers within census tract). SAVE your map.

15. Print your map.

The results are as presented in the attached for Miami, FL. The census tract or neighborhood area that is highlighted in this exercise for Miami, FL is located west of downtown and south of the Miami River. Researching a bit about Miami, I find that this area in Miami is known as Little Havana, and as the name suggests, is a significantly Spanish-speaking neighborhood. The intersection of linguistic roots × high poverty × significantly older housing stock suggests that if you were organizing a public health campaign to focus on prevention of childhood Pb exposure, this is a neighborhood in which you'd want to be aware that standard public health campaigns may not be reaching potentially impacted families. Identifying community organizations working within Little Havana would therefore be an essential first step for determining how best to create a helpful prevention program.

In addition, with the neighborhood's adjacency to the Miami River, Little Havana also represents a neighborhood in which increasing storm frequency and rising sea levels will result in increasing frequency and severity of flooding. Knowing that this neighborhood has older housing (and, likely, older infrastructure, overall) and a population without significant economic resources, this is also a neighborhood in which climate change resilience planning should absolutely be focused.