Spatial Variation in Air Quality and Asthma in Utah County

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Introduction

Throughout the world water is the main geomorphic agent shaping the earth's surface. However, in arid and semi-arid lands which cover 25-30 % of earth's land surface wind becomes a major geomorphic agent shaping the earth's surface as soil and sediments are only held together by sparse vegetation and are easily picked up by the wind. Dust storms and generally increased levels of particulate matter pollution in the air are associated with arid and semi-arid regions. The focus of this work is on some potential human health impacts of enhanced levels of particulate matter pollution in the heavily populated semi-arid urban areas of Utah County, Utah. We summarize the spatial patterns in PM2.5 and PM10 pollution from the Purple Air Network for a seven year period. We also investigate spatial patterns in particulate matter pollution through AOD data from Sentinel 2 imagery and from particulate matter collected from wet and dry atmospheric deposition by marble traps dispersed throughout the urban area. We investigate statistical links between these spatial patterns as well as socio-economic factors and the patterns of asthma adult prevalence, ER visits and hospitalizations for Utah county in 2016.

Methods

Asthma Data: 2016 health data on Adult Asthma Prevalence (AAP), Asthma ER visits (AER) and Asthma Hospitalization (AHOS) rates (Fig. 1), the Health Improvement Index (HII, social determinants of health), Median Household Income (MHHI) and rates of Obesity and Smoking for Utah Small Areas (n=99) were extracted from https://ibis.health.utah.gov/ibisph-view/. These data were disaggregated by Area to Point (AtoP) Kriging to a 250 m grid.

Purple Air Data: Daily minimum, mean, median and maximum PM2.5 and PM10 levels were extracted from all outdoor Purple Air Network stations within Utah for a 7 year period (2015-2022). The data for all stations each day were converted to z-scores and the proportion of observations with z-scores >1 for each site was calculated and interpolated by Poisson kriging to a 250 m grid. These maps show the proportion of observations for each location that were in the highest 15% of PM2.5 and PM10 levels over the 7 year period. Indicators of whether daily WHO PM2.5 and PM10 thresholds (10 and 20 ppm, respectively) were exceeded were also calculated and the proportions of observations exceeding these thresholds for each location was interpolated by Poisson kriging to a 250 m grid (Fig.2). The data were then aggregated to Utah small areas (n=99)

Marble Trap Data: Students put 3 marble traps out each, in open areas close to where they lived. They left them there for three months. The purpose of these traps was to collect particulate matter that came from the atmosphere due to wet and dry deposition. After 3 months, dust collected on the marbles and in the trap was washed through filter paper and dried in an oven. The weight of particulate matter was then determined.

Figure 1. Picture of a student's marble trap

Results

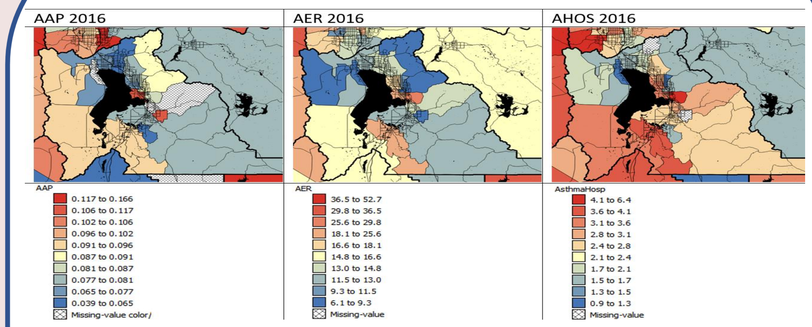


Figure 2. Maps showing (A) AAP, (B) AER and (C) AHOS rates in Utah County, 2016

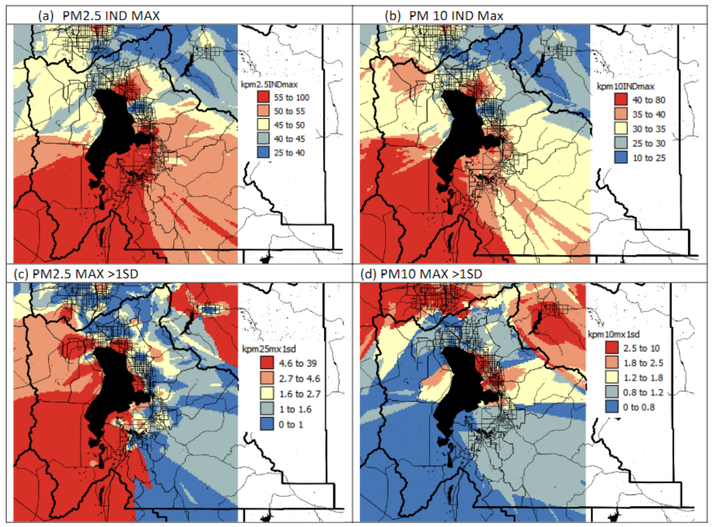
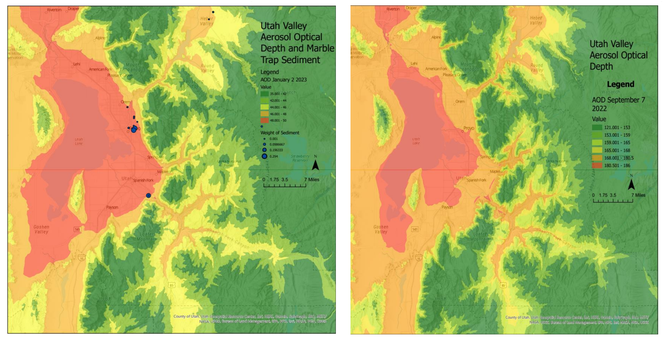


Figure 3. Maps of Particulate Matter Pollution Data for 2016-2022 in Utah County: a) Percentage of observations where MAX PM2.5 levels exceed WHO threshold (10 ppm), b) Percentage of observations where MAX PM10 levels exceed WHO threshold (20 ppm), c) Percentage of observations where MAX PM2.5 levels are greater than 1 SD above the mean (i.e. observations are in the top 15% of observations), d) Percentage of observations where MAX PM10 levels are greater than 1 SD above the mean (i.e. observations are in the top 15% of observations).



A B

Figure 4. Maps of AOD from one date in winter(A) and summer(B). Marble Trap Particular Matter weights are shown as dots on the Winter map

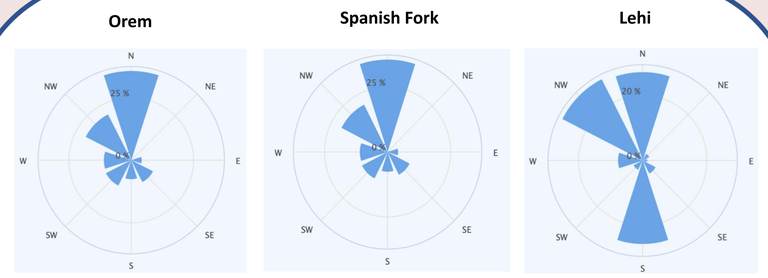


Figure 5. Wind roses for Orem, Spanish Fork, and Lehi, Utah County, 2022
Wind rose maps above show annual average wind direction for Utah County cities

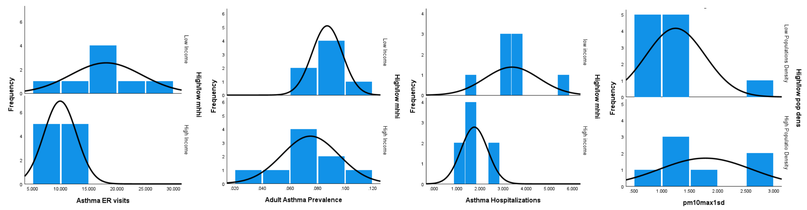


Figure 6. Split histograms showing the difference in Asthma ER Visits (AER), Adult Asthma Prevalence (AAP), and Asthma Hospitalization (AHOS) with Low and High Median Household Income (MHHI) and PM10 max 1SD between areas with Low and High MHHI.

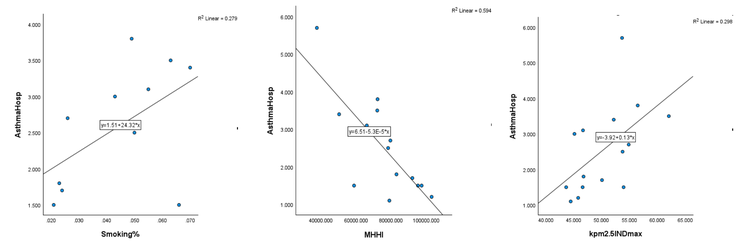


Figure 7. Scatter plots showing the relationship between Asthma Hospitalization (AHOS) and Smoking, Median Household Income (MHHI) and PM2.5Ind MAX.

Discussion and Conclusions

Asthma maps (Fig. 2) show that AAP hotspots are in Provo East Bay and Springville, whereas AER and AHOS are highest in central Provo and Spanish Fork. AHOS also shows high levels in the west of Utah county. Maps of PM2.5 and PM10 from Purple air data show the highest levels in South west Utah county apart from for PM10 max 1SD – the highest levels of PM10. The levels for this are highest in areas close to the north east shore of Utah Lake – the vineyard area where there has been a lot of Construction recently on old Geneva Steel land. The other PM measures also show high levels in this area. Fig. 8 shows a picture of piles of dirt in this area that could be a large source of PM10 pollution.

The AOD layer data (Fig. 4) show that in Winter and Summer lower elevation areas have higher particulate matter levels and that these areas are more widespread close to the lake in winter. The marble trap data (Dots in Figure 4) also show that the most particulate matter was found in lower elevation areas and around central Provo where the AHOS levels were also highest. Wind Roses (Fig. 5) show that in Orem and Spanish Fork, winds mainly come from the north, whereas in Lehi they come from North, Northwest and South. Fig. 6 shows significant differences in the AAP, AER and AHOS as well as PM2.5max between low and high income areas and high and low population density areas. Fig. 7 shows that there are significant relationships between AHOS and Smoking, MHHI and PM2.5max. Smoking and PM2.5 max are positive while MHHI is negative showing that lower income areas are more prone to AHOS.

Figure 8. A photo of the Geneva

Reference List available from First Author upon request