HUMAN CELLULAR RESPONSE TO TEMPERATURE INVERSIONS IDENTIFIED BY THE ATMOSPHERIC INFRARED SOUNDER (AIRS)

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1. INTRODUCTION

Temperature inversions result in the accumulation of air pollution, often to levels exceeding air quality criteria. Recent studies have shown that certain inflammatory cell types in the lungs respond to exposure to air pollution [1,2, 3]. The cellular response includes an increase in the number of cells to contain the inflammation. We investigate whether these inflammatory cells exhibit a response on inversion days, when the air pollution levels are enhanced. We focus on total cell counts (TCC) as well as percentage of two types of cells; neutrophils and macrophages, both of which respond to inflammation caused by particulate matter and other pollutants. The study area is the Hamilton Census Metropolitan Area, Ontario, Canada.

2. METHODS

Vertical temperature profiles from the Atmospheric Infrared Sounder (AIRS) were used to determine the occurrence of an inversion in the lower troposphere. These inversions tend to be regional in extent, and may persist over several days. Data for both AM and PM overpasses were retrieved using the GES-DISC Interactive Online Visualization ANd aNalysis Infrastructure (GIOVANNI), part of the NASA's Goddard Earth Sciences (GES) Data and Information Services Center (DISC). AIRS is one of six instruments on board the NASA Aqua satellite. The satellite has a sun synchronous orbit, covering the Earth twice daily with equatorial crossings at 1:30 am and 1:30 pm. An inversion was defined as a temperature increase from ground level to the 950 hPa pressure level. The average inversion temperature gradient between the two pressure levels was 2.8K for nocturnal inversions and 2.4K for daytime events.

Each 24-hr day was assigned dichotomous variables defining a normal or inversion night and a normal or inversion day. Subsequently, these variables were attached to the patient databases with a relational join. Criteria air pollutants carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter of aerodynamic diameter 2.5 um or less (PM2.5) and ozone (O_3) were selected for analysis. The hourly pollutant data were averaged over daytime hours (9:00 am to 7:00 pm) and night-time hours (8:00 pm to 8:00 am) for same day and previous night analyses.

The study included subjects who live in the study area and attended the Firestone Institute of Respiratory Heath, also located in Hamilton. Visits were made between January 2004 and December 2006. At each visit, sputum samples were collected and total and differential cell counts were determined using validated quantitative methods [4]. Patients were deemed stable or exacerbated based on physician's diagnosis and separate databases were developed with 485 stable and 189 exacerbated patients. The patient's age, smoking status and medication type and quantity were included.

3. RESULTS

During daytime inversions, CO, NO2 and PM2.5 increased by 24%, 10% and 7% respectively. O_3 actually decreased by 27%. During nighttime inversions, these pollutants increased by 30%, 53% and 27% respectively and O_3 decreased by 2%.

TCC in the stable group increased from 9.5 to 11.4 million cells on inversion days. Percentage of neutrophil increased from 60.3% on normal days to 71.6% on inversion days. Analysis of Variance (ANOVA) indicate that the increase in neutrophil percentage on inversion days was statistically significant ($p= 0.024$). Results for cells counts on previous nights revealed only small differences between normal and inversion scenarios. Further exploration of the data revealed that the increase in TCC on inversion days appeared to be driven by stable patients with Chronic Obstructive Pulmonary Disease (COPD). They exhibited a 46% increase in TCC. Neutrophil counts increased from 9.2 to 13.7 million in this group. In asthma patients, neutrophils counts also increased from 3.9 to 6.9 million cells, and neutrophil percentage of TCC increase from 51.5 to 75.3%.

Multivariate regression analysis with outcome of neutrophil percentage, controlling for age, smoking, medication, daytime surface temperature and humidity, indicate that an inversion on the day of the visit was associated with neutrophil increase of 15.2 percentage points, and was statistically significant ($p = 0.010$).

The TCC for the exacerbated group was significantly higher than that of the stable group, with an average of 19.25 millions cells compared to 10 million cells in the stable group. Percentage of macrophages increased significantly from 28 to 45% on inversion days. COPD subjects show a 27.6 percentage point increase in macrophages on inversion days. Previous night inversions were associated with significant increases in TCC in exacerbated patients. Multivariate regression analyses suggest that a same day inversion was statistically significant ($p=0.003$), resulting in a 4.7 percentage point increase in macrophages. Previous night inversions were not significant.

. 4. CONCLUSION

We have identified increases in inflammatory cells in the lungs associated with regional daytime temperature inversions over the Hamilton CMA. The results have demonstrated that atmospheric remote sensing can be used to directly assess health impacts of air pollution, during regional temperature inversion episodes. Perhaps the most intriguing result is that regional satellite data can be used to link microscopic cellular changes in humans to air pollution. We hope to continue research in this area to confirm and expand on these studies.

5. REFERENCES

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