Individual effects and interactions between ultrafine particles and extreme temperatures on hospital admissions of high burden diseases

Quan Qi[1], Najm Alsadat Madani[2], Yukang Xue[3], Randy T. Tangang[4], Fangqun Yu[5], Arshad Nair[5], Xiaobo Romeiko Xue[4], Gan Luo[5], Isa Brackett[6], Chris Thorncroft[5], Shao Lin[4,7,*]

[1] Department of Economics, University at Albany, State University of New York, Albany, NY 12222, USA
[2] Department of Environmental Health Sciences, University at Albany, State University of New York, Rensselaer, NY 12144, USA
[3] Atmospheric Sciences Research Center, University at Albany, State University of New York, Albany, NY 12203, USA

Background and Objective

Background:
Research on the health effects of ultrafine particles (UFPs) is limited, especially considering its individual and interaction with extreme temperatures.

Knowledge Gaps:
1) Lack of studies on the association between UFPs and specific health outcome such as ischemic heart disease, stroke, diabetes, kidney disease, and depression – Also, health disparities across different demographic and socioeconomic groups.

Objectives:
1) Examine the associations between high concentration of UFP or extreme heat and cold temperatures and hospital admissions for HBDs, respectively;
2) test the potential interaction effect between temperature and UFPs
on HBDs
(3) Investigate whether there are sociodemographic and seasonal disparities in the associations between UFPs/temperature and HBDs

Methodology

Study design:
Time-stratified case-crossover study by single lag days from 0 to 6.

Exposure data source and definition:
Daily exposure to UFPs, temperature, and criteria pollutants were obtained from a validated chemical transport model with size-resolved particle microphysics, 2013-2018. Interquartile range (IQR = 75% percentile – 25% percentile) is used as a major measurement for both temperature and UFPs We then defined high UFPs concentration as > 50th percentile and extreme heat as > 90th percentile and <10th for cold, in interaction analysis.

Outcome data source and definition:
Hospital admissions with a principal diagnosis matching one of the five high burden diseases were obtained from New York Discharge Data, 2013-2018. These five diseases include ischemic heart disease (ICD10: I20-I25), diabetes (ICD10: E08-E13), stroke (ICD10: I60-I67), kidney (ICD10: N00-N19), and depressive disorders (ICD10: F32-F33) due to their larger absolute increases in the number of disability-adjusted life-years between 1990 and 2019. Excess risk of each IQR increase (ER_{IQR}) was examined.

Statistical methods:
Conditional logistic regression was applied while controlling for NH_3, $PM_{2.5}$, SO_2, relative humidity, and time-varying variables in case-crossover study. We then evaluated the potential interaction between extreme heat and UFPs on high burden diseases at both the multiplicative and additive scales.

Results

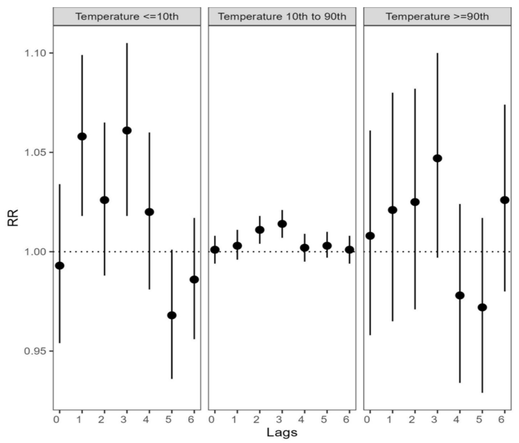

Figure 1: The association between ultrafine particles and hospital admission stratified by temperature (T<=10th percentile, 10th < T< 90th percentile and T >= 90th percentile) for all high burden diseases, 2013-2018, New York State

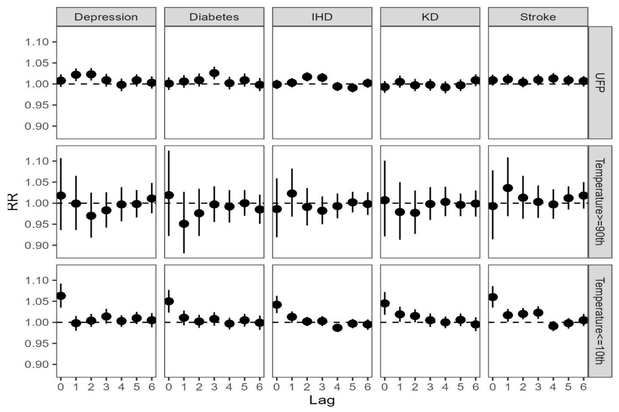

Figure 2: The association between ultrafine particles, extreme heat, extreme cold, and hospital admissions (risk ratio per interquartile range increase and 95% confidence interval) by specific high burden diseases, 2013-2018, New York State

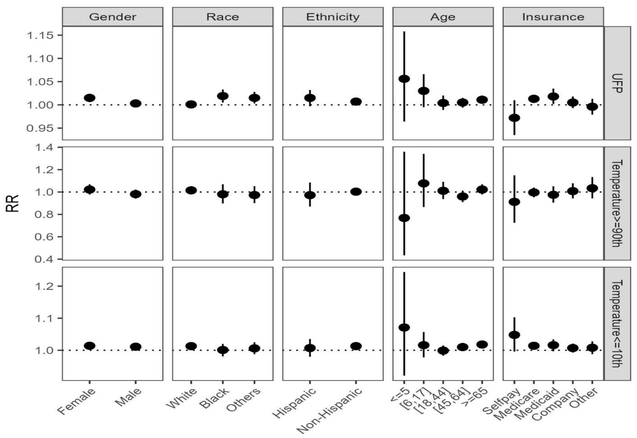

Figure 3: The association between UFPs, extreme heat, extreme cold, and hospital admissions (risk ratio per interquartile range increase and 95% confidence interval) at lag1 by sociodemographic, 2013-2018, New York State

Table 1: The associations between ultrafine particles, extreme heat, extreme cold, and hospital admissions for all high burden diseases [a], 2013-2018, New York State

Lag	Cases	Risk ratio
RR_{IQR} for UFP [b]		
0	1,308,518	1.002 (0.996, 1.008)
1	1,307,924	1.009 (1.003, 1.015)
2	1,307,344	1.011 (1.005, 1.017)
3	1,306,808	1.012 (1.006, 1.018)
4	1,306,163	1.000 (0.994, 1.005)
5	1,305,544	1.002 (0.996, 1.008)
6	1,304,950	1.003 (0.997, 1.009)
RR for T>=90th [c]		
0	37,369	1.005 (0.967, 1.044)
1	37,369	0.999 (0.969, 1.030)
2	37,369	0.986 (0.963, 1.009)
3	37,369	0.990 (0.973, 1.007)
4	37,369	0.995 (0.980, 1.011)
5	37,369	1.004 (0.991, 1.016)
6	37,369	1.004 (0.990, 1.018)
RR for T<=10th [d]		
0	30,478	1.053 (1.042, 1.064)
1	30,459	1.012 (1.005, 1.019)
2	30,403	1.009 (1.003, 1.015)
3	30,361	1.011 (1.005, 1.018)
4	30,319	0.994 (0.988, 1.000)
5	30,291	1.002 (0.997, 1.008)
6	30,280	0.999 (0.993, 1.006)

Conclusion

1) We observe short-term associations between exposure to elevated UFP concentrations or extreme cold and increase hospitalizations for HBDs.
2) These adverse effects vary across sociodemographic groups and seasons.
3) UFPs' adverse effects were stronger during winter and extreme cold periods.

Strengths & Limitations

Strengths:
1) Large sample size of 1,268,526 cases was included.
2) High resolution (0.25 degree x 0.3125 degree) nested domain simulation model was used to obtain air pollutants observations.
3) Health outcome for five high burden disease was examined.

Limitations:
1) The result can not be generalized to all cases due to only severest cases, those who are hospitalized, are considered.
2) Uncontrolled confounders exist in this paper such as air conditioner use and activity pattern which are not available.

Research Findings

1) Our results indicate the positive association between UFPs concentration and HBDs hospitalization with the increased risk ranges from 0.9% to 1.2% in NYS.
2) We found significantly increased risks (1% to 5%) of extreme cold for all HBD in low temperature (T<=10th), but no significant findings for extreme heat.
3) Our interactive effects of UFPs on HBDs were significantly increased at low temperature (T<=10th percentile) and moderate temperature range (i.e., 10th <T<90th percentile) not at high temperature
4) Our findings indicate that the effect of UFPs was stronger among young children and older adults, females, minority groups (Black individuals and Hispanics), and Medicaid recipients.

Acknowledgement: This work was supported by Grant #1R15ES02800001A1 from the National Institute of Environmental Health Sciences of United States and Grant #137487 from the NYS Energy Research and Development Authority.

Contact: Dr. Shao Lin (corresponding author): slin@albany.edu
Ms. Quan Qi: qqi2@albany.edu