THE COMPOUND RISK OF EXTREME HEAT AND COVID-19 IN NEW YORK CITY: DEVELOPING A HEAT EXPOSURE INDEX

Natasha Stamler[1, 2 *], Mary Hannah Smith[1], Sylvie Binder[2, 3], Janelle Knox-Hayes[1], Juan Camilo Osorio[1, 4], Cynthia Rosenzweig[2, 3]
[1] Massachusetts Institute of Technology, Cambridge, Massachusetts
[2] NASA Goddard Institute for Space Studies, New York, New York
[3] Center for Climate Systems Research, New York, New York
[4] Pratt Institute, Brooklyn, New York

1. INTRODUCTION

In early March 2020, the presence of the COVID-19 virus exponentially increased in New York City, with case rates rising to a peak of 6,800 cases per day on April 6th, 2020 (NYC Health 2020). Certain neighborhoods that are predominantly home to communities of color and lower-income households were most at risk for COVID-19, experiencing a disproportionate number of cases and deaths (Borjas 2020).

Extreme heat is also a major issue in New York City. In 2015, there were 18 extreme heat days when the temperature exceeded 90°F. The New York City Panel on Climate Change (NPCC3) reports that the dangers of extreme heat will worsen with time, predicting 34 days per year above 90°F in the 2020s and 56 days per year above 90°F in the 2050s (90th Percentile) (González et al. 2019). Previous studies have shown that New York City heat-related mortality, like that related to COVID-19, disproportionately impacts neighborhoods that are predominantly low-income and communities of color (Madrigano et al. 2015; Klein Rosenthal et al. 2014).

Compound risk is when more than one risk occurs at the same time, possibly exacerbating each other (Davies et al. 2020). Our study first seeks to determine whether the neighborhoods most impacted by COVID-19 are also more exposed to the compound risk of high levels of environmental hazards, including extreme heat. Additionally, due to the challenge of social distancing and the lack of individual heat relief measures like air conditioning, these neighborhoods may need increased access to open and cool spaces to mitigate heat risks on hot days while decreasing the risk of COVID-19 transmission.

To reduce the impact of both extreme heat and COVID-19 on vulnerable communities, the government of New York City introduced and expanded heat risk reduction and social-distancing policies during the summer of 2020, including the street-level and outdoor programs "Open Streets" and "Cool Streets." Open Streets are streets closed from 8am-8pm to increase social distancing during the COVID-19 crisis (NYC Department of Transportation (DOT) 2020). They were initially placed near parks to combat overcrowding. Currently, Open Streets are mostly concentrated in Manhattan and Queens. Cool Streets expand cooling on existing Open Streets by installing fire hydrant spray caps in tree-shaded areas (NYC Parks 2020). Simultaneously, the city government curbed traditional community cooling strategies, such as cooling centers and public pools, to mitigate the spread of COVID-19.

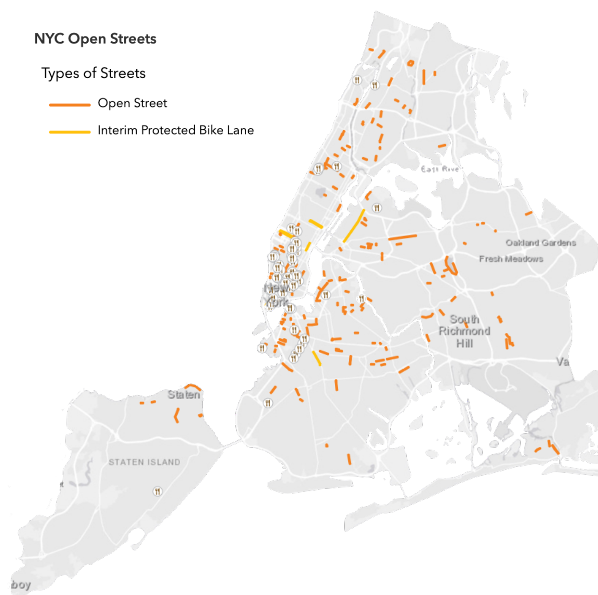


Figure 1. Map of Open Streets and interim protected bike lanes in New York City, as of December 24, 2020 (NYC DOT 2020).

Currently, the City estimates neighborhood heat vulnerability based on a study by Madrigano et al. (2015), from which it developed a heat vulnerability index (HVI), as shown in Figure 2. The goal of this study is to evaluate the compound risks to communities subject to high relative exposures to heat and COVID-19. The eventual outcome of this research will be the development of a Combined Heat and COVID-19 Compound Risk Index at the neighborhood level, similar to the existing HVI, which is at the sparser community district level. This index can then be used to evaluate current and future interventions to the combined challenges of COVID-19 and extreme heat.

* *Corresponding author address:* Natasha Stamler, Massachusetts Institute of Technology, Depts. of Mechanical Engineering and Urban Studies & Planning, Cambridge, MA 02138; e-mail: stamlern@mit.edu.

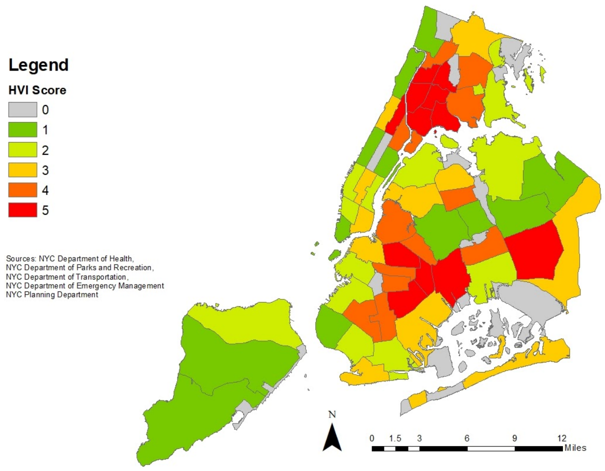


Figure 2. New York City Heat Vulnerability Index (HVI) (NYC Health).

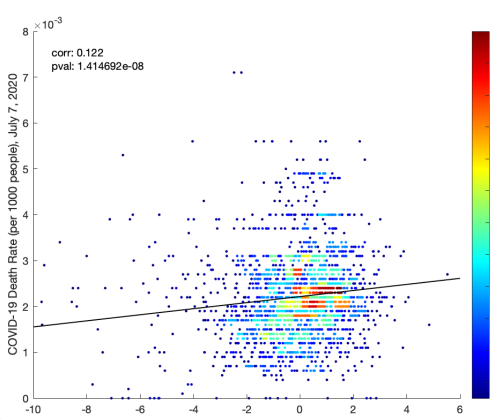
2. METHODS

This study was composed of three main parts. First, literature review and discussions with New York City government officials were used to select exposure factors related to heat and COVID-19 to evaluate as candidates for the index. Second, GIS mapping was performed to determine where exposure features are concentrated. Finally, Principal Component Factor Analysis (PCA), was used to determine how factors correlate.

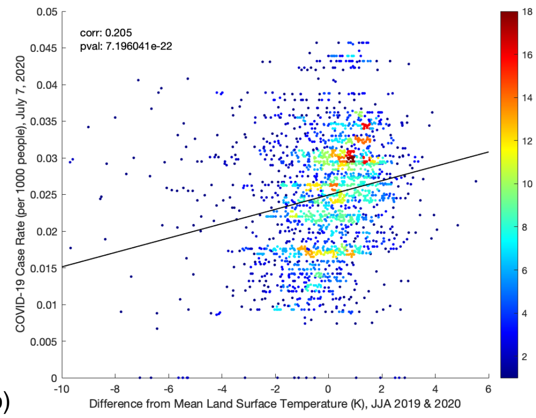
Landsat 8 land surface temperature (LST) from the summers (June, July, and August) of 2019 and 2020 was used as a proxy for heat and the COVID-19 case rate for summer 2020 was used as a proxy for COVID-19 exposure. Dozens of variables were considered related to the built environment, socioeconomic conditions, and mitigation efforts addressing heat and COVID-19. The factors that significantly correlated with LST and the COVID-19 case rate were deemed important for the index and relevant for policymaking.

3. RESULTS

LST positively correlated with both COVID-19 case and death rates, indicating a compound risk, as shown in Figure 3.



(a)



(b)

Figure 3. Density scatterplot of (a) COVID-19 death rate and (b) case rate vs. LST.

Similarly, LST and COVID-19 case rates were concentrated in similar neighborhoods. As shown in Figure 4, the LST hotspot neighborhoods – the South Bronx; Jamaica, Queens; Elmhurst, Queens; Maspeth and Sunnyside, Queens; Greenpoint and Williamsburg, Brooklyn – tended to also have high COVID-19 case rates.

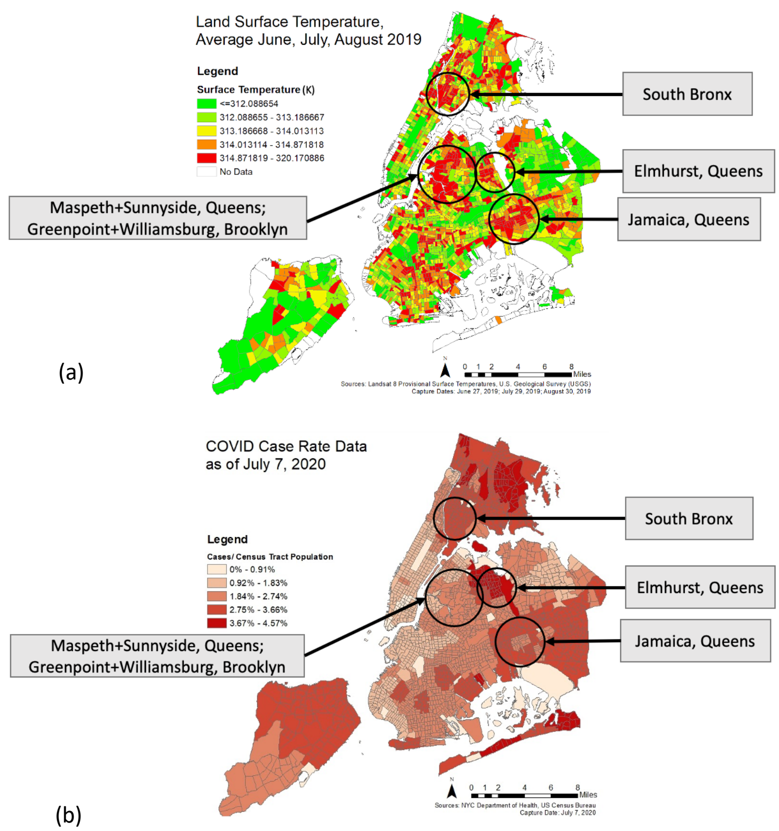


Figure 4. (a) LST hotspots tended to have (b) high COVID-19 case rates.

The PCA yielded 5 significant factor groups for this compound risk: Ground Cover: permeable (grass, trees, normalized difference vegetation index (NDVI)>0.5) and impervious surfaces (buildings, sidewalk); Distance to Open Space: distance to parks with tree canopy, grass/shrubs, and/or water features; Overcrowding (Rental): total and rental overcrowding; Mixed Density: single family units, population density, multi-family units (with elevator), mixed commercial-residential, and overcrowding (owner); and Public Cooling: open public pools, all pools, percent lacking A/C, Open and Cool Streets, cooling centers. These factor groups and their correlations with LST and COVID-19 case rate are shown in Table 1.

Table 1. Factor groups and their correlation with LST and COVID-19 case rate.

Factor Group	LST	COVID-19 Case Rate
Ground Cover	Slight -	Strong +
Distance to Open Space	Slight +	Slight +
Overcrowding (Rental)	Slight +	Strong +
Mixed Density	Slight -	Slight -
Public Cooling	Slight +	Strong +

All factor groups correlated significantly at the 99th confidence interval. Public Cooling and Overcrowding (Rental) correlated strongest with COVID-19. This indicates that neighborhoods with higher COVID-19 case rates depend on City-run public cooling resources. Additionally, it shows that denser areas tend to have higher incidences of COVID-19, supporting findings from previous studies (Brown et al. 2020; Carozzi et al. 2020; Robertson 2020; Hamidi et al. 2020). This study is the first to correlate the incidence of COVID-19 with density at the neighborhood level. The negative correlation with mixed density shows that it is not just urban density that is associated with higher COVID-19 rates, but the *kind* of density.

Public Cooling and Ground Cover correlated strongest with surface temperature. This indicates that the City is properly targeting heat-prone areas with public cooling measures. Additionally, it confirms the importance of green space in reducing urban heat (Price et al. 2015; Chun and Guldmann 2018).

While the City is generally targeting vulnerable areas with its mitigation programs, the coverage of these neighborhoods by mitigation measures is uneven. Figure 5 demonstrates the uneven mitigation measures to address the compound risk of heat, COVID-19, and overcrowding. Of the hotspot neighborhoods vulnerable to the compound risk of heat and COVID-19, Jamaica and Elmhurst, Queens could benefit from further interventions due to their lack of existing measures.

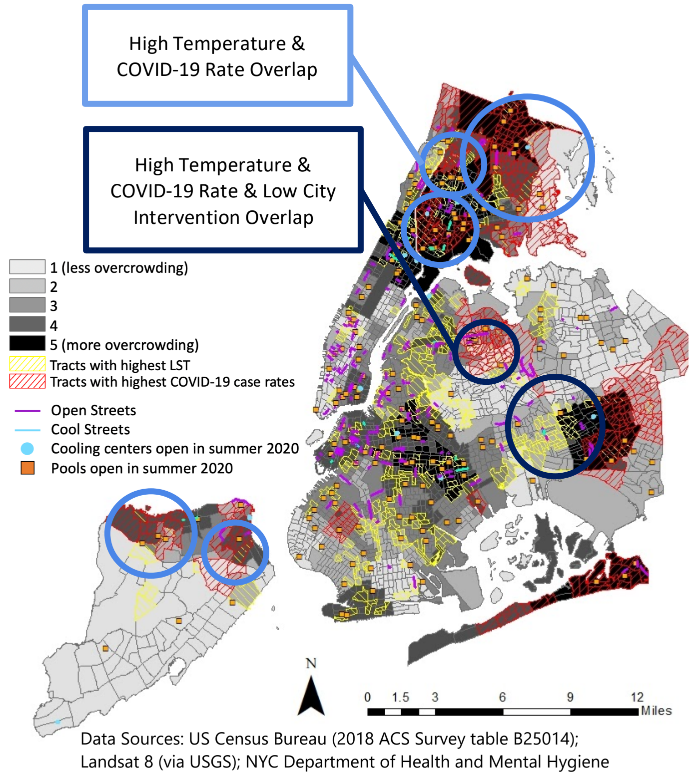


Figure 5. An example compound risk map showing the overlap of high temperature, COVID-19 case rates, and overcrowding. Only some of these neighborhoods have City mitigation measures.

4. CONCLUSIONS AND FUTURE WORK

Our findings demonstrate that the compounding risks of COVID-19 and heat stress are both public health and equity challenges. Several neighborhoods were identified as vulnerable to the compound risk of extreme heat and COVID-19. Future work will develop a Combined Heat and COVID-19 Compound Risk Index similar to that used by Madrigano et al. (2015) using the significant factor groups. This index will serve as a valuable tool for policymakers seeking to mitigate the dangers of both extreme heat and COVID-19.

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