Measuring Social Impacts of Energy Performance

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***Abstract*—Using data from New York City's Local Law 84 energy disclosure requirements, this paper seeks to investigate the social impacts of energy use and efficiency through asthma rates and neighborhood level income. Using an ordinary least squares regression, energy consumption is measured as a predictor of hospital discharge rates of asthma, while median household income is measured as a predictor of the energy efficiency of a building. Little correlation is found between asthma and energy use, but energy efficiency is shown to decrease as median income increases. Implications of this relationship are discussed, along with suggestions for further study into factors behind the affordability of energy efficiency.**

Keywords—energy, income, asthma, New York City

I. Introduction

In 2009, Local Law 84 required buildings with floor areas of over 50,000 square feet to report their energy use in an effort to better measure, benchmark, and ultimately reduce energy use and carbon emissions in New York City [1]. The benefits of this newly available data lie not only in efforts to lower the environmental impact of New York City, but also in examining the social impact of building energy and emissions. By comparing energy data to metrics related to public health and the socio-economics of those who live in the city, there is potential to better understand how energy use can disproportionately impact those across the city financially and physiologically.

II. Literature Review

With New York City's goal of reducing its carbon emissions to 80% below 2005 levels by 2050, measuring and understanding New York City's building energy use and greenhouse gas emissions is a key first step to making subsequent emissions reductions [1]. New York City's buildings are the largest source of green house gas emissions, making up 42% of total emissions. These emissions are from fossil fuels being burned by buildings for heat and hot water, while several of the largest sources of energy include electricity, natural gas, fuel oil, and steam [1, 2]. Major benefits of achieving large reductions in carbon emissions include improved air quality, which has the potential to lead to the avoidance of 40 premature deaths per year, energy savings of up to $300 million per year, and the creation of 17,000 green jobs [2].

To equitably realize these benefits, energy policy must not only be informed by energy benchmarking and technology based methods, but also by public health impacts of building energy use and emissions. One of the main pollutants associated with fossil fuel combustion are fine particulates (PM 2.5), which when breathed in can damage a person's respiratory and cardiovascular systems over time. One study in particular found that with every PM 2.5 increase of 10 $\mu g/m^3$, on average a population's life expectancy would decrease by over half of a year [3]. It is difficult to associate illnesses like asthma attacks, strokes, and heart attacks with one cause, but studies have shown that such events occur more frequently on days with higher air pollution concentrations [3].

Further, another important component of understanding energy policy and air pollution is in the context of equity and social impact. In New York City, 1990 hospital admission rates for asthma were found to be clustered both spatially and by race. It was found that per 100,000 people, the city experienced an average hospital admission rate of 681 people, while this number grows to 1,003 and 810 for Hispanic and black populations respectively, while having a rate of 242 for whites. The zip codes within Bronx and Manhattan were also have found to have experienced the highest asthma rates [4]. Prior studies have shown that high income neighborhoods in Manhattan have greater concentrations of PM 2.5 because of increased building density and traffic [5]. The high asthma rates experienced in Bronx and Manhattan may then not just be due to PM 2.5, but other pollutants like oxides of nitrogen (NO_X) [5], and other factors like noxious land use or poor housing conditions [6].

III. Data and Methods

To measure energy use, Local Law 84's 2014 Energy and Water Data Disclosure was utilized, as it describes each building over 50,000 square feet in terms of a building's energy use intensity ($kBtu/ft^2$) [7]. The energy use intensity data was cleaned by dropping all zero and non-existent values, while outliers were removed by taking only values within plus or minus two standard deviations of the mean of the log energy use intensity, assuming these outliers are incorrectly reported values. Next, the building's energy use was calculated by multiplying the energy use intensity by the reported property floor area, measured in square feet. The energy use was then aggregated to the zip code level which was provided in the Local Law 84 dataset, finding the median of energy use for each zip code.

The energy use data was then joined by zip code to a dataset detailing hospital discharge rates (per 10,000 people) relating to asthma from 2012-2014, provided by the New York State Department of Health [8]. Several of the zip code's rates were not provided for confidentiality reasons as the rate was below 6, so these zip codes were excluded from the analysis. The energy use and asthma rates by zip code were then compared using an ordinary least squares regression to find any correlation between the two variables.

To examine neighborhood income and residential building energy use, the 2014 Local Law 84 data was again used, except only using rows with a primary property type of multifamily housing to isolate residential buildings. Because the energy data came in the form of individual building but the intended geographic output is by neighborhood, the energy data was joined to New York City PLUTO data by each building's Borough-Block-Lot code (BBL) [9]. The PLUTO data contains information about land use, and for the purpose of this analysis community districts, of which New York City has 59. The joined energy and PLUTO data was then aggregated by mean to the community district level to look at New York City neighborhoods. Joining the energy data with median household income data from the American Community Survey, which was also organized by community district, another ordinary least squares regression was performed to find the relationship between average energy use intensity and median income [10].

IV. Results

A. Asthma and Energy Use

The first ordinary least squares regression was run to determine if energy consumption, measured in kBtu's, is a predictor of hospital discharge rates related to asthma, measured per 10,000 people. The linear model yielded an extremely small negative correlation coefficient of -1.603e-07 with a p-value of 0.366, indicating that the relationship between the two variables is statistically insignificant. The R-squared value of 0.005 also showed that the model describes very little of the data.

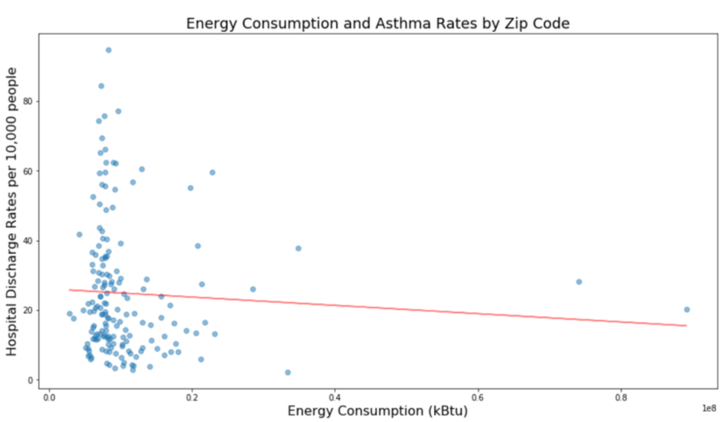

Fig. 1. The relationship between energy use and asthma rates. The correlation was found to be insignificant.

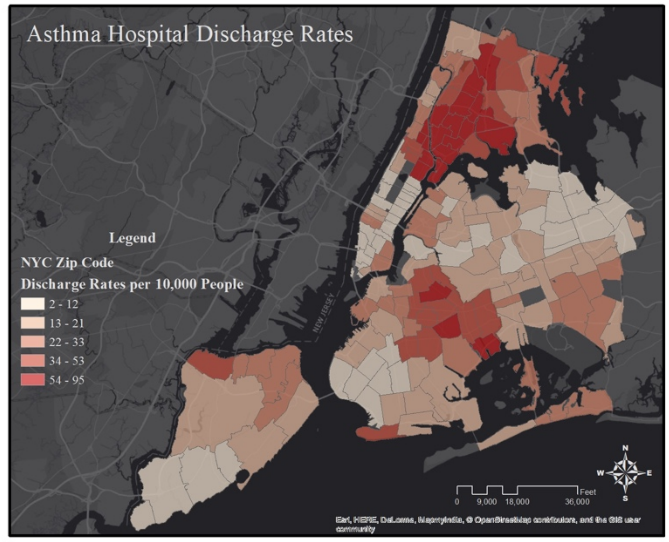

Fig. 2. Mapping asthma hospital discharge rates. Significant rates can be found in northern Manhattan, the Bronx, and Brooklyn.

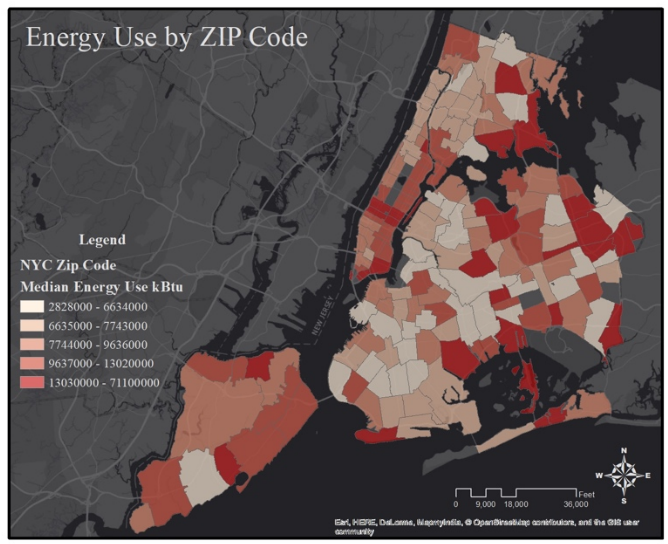

Fig. 3. Mapping median energy use throughout New York City.

B. Energy Efficiency and Median Household Income

The second ordinary least squares regression was run to determine if median household income, measured by community district, is a predictor a household's energy efficiency, measured in kBtu/ft^2. This linear model showed a negative relationship with a correlation coefficient of -778.5 and a p-value of 0.03, indicating the relationship is statistically significant. The R-squared value of 0.08 show that the model does not describe too much of the data, but the predictive capability of the model itself is notable.

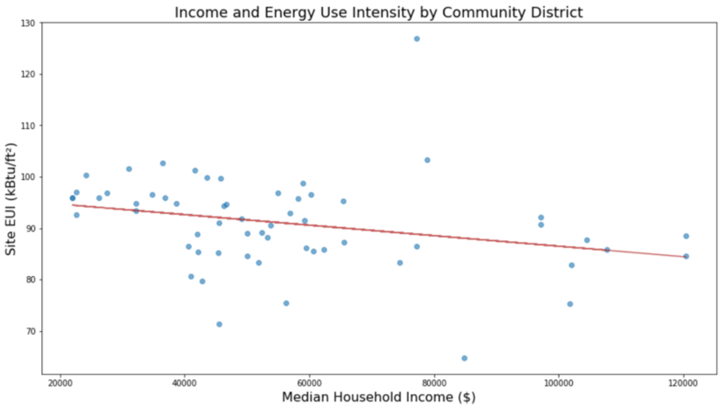

Fig. 4. The relationship between median household income and energy efficiency. The negative correlation was found to be statistically significant.

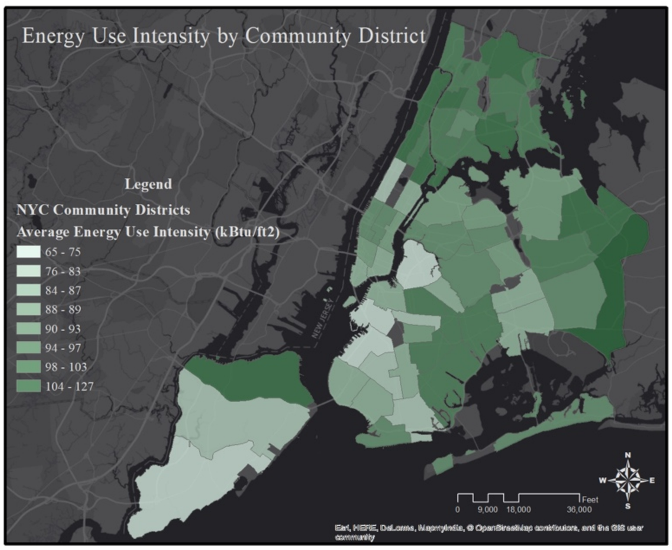

Fig. 5. Mapping Energy Use Intensity throughout New York City. Higher rates can be found in northern Staten Island, the Bronx, and eastern Brooklyn.

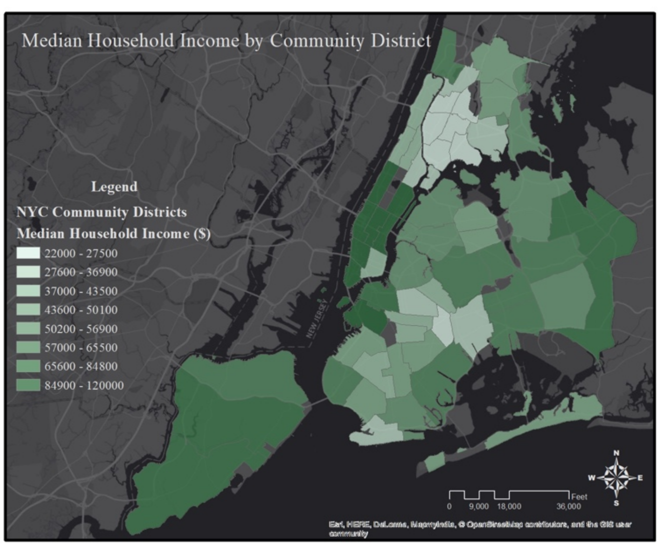

Fig. 6. Mapping household income throughout New York City. Higher median incomes can be found in Manhattan and Staten Island.

V. Discussion

In order to conduct this analysis, several assumptions had to be made when interpreting the data to approximate measures of real world occurrences. When aggregating to the zip code level, the building energy use was calculated to each zip code's median energy use, as many high values existed within the data that would throw off a central measure. This was not used for the energy use intensity for each community district however, as this data reflected a tendency to a more normal distribution, so instead was averaged. Energy use was chosen as the predictor to asthma rates because energy use was interpreted as the total impact on people which would potentially create more emissions. For the second model energy usage intensity was chosen, as this question had more to do with energy efficiency and potential cost saving for homes when compared to the income of its occupants.

There were several limitations of the study, one of which being the geographical measures. While the building energy data was precise to the spatial resolution of a building, the measures it could be compared to, income and asthma rates, were at less detailed levels of community districts and zip codes, which especially for the case of zip codes are arbitrary geographical measures to aggregate to. Such aggregations reduce the precision of the analysis and make relationships more difficult to ascertain.

Another limitation relevant to the asthma study is where people come into contact with pollution, as the comparison of energy use and asthma rates in the same neighborhood may not account for someone's daytime commute or workplace. The Local Law 84 dataset itself is not perfect, and includes missing or inaccurate information that can throw off the predictive models. Especially for boroughs outside Manhattan, the lack of data on buildings smaller than 50,000 feet mean a less robust representation for those who live in smaller buildings. Last, energy use when compared to asthma rates may not be the best metric for measuring a buildings impact on public health, as different forms of energy consumption generate different concentrations and types of air pollution that effect health in different ways.

VI. Conclusion

Based on the results of the analyses, there is no notable relationship between hospital asthma rates and energy consumption alone, as median energy consumption seemed particularly centered around 0.1 kBtu for a wide range of asthma rates. The analysis would benefit from further study into understanding other causes and correlations of factors that have been shown to contribute to asthma rates.

The relationship between energy use intensity and median household income however shows a clearer negative trend, with higher income houses tending to have fewer kBtu's per square feet. This relationship could be explained by a difficulty for those with lower income to afford to implement energy efficient solutions and products around the home, or the building itself being of substandard energy efficiency quality. To look into this issue further, understanding behavior and knowledge of energy efficient solutions could be compared both by income and against how different priced units can have differing energy efficient rates. Such a study would have potential to uncover disproportionate costs on different income levels within New York City, along with its implications on sustainability.

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