Urban Science Intensive – Spring 2016

A Seasonal Flu Social Vulnerability Index for NYC

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INTRODUCTION

Seasonal influenza (flu) is one of the most common disease outbreaks in New York City (NYC)[1]. Each year approximately 2,000 residents perish from flu and pneumonia, which can develop as a flu complication[2]. For 2014, this was more than homicides (328)[3] and HIV/AIDS related deaths (1,473)[4] combined. Nationally, the Centers for Disease Control (CDC) estimates that 5-20% of people contract seasonal flu annually, this is upwards of as many as 1.7 million NYC residents. There are 209 different types of human influenza A virus and the number is constantly increasing[5]. The flu virus has the ability to evolve with humans has made it difficult to develop a permanent solution to influenza.

In addition, the density, complex infrastructure, and international stature of the city increase the risk of spreading illness. Because of this, prevention measures such as educational outreach and vaccines are of utmost importance. Given that any agency needs to optimize their budgets, a targeted prevention outreach strategy would be helpful in decreasing the number of seasonal flu deaths. To assist in that effort this project creates a NYC Seasonal Flu Social Vulnerability Index (Flu SVI), using demographic and social variables to identify areas where the flu is likely to affect large portions of the population.

BACKGROUND

[1] https://www1.nyc.gov/html/doh/downloads/pdf/ip/ip-death-all-rank.pdf
[2] http://www.nyc.gov/html/doh/flu/html/public/general.shtml
[3] http://www.nyc.gov/html/doh/downloads/pdf/dires/2014-hiv-surveillance-annual-report.pdf
[4] http://www.nytimes.com/2015/01/01/nyregion/new-york-city-murders-fall-but-the-police-arent-celebrating.html?_r=0
[5] http://www.fludb.org/brc/home.spg?decorator=influenza

Currently efforts to track and quantify flu cases occur on the federal, state, and local levels. Nationally, CDC track viral strains, pediatric mortality rates, influenza-associated hospitalizations, and other statistics on the flu. The New York State Department of Health tracks similar statistics and produces a weekly report on the county level. At the city level, the Department of Health and Mental Hygiene (DOHMH) monitors emergency department (ED) discharges to track trends over time.

While the seasonal flu outbreaks are tracked, there is no evidence of planning for their occurrence. There is, however, planning efforts for the pandemic (global epidemic) flu as it is estimated that it could have a fatality rate up to 40,000 residents in a single wave (or cycle)[6]. Both the CDC and DOHMH have developed ways to measure risk.

In 2011, the CDC published *A Social Vulnerability Index for Disaster Management* [7](Index), which uses 15 census variables, put into four categories:

- Socioeconomic status,
- Household composition and disability,
- Minority status and language, and
- Housing and transportation,

to better assist disaster management planning. The Index was a shift from traditional disaster management planning, which tended to focus on infrastructure only, and it incorporated social factors such as mobility and primary language. Every census tract in the United States with a non-zero population (65,081) was given an index number based on the percentile rank of the individual and grouped variables.

[6]http://www1.nyc.gov/assets/em/downloads/pdf/hazard_mitigation/nycs_risk_landscape_chapter_4.9_pandemic_flu.pdf

[7] http://gis.cdc.gov/grasp/svi/A%20Social%20Vulnerability%20Index%20for%20Disaster%20Management.pdf

The DOHMH released *Vulnerable Populations: A Function-Based Vulnerability Measure for the New York City Region*[8] in 2013 which took into account individual level data to create a score for each American Community Survey (ACS) Public Use Micro data Sample (PUMS), a demographic designation that has individual level data while still providing confidentiality. While both models are significant undertakings, the focus is on collecting information after people are diagnosed or on large-scale, global (pandemic) outbreaks.

With respect to outreach, the DOHMH offers information about flu vaccination locations and preventative measures for schools and employers on their website[9]. There is no evidence to suggest a more proactive outreach approach. Efforts have also been made to require mandatory flu shots for children to varying effectiveness. As such, flu vaccinations remain a voluntary activity.

This project borrows and builds upon both models, most specifically using census tract level data and percentile ranks like the CDC Index, to create the NYC Seasonal Flu Social Vulnerability Index (Flu SVI). The Flu SVI differs from previous models because it takes into account NYC specific variables like the high percentage of residents that commute to work via public transportation and high residential density.

DATA

The majority of variables used in the Flu SVI were collected from the 2010-2014 5 year estimates American Community Survey (ACS) and Longitudinal Employment-Household

[8] http://www1.nyc.gov/assets/doh/downloads/pdf/em/regional_hazards_vulnerability_measures.pdf
[9] http://www1.nyc.gov/site/doh/health/health-topics/flu-seasonal-brochures-and-posters.page

Dynamics Origin-Destination Employment Statistics (LODES). Variables used for each census tract are:

Variable Name	**Explanation**	**Normalization Variable**	**Source**
Vulnerable Age	Percentage of resident aged below 18 and above 65	Total Population	ACS 2010-2014
Insurance coverage	Percentage of resident without health insurance	Total Population	ACS 2010-2014
Population Density	Number of resident per square mile	-	ACS 2010-2014
Commute	Percentage of resident to work using public transportation (MTA & Taxi, resident only)	Total Population	ACS 2010-2014
Poverty Rate	Percentage of resident earning less than $19,999 (as approximation of official NYC poverty rate of $20,160 for three-person household)	Household	ACS 2010-2014
Household Income	Median household income	Household	ACS 2010-2014
Employment Density	Total jobs	Area	LODES Workplace Area Characteristic

Table 1

Once the variables were normalized by normalization variable as mentioned in table 1, they were each given a percentile rank. Percentile ranking allows for even distribution among the census tracts. It can, however, overestimate skewed distributions.

Census tract level cartographic boundary shapefiles for spatial analysis and visualization are obtained from the United States Census Bureau.

METHODOLOGY

In total, there are 2,064 census tracts in NYC. Census tracts with non-zero populations were removed from the index because they are largely parks and cemeteries and do not have population or employment density (or statistically significant values) available.

For each variable in the data, a percentile ranking was generated on a scale of 0 and 100. The index is then constructed by summing across the variables using the formula:

$$\text{Vulnerability Index} = \sum_{i=1}^{N}(V1 + V2 + \cdots + Vj)$$

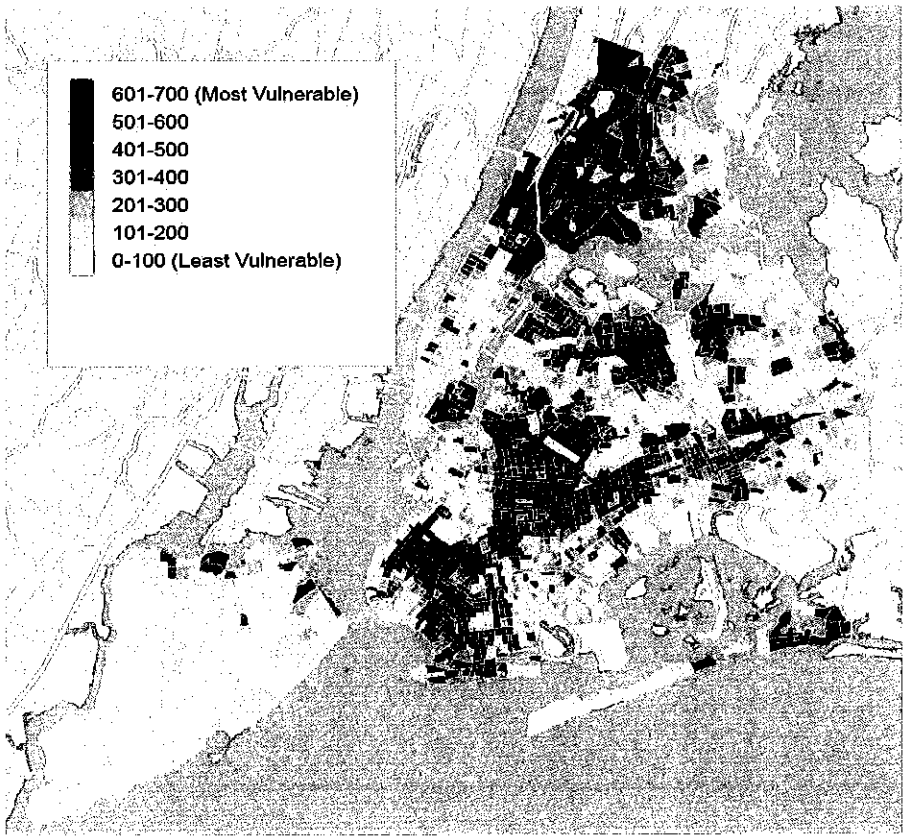
In addition to that, two "flag" variables were created with a value of 1 if each of the individual percentile rank exceeded either the 90^{th} (PCT_90) or the 75^{th} percentile (PCT_75). Both the index and flags were mapped into their corresponding census tract in the boundary map and then plotted.

RESULTS

VULNERABILITY INDEX

Figure 1 illustrates the spatial distribution of census tract SVI values, with a progression from beige to red, indicating the severity. A breakdown of each borough described in Table 2. The area with darker red color indicates high SVI value, which is mostly distributed in Bronx, Queens, and Brooklyn. Bronx is especially highly vulnerable with more than 67% of its

population living in census tracts with SVI 400 and above, implying an average of 60th percentile in every category.



How closely does this map match income distribution? This is the question you should consider proactively addressing!

Figure 1

SVI score range	Bronx	Brooklyn	Manhattan	Queens	Staten Island
0-100		0.22%	0.38%	0.46%	5.46%
101-200	6.62%	4.00%	5.39%	10.60%	58.01%
201-300	8.58%	19.53%	39.34%	23.38%	22.19%
301-400	16.69%	22.61%	19.81%	35.03%	10.95%
401-500	18.50%	37.43%	18.59%	20.64%	3.02%
501-600	44.18%	15.91%	16.49%	9.88%	0.37%
601-700	5.42%	0.30%			

— great table

Table 2

FLAG MAP

While the Flu SVI map provides a general overview of social vulnerability across the city, the "flag" map is used to pinpoint, which census tracts have an individual percentile rank scoring above a certain value. The assignment of the flag value for both 75th and 90th percentile threshold is illustrated in Figure 2 with the number of census tracts by flag value by borough is described in Table 3.

say more about this - how would you interpret these flags?

Figure 2

Borough	Bronx		Brooklyn		Manhattan		Queens		Staten Island	
Flags	75	90	75	90	75	90	75	90	75	90
0	172	67	510	221	104	40	451	278	98	66
1	81	77	116	207	61	32	43	82	9	34
2	51	61	82	150	90	130	119	175	1	6
3	25	46	14	78	11	34	10	53	-	2
4	6	50	3	51	3	15	2	34	-	-
5	2	24	-	18	-	18	-	3	-	-
6	-	12	-		-	-	-	-	-	-

Table 3

The difference of threshold value choice will affect the extent of focus area. If used to determine census tract level outreach targeting, this will change the implementation scope and resource requirement.

CORRELATION TESTING

Producing a correlation matrix allowed for an investigation into the dependence between multiple variables at the same time. Values near 1 and -1 show variables that are highly correlated. Figure 3 shows the variables in the Flu SVI are mostly uncorrelated, with the exception of household size and employment density, which appear to have perfect correlation. Additional investigation would have to occur to determine why these variables appear so closely linked.

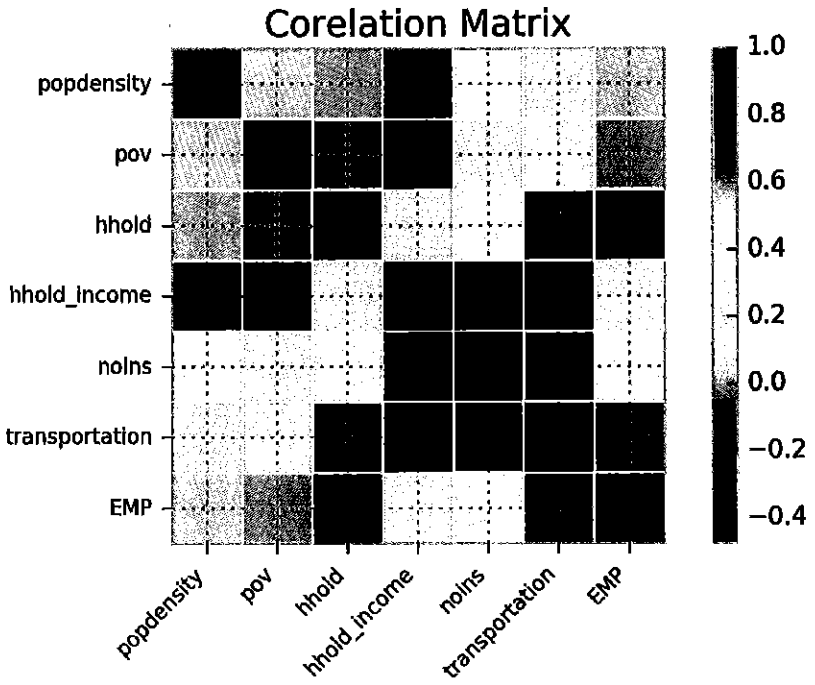


Figure 3: Correlation Matrix for all 7 Variables

SPATIAL AUTOCORRELATION

The percentile ranking use for the Flu SVI helps in detecting the outliers because it helps to gauge census tracts, which are at a greater risk. Obtaining additional information about the surrounding census tracts (the ones perceived as most vulnerable) will help in knowing if there is a match in attributes in the surrounding areas.

We have performed a spatial correlation using coefficient from Moran I (Moran 1950) and "queen" criterion of neighborhood which took census tracts sharing common boundary for correlation, resulting in closely placed census tracts with similar SVI will be grouped together and not the ones located beyond a specified distance. If a census tract stands out from the rest of its surrounding or a group of census tracts together are at a greater combined risk, helping to generalize better over a larger area the relative risk-prone areas when used in conjunction with index and flag map. The resulting boundaries can also be used to determine new boundaries for operationalization of the outreach, which may span multiple community district.

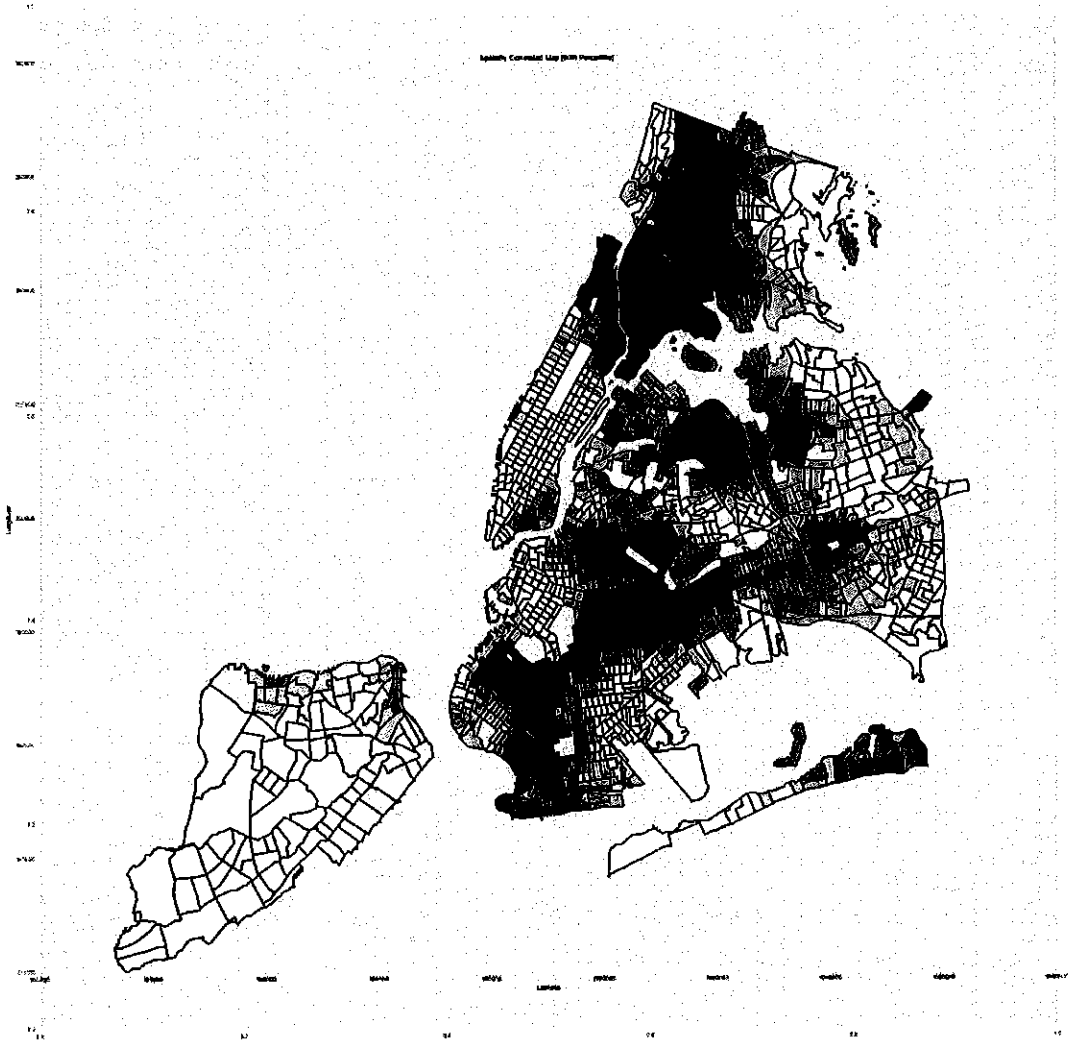


Figure 4: Spatially Correlated Map [Flu SVI]

ACCESS GAP

One of the main ways to prevent the spread of flu is through ensuring equal and easy access to vaccinations. NYC DOHMH maintains the location where flu shots can be purchased, which price range from $0 with insurance to $40 without. Lack of access to these facilities may exacerbate the vulnerability of residents in the given census tract. Under the assumption that distance is an additional variable that must be considered, the vaccination locations for NYC

were overlaid on the Flu SVI with a quarter-mile buffer (Figure 5) to illustrate the access gap. Using appropriation method based on percentage of area covered, the computed access gap for each borough is presented in Table 4.

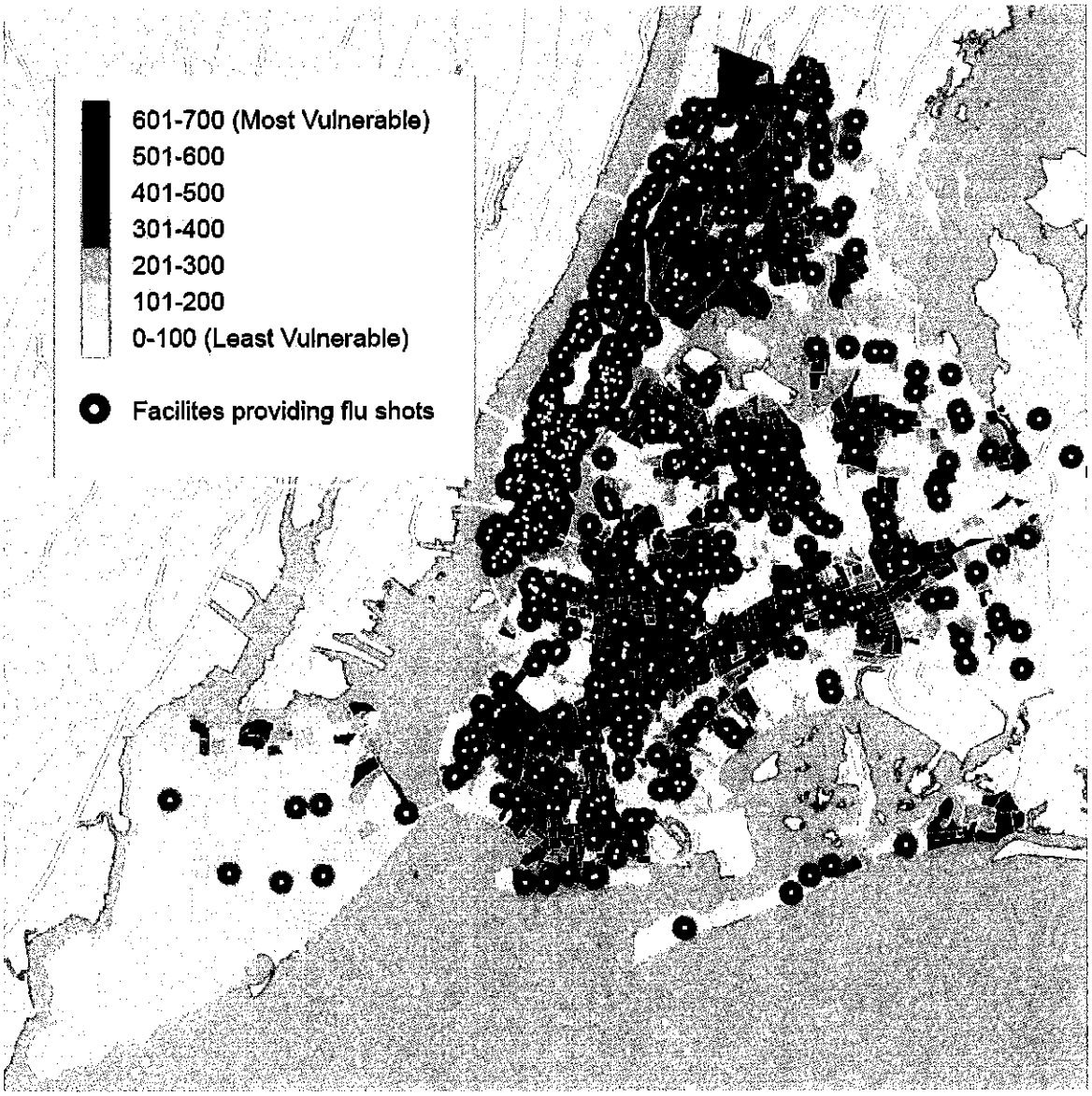


Figure 5: Access Gap Map

clearly shows gaps in access

Borough	Bronx	Brooklyn	Manhattan	Queens	Staten Island
Number of vulnerable-age resident with limited access to vaccination location	273,332 (53.94%)	518,916 (60.36%)	90,302 (21.68%)	478,792 (66.74%)	165,052 (98.16%)
Number of vulnerable-poor households with limited access to vaccination location	41,967 (50.87%)	69,333 (58.97%)	15,977 (23.38%)	44,132 (60.54%)	12,585 (98.37%

great

Table 4: Access Gap Table

CASE STUDY

There are many places in NYC, which need targeted attention, and, based on these maps, it would be easy to identify them. For example, area between Sunset Park and Borough Park in Brooklyn is highly vulnerable to flu (based on SVI index) as shown in Figure 6. This area does not have any location providing flu shots. Such areas could be considered when designing a flu outreach plan.

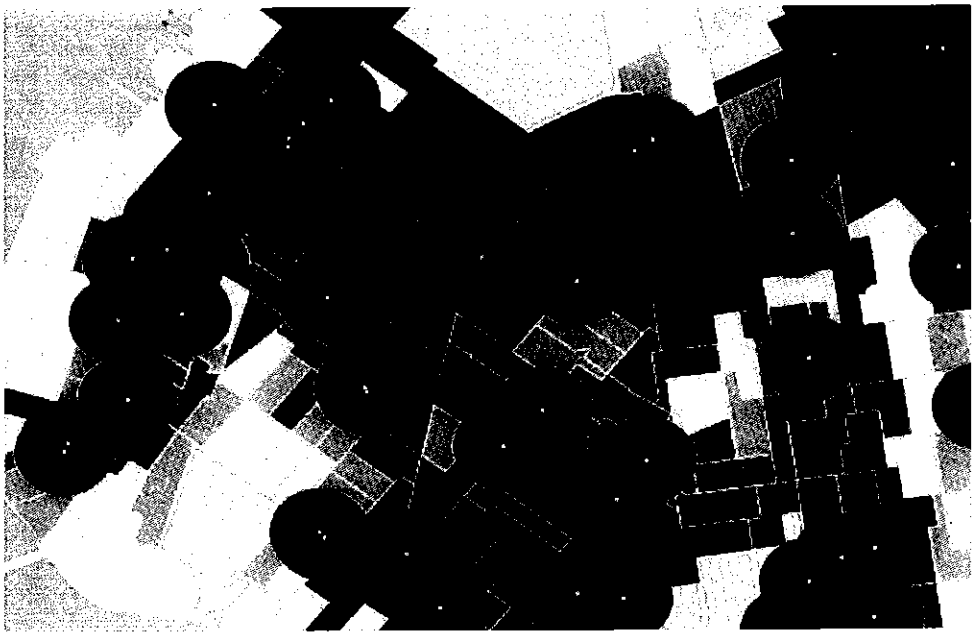


Figure 6: Case Study [Sunset Park]

LIMITATION

The main limitation of the Flu SVI is the inability to include illness and mortality rates due to the lack of publicly available sources providing data on the same level granularity. The use of census tract level of these data has been proposed to see the link between them and vulnerability-related characteristic of the area (Hadler, 2016[10]). Percentage of residents who are immunized against flu could also be considered as one of the index variable, but the CDC Behaviourial Risk Factor Surveillance System (BRFSS) survey is the only source of the large scale public data only statistically valid up to county (borough) level. Furthermore, prior research [11]indicated that other factors[12] such as preexistent beliefs on vaccination, racial discrimination,

[10] Hadler JL, Yousey-Hindes K, Pérez A, et al. Influenza-Related Hospitalizations and Poverty Levels — United States, 2010–2012. MMWR Morb Mortal Wkly Rep 2016;65place_Holder_For_Early_Release:101–105.

[11] K. Armstrong, "Barriers to influenza immunization in a low-income urban population," Am. J. Prev. Med., vol. 20, no. 1, pp. 21–25, Jan. 2001.

immigration status, and language barrier to outreach materials are contributing in vaccination rate of a community.

OUTREACH PLAN

Based upon the Flu SVI index and access gap information, targeted outreach should be conducted at various places in the city. Several specific locations that could benefit from the program includes Sunset Park, Brooklyn, Parkchester, Bronx, 108th street Roosevelt Avenue, Queens, Crown Heights, Brooklyn, Errington Place and Warren Street in Staten Island. These locations lie in high vulnerability areas as identified by 75th percentile map and lack accessibility to flu shot locations.

CONCLUSIONS

The Flu SVI, in its current form, highlights areas of high vulnerability for seasonal flu outbreaks. Next steps could include utilizing infection rates at a low level of granularity, such as census tract, to further refine outreach and healthcare needs. This SVI can also be used for other easily communicable airborne diseases. Outreach at a Community District level may be the best approach, as it will cover the census tracts of high vulnerability and their surrounding area.

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[12] J. Y. Chen, S. A. Fox, C. H. Cantrell, S. E. Stockdale, and M. Kagawa-Singer, "Health Disparities And Prevention: Racial/ethnic Barriers To Flu Vaccinations," J. Community Health, vol. 32, no. 1, pp. 5–20, Sep. 2006.

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Project and Report is very (very) good:

- Establish strong case for the importance of flu prevention. Demonstrates extensive background research and thoughtfulness on SVI and prior/current National and local efforts
- Overal structure clear with strong writing – some arguments are only partially developed or described (flags, forexample).
- Results are clearly communicated through maps and charts (consistently excellent), but the interpretation of many of them is lacking or shallow. Developing this aspect – the depth of the analysis – is important.
- The Access Gap is very important helps drive action and deployment of resources. In addition to identifying neighborhoods that need additional facilities/programs, what sort of information do you think the DOHMH would want to take action?