Project Deliverable 1

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1. Introduction

In Massachusetts, vaccine hesitancy emerges as a critical public health challenge, necessitating nuanced strategies. This multifaceted conundrum warrants an integrative approach that elucidates causative elements in hopes of sculpting potent interventions. Healthcare authorities in MA are concerned about vaccine uptake disparity among diverse demographic groups, especially the pediatric and geriatric cohorts.

Building upon the previous year's analysis that focused on age, race, and the impact of grassroots initiatives, we conduct an in-depth examination of a broader scope of variables including age, ethnicity, the Social Vulnerability Index (SVI), gender, economic status, employment, and population density. These factors are scrutinized to understand their correlation with vaccine hesitancy in MA, particularly in urban locales like Revere, Wellesley, and New Bedford. Our methods, encompassing census and health record data interpolation, regression, and hypothesis T-tests, aim to uncover patterns in vaccine perceptions across different demographics.

By uncovering the roots of vaccine reluctance, our overarching goal is to help foster a collaborative environment, uniting MA policymakers and community leaders to promote health inclusivity. We hope our efforts will provide actionable insights into various population strata, shaping practical policies to increase vaccine acceptance and thereby elevate the overall public health.

2. Data Collection

The MA COVID-19 Vaccination Data is collected and maintained by the MA Department of Public Health (MDPH). This dataset is crucial for understanding the progress of the COVID-19 vaccination campaign, identifying areas with lower vaccination rates, and planning public health interventions. The data encompasses detailed information regarding COVID-19 vaccination rates across different age groups, gender and race in various cities of MA, including Wellesley, Newton, Revere, Chelsea, and New Bedford. The dataset includes key metrics such as the number of people vaccinated in each age group, the total population of each age group, and the breakdown of those partially vaccinated, fully vaccinated, and boosted as well as gender and race. This comprehensive data collection enables the MDPH to monitor vaccination trends, assess community health needs, and guide policy decisions. We access this data through the MDPH's public health database API, which ensures timely and accurate information.

This dataset is instrumental in calculating SVI, such as identifying vulnerable populations based on age and vaccination status, and understanding the distribution of healthcare resources.

The US Census data is collected by the US Census Bureau and serves various purposes, including determining congressional representation, allocating federal funding, and understanding population trends.The US Census data covers a wide range of information, including race, ethnicity, population and housing statistics, redistricting data, and more. We use the US Census API to obtain the SVI (poverty level, education, unemployment, elderly population) as well as income and unemployment rate.

3. Preliminary analysis

We want to investigate the differences of vaccination rate among five cities: Chelsea, New Bedford, Newton, Revere, and Wellesley. We start with looking at the vaccination rates among five cities.

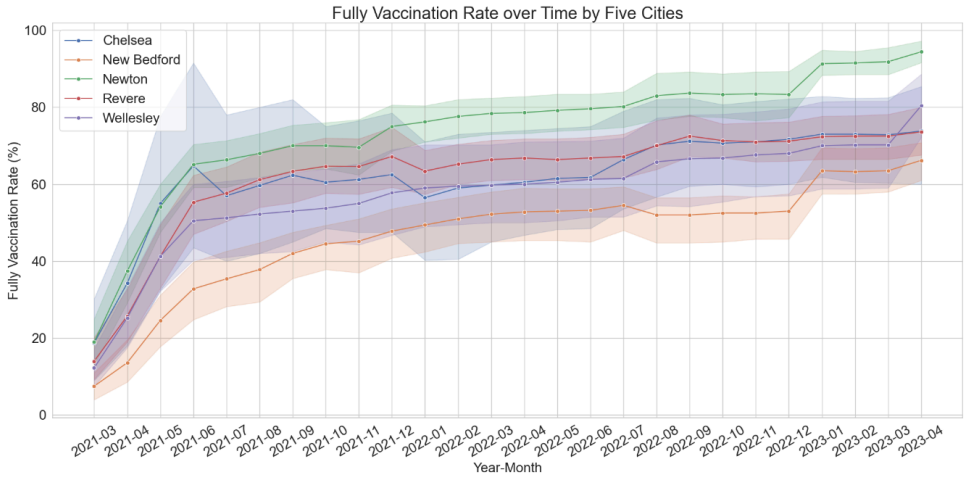

Figure 1. Fully Vaccination Rate over time by Five Cities.

The provided graph delineates the progression of full vaccination rates over time in five distinct cities spanning from March 2021 to April 2023. The vaccination rates have increased across all cities, yet the gradient of increase and the final vaccination percentages point to a significant heterogeneity in public health outcomes. Newton leads with the highest vaccination rates, potentially reflective of its elderly population. Revere and Chelsea exhibit comparable rates, suggesting similar healthcare outreach or demographic patterns, while Wellesley and New Bedford follow, with New Bedford showing the lowest rates. This may indicate disparities in vaccine distribution or varying levels of vaccine hesitancy.

Personal beliefs and attitudes can significantly influence vaccination decisions. In the elderly, these decisions are often shaped by lifelong beliefs and the potential for side effects, which may cause hesitancy towards vaccines. For children, parents' or guardians'

beliefs and the social milieu shape vaccination choices, balancing perceived risks and benefits.

Furthermore, Healthcare policies and public health campaigns play a pivotal role in vaccination uptake. Targeted campaigns and policies that remove financial barriers, like Medicare, can increase vaccination rates among the elderly by emphasizing the risks of non-vaccination. For children, mandatory school vaccinations and public education on community health responsibilities ensure higher vaccination rates.

Finally, socioeconomic status is a key predictor due to its links with education and healthcare access. Among the elderly, factors like retirement income and social support impact vaccination decisions, with those in lower income brackets possibly prioritizing other needs due to cost concerns and facing challenges like limited transportation. For children, family socioeconomic status plays a significant role; higher status often correlates with better access to healthcare and higher vaccination rates, while lower status may lead to barriers such as costs and limited healthcare access. However, the 1-dose pediatric vaccination data revealed a curious trend that may indicate that high socioeconomic status may not necessarily predict a high vaccination rates.

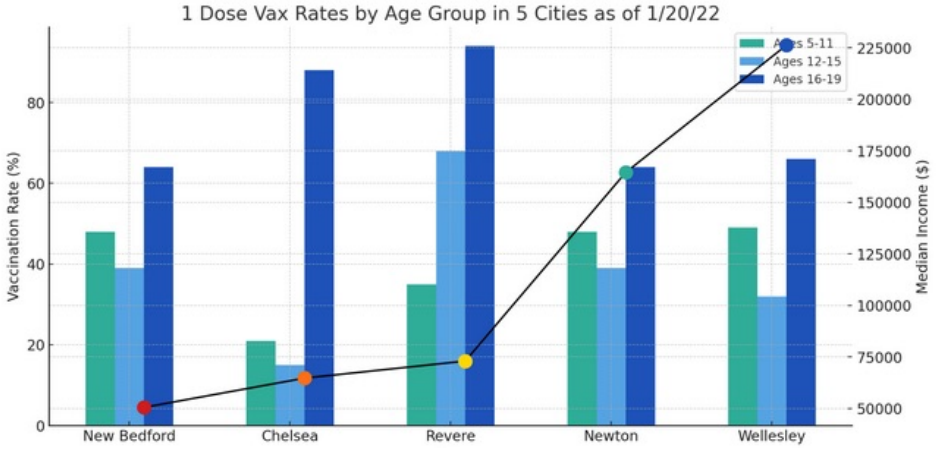

Figure 2. 1-Dose Vaccination Rates by Age Group in 5 Cities

Figure 2 depicts the first-dose vaccination rates across five cities, categorized into three pediatric age groups as of January 20, 2022. Notably, the 16-19 age group in a less affluent city such as Revere exhibits the highest vaccination rate. Meanwhile, the vaccination trends in more affluent areas like Newton and Wellesley suggest a surprising tendency for the wealthier populations to be more hesitant about COVID-19 vaccinations for their children.

Given the different vaccination rates among five cities, we are looking for the factors that may impact on the vaccination rates. As vaccination rates are highly influenced by the geographic demographic and economic indicators. In the process of exploratory data analysis, we are investigating how the income level, poverty level,

employment rate, education, age, race and gender departs among five cities. Further, how these factors affect the difference of vaccination rate among five cities.

Social Vulnerability Index (SVI)

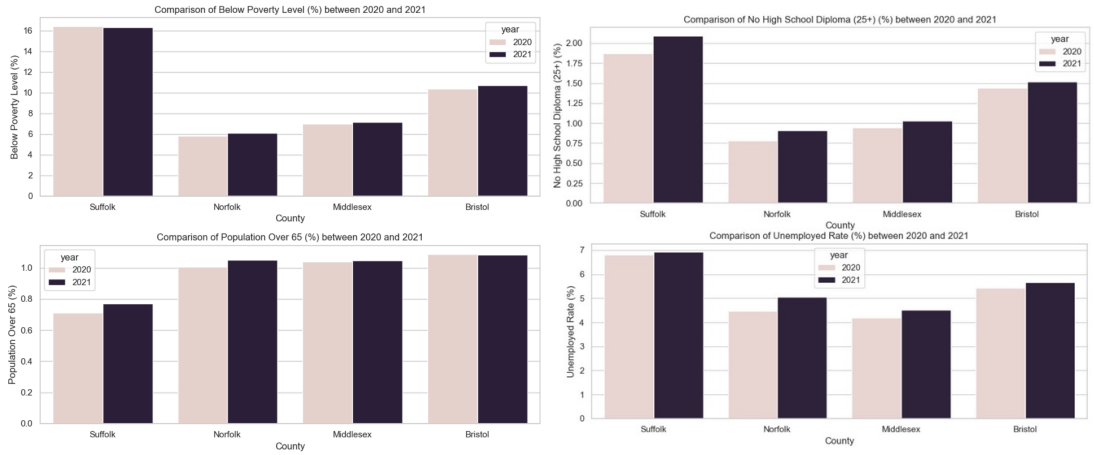

Figure 3. SVI among Five Cities

The SVI comparison utilizes bar graphs to represent four distinct socio-economic indicators: poverty level, lack of high school diploma, population over 65, and unemployment rate. Each indicator is compared between 2020 and 2021 across Suffolk, Norfolk, Middlesex, and Bristol counties.

The year-over-year Poverty Level comparison suggests that Suffolk County has the highest economic vulnerability. The data on educational attainment reveals a higher rate and the highest unemployment rate in Suffolk County compared to the others. Regarding the senior population, the trend across the counties shows a consistent or slightly increasing percentage of residents over 65.

Suffolk County exhibits higher vulnerability in terms of poverty and education, which may negatively impact its resilience. The other counties, while displaying lower poverty and higher education levels, are not without their challenges. The data suggests that these counties may be better positioned to support vaccination efforts and other health initiatives due to their economic and educational advantages.

Furthermore, our analysis extended to socio-economic factors, specifically income levels and unemployment rates.

Economic Factors

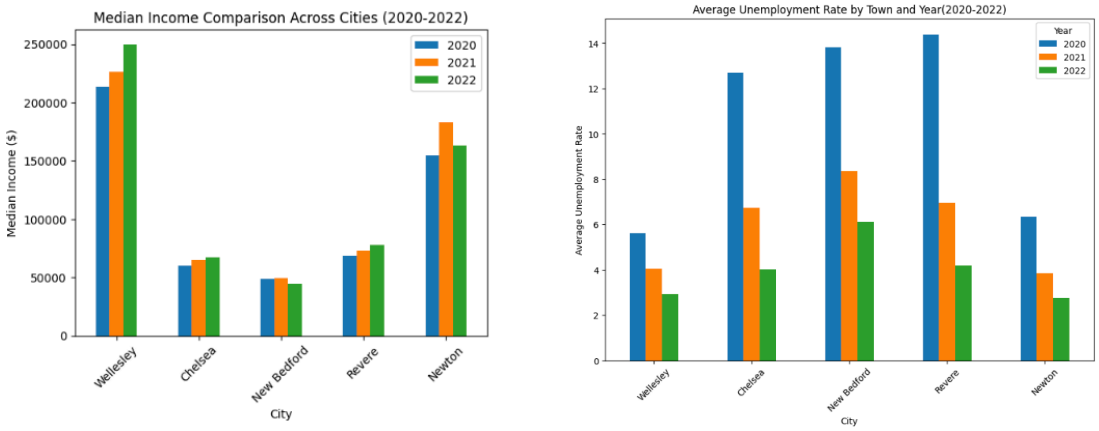

Figure 4 & 5. Income & Unemployment Rate by City and Year

Figure 4. shows that Wellesley and Newton, with the highest median incomes among the five cities studied, may experience better healthcare access and higher vaccination rates. Higher incomes typically afford residents more flexible schedules and better healthcare literacy, enabling easier access to vaccination services. The observed data suggests a correlation between economic stability and vaccination uptake, as wealthier areas like Wellesley and Newton show increased vaccine acceptance. Factors contributing to this trend may include a higher level of education regarding health and more substantial trust in healthcare systems.

Figure 5. illustrates a distinct economic pattern within the data set, showing that Chelsea, New Bedford, and Revere have experienced the highest unemployment rates over the past three years. This economic indicator is crucial as it often reflects broader socio-economic challenges within these communities, including poverty.The assumption that these three cities might have lower vaccination rates due to poverty is based on several interrelated factors associated with economic disadvantage such as health prioritization, and information and education.

Race

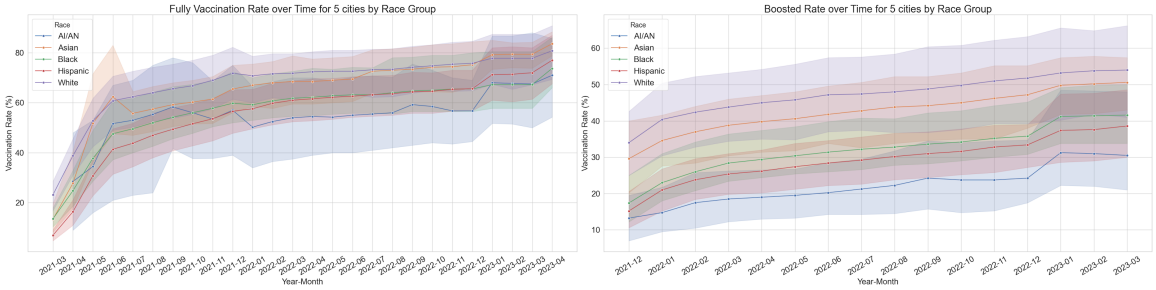

Figure 6 & 7 : 2-Dose & 3-Dose Rate over Time for 5 Cities by Race

From Figure 6, stratified by racial demographics, a clear upward trend is observed from March 2021 to April 2023 among five cities with initial rates near 20% escalating to a range between 70-80%. The data indicate a hierarchy in vaccination rates with the White population leading, followed by Asian, Black, Hispanic, and American Indian and Alaska Native (AI/AN) groups, respectively. This hierarchy suggests potential disparities that could be rooted in systemic factors such as healthcare accessibility, socioeconomic status, or vaccine hesitancy.

Figure 7. reflects the booster vaccination rates across five racial groups in five cities from December 2021 to March 2023. The booster rates have risen from an average of approximately 15% to around 40% for all groups. The data indicate a hierarchy in vaccination rates with the White population leading, followed by Asian, Black, Hispanic, and AI/AN groups, respectively. It indicates that while progress has been made in administering booster shots, there is a crucial need for strategies to increase equity in vaccination efforts.

Age

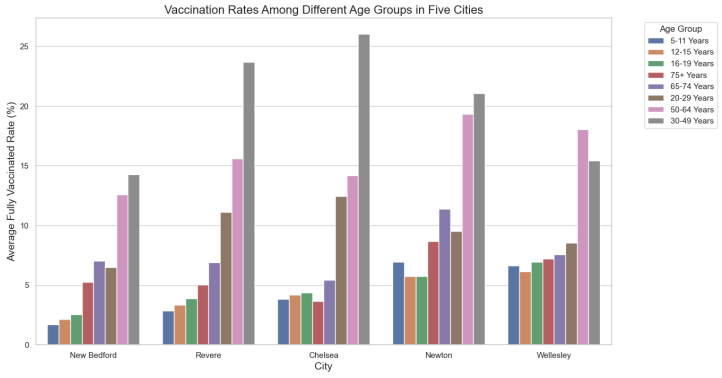

Figure 8. Vaccination Rates Among Different Age Groups in Seven Cities

The bar chart showcases the vaccination rates across different age groups in seven cities as of September 6, 2022. This visualization reveals distinct patterns in vaccination uptake among various age demographics. Chelsea ranks third in average vaccination rates

among the considered age groups, suggesting effective local vaccination campaigns possibly bolstered by grassroots organizations. The vaccination rates in Chelsea appear consistent and high relative to other cities, indicating successful outreach and education efforts targeting diverse demographics.

Population Size

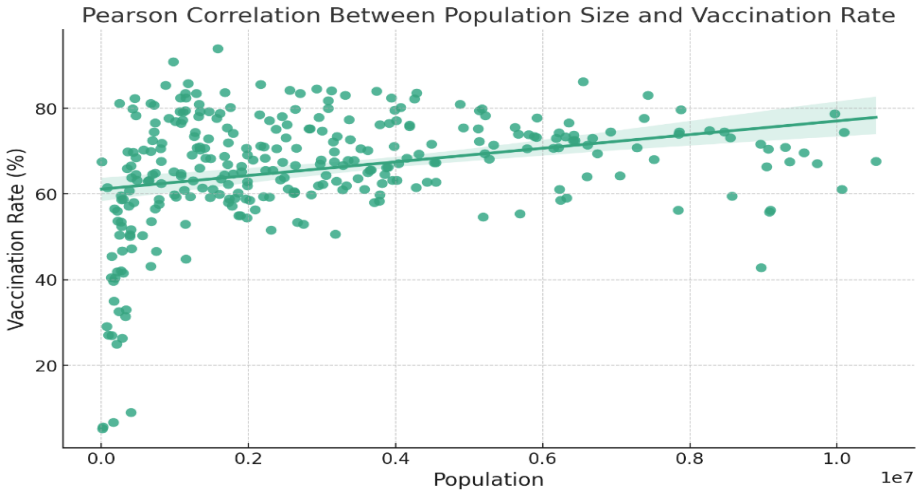

Figure 9: Pearson Correlation Between Population Size and Vaccination Rate,

Figure 9 visualizes the correlation between population size and vaccination rates as of 2023-02-15 across various cities (green dots). The distribution of these points suggests that population size is not a strong linear predictor of vaccination rates, highlighting the multifaceted nature of vaccination campaigns influenced by public health policies, community outreach, and socio-economic conditions. This complexity calls for a nuanced approach to public health strategies.

Gender

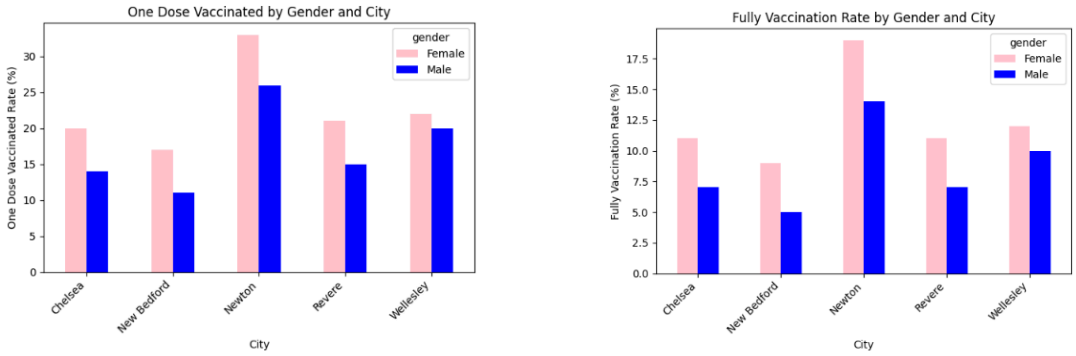

Figure 10 & 11. 1-Dose & 2-Dose Rate by Gender and City

Additionally, we analyzed data by gender to identify any significant disparities in vaccine administration between males and females. The graphs Figure 10 and 11 indicate that women generally have higher vaccination rates than men in most cities, suggesting better outreach to or acceptance among females. Newton displays the most significant gender disparities in both one-dose and full vaccination rates, hinting at a gender-specific gap in uptake or access. Two hypotheses emerge from this trend: the occupational factors hypothesis, which suggests women's predominant roles in healthcare and education may lead to higher vaccination due to workplace exposures and mandates. Additionally, the societal roles hypothesis posits that women's caregiving responsibilities for dependents might motivate a higher vaccination rate to protect family members. These observations could guide targeted public health strategies to address gender disparities in vaccination.

Mortality

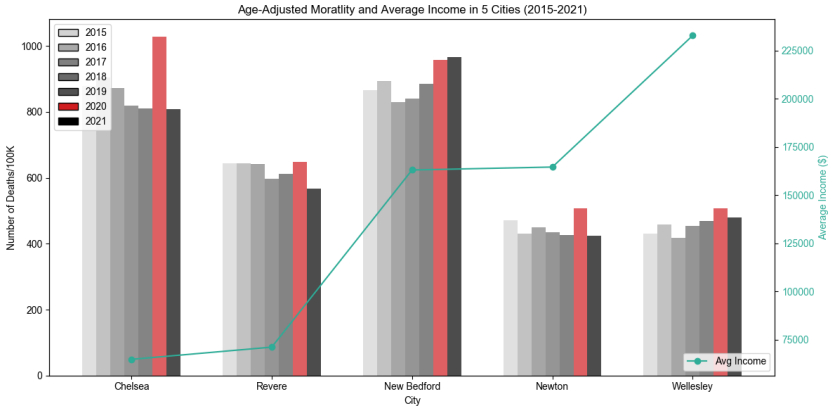

Figure 12. Age-Adjusted Mortality and Income by City

Figure 12 illustrates the mortality rates in five cities from 2015 to 2021, with data for 2020 highlighted in red. Newton and Wellesley, cities with higher average incomes, show consistently lower mortality rates, suggesting an inverse relationship between income and mortality. However, New Bedford stands as an exception to this trend.

4. Limitations

Given the datasets we have, we may have the following limitations. 1. Correlation Does Not Imply Causation: The relationships observed between vaccination rates and various socio-demographic indicators do not necessarily imply causation. While these correlations are insightful, they should be interpreted with caution, as other unmeasured variables could also influence the outcomes. 2. Complexity of Public Health Dynamics: Vaccination uptake is influenced by a myriad of factors, including public health policies, individual beliefs, and community engagement. Our dataset captures only a fraction of these elements, potentially omitting crucial variables that play a significant role in vaccination campaigns. 3. Challenges in Measuring Community Initiatives: Without specific data from grassroots organizations, it's challenging to quantify their contribution to vaccination efforts. This gap hinders our ability to fully understand and acknowledge the role of community-based initiatives in public health outcomes.

Recommendations for Further Analysis. Investigate Other Sources of Data: To compensate for the lack of grassroots data, explore alternative sources that may provide indirect insights into the activities of these organizations, such as local news reports, community surveys, or public health bulletins. Conduct Qualitative Research: Engage in qualitative studies, including interviews and focus groups with community members and local health workers, to gather anecdotal evidence of grassroots organizations' impact on vaccination rates. Compare with Similar Cities: Analyze vaccination rates in cities with similar socio-demographic profiles but without significant grassroots activities. This comparison could offer indirect insights into the potential impact of such organizations.

5. Summary

This report on vaccine equity in MA emphasizes the critical public health challenge of vaccine hesitancy and the necessity for nuanced strategies. Building upon previous analysis, this project delves into a broader scope of variables, including age, ethnicity, gender, economic status, and the Social Vulnerability Index (SVI), to understand their correlation with vaccine hesitancy.

The preliminary analysis investigates vaccination rates among different demographics and cities, revealing significant disparities influenced by factors like socioeconomic status, education, and race. However, the lack of specific data on grassroots organizations' impact and the complexity of public health dynamics. We suggest further analysis, including exploring alternative data sources, conducting regression analysis, and expanding to other cities. In summary, the report underscores the importance of community engagement, comprehensive data collection, and collaboration among stakeholders.