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Title: Vaccination As a response to the covid-19 pandemic

Abstract

The research study aims to investigate the public response to COVID-19 vaccination in Poland by focusing on various drivers to change societal behaviour. We have studied impact of political views, demographic profiles, and urbanization by using open-access data from Polish Ministry of Health and Data Bank of Statistics Poland websites for 2020. Using secondary data about geographic and demographic characteristics, we analyzed correlation and regression between vaccination rates and municipality size, geographical partitions, age demographics, political affiliations, and neighborhood influences. The main research objective is to find answers for research questions regarding impact of selected independent variables (municipality size, geographical partition, and demographic profiles (e.g., age and gender) on dependent variable (vaccination rate). findings reveal disparities in vaccine uptake between urban and rural areas, with younger age groups exhibiting lower acceptance rates. Additionally, urbanization and political trusts in some regions contributed to positive attitude towards vaccination.

Introduction

In the realm of public health studies, it is crucial to research intricate dynamics of a society which can shape societal behaviour and responses towards a situation. This better understanding is important for governmental bodies and policy makers for effective planning in resources allocations and policy making. Massive research on economic factors, political factors, and demographical profiling remained assets for policy makers to address public health issues (CHRISTENSEN & LÆGREID, 2014; Kraśnicka, et al., 2018). Although, these factors had limitations to provide useful insights for uncertain events. A recent event of

COVID-19 pandemic, captured research attention to investigate societal factors changing responses towards public health initiatives during uncertainty. Various new factors such as political views, media campaigns, social interactions, economic conditions, cultural norms, and past experiences are explored by empirical research studies.

This research aims to investigate vaccination as a response to the COVID-19 pandemic in Poland. COVID-19 pandemic started in 2019 from China that rapidly spread over world until the end of 2020. In European Union, European Medicines Agency took initiative on 21 December 2020 for conditional marketing authorization of first vaccination. This initiative enforced EU member states to support implementation of EU vaccination strategy. As a member of EU, Poland should have vaccinated at least 70% of adult population by summer 2021 to achieve herd immunity (Babicki & Mastalerz-Migas, 2021). Under this strategy, government developed a National COVID-19 vaccination program. As fifth most populous country in European Union, Poland required massive vaccination campaigns in the whole country to attain this target. Following available research evidences, government received different responses from urban and rural areas of Poland (Żuk, Żuk, & Lisiewicz-Jakubaszko, 2019). The historical partition and subsequent geopolitical changes also offers compelling landscape for some factors to shape vaccination response. Can some underlying drivers such as political views, urbanisation and demographic profiles change vaccination response? The diverse geography and rich history of Poland suggest us to explore these factors to answer this question with empirical evidence. Finding answers to these questions we have following research objectives:

Research Objectives:

- To determine impact of increase in the size of municipalities/cities on overall response to vaccination.
- To confirm if geographical partitions influenced resident's attitude towards vaccination.
- To find association between age and vaccination percentage
- To find which class represented best attitude towards vaccination
- To identify relationship between vaccination rate and political views (if any)
- To explore data for finding meaningful insights regarding neighbourhood impact on vaccination response.

Literature Review

This section provides a brief overview in the areas of studying whether demographic ,political and economic and geographical factors effect the rate of Covid vaccination in Poland. Research consistently shows a strong link between political views and Covid 19 vaccination rate with Republican leaning areas having lower rate. Albrecht (2022) examines that the critical factor of curbing the vaccination rate is political view which extends our study to seek whether Eastern and Western part of Poland shows the real differences. It is crucial to overcome the political division and rebuild the trust in health science to improve the vaccination rate . Lillebraten et al (2023) investigates to find the association between socio economic status and vaccination rate in Norway. Interesting they found that above low income group are more likely to take Covid vaccines than low income group reflecting the importance of education and socio economic status. In their findings the age group of 18-29 belonging to higher income group have significantly likelihood of taking vaccines which supports our study of finding high rate of vaccine uptake in urban areas of Poland. Leveraging on the findings of Ma and Monnat(2021) on how the socioeconomic factors affecting the vaccine uptake rate it is pertinent to investigate whether these factors are pivotal in case of Poland as their findings captured that 11.45% of adults in rural countries are vaccinated in comparison to 59.8% in urban countries. Moreover in the findings of Malik et al (2022) it is reflected that there is noticeable geographical and demographic disparities in Covid vaccine uptake rate in US which is useful to find the impact of these disparities in our study. Education, Unemployment rate and Geographical division are most likely to affect the acceptance of Covid vaccine. Steinert et al (2022) investigated that there is hesitancy of taking vaccine determined by some factor as mistrust in Government, low health literacy rate, concerns around vaccine safety and efficacy. Theie study reveals that 61.8% of highest hesitancy in Bulgaria and lowest 6.4 % in Spain which is quite obvious of effective health policy with contingency on holding vaccination certificate can decrease this hesitancy as per the observation in Germany and United Kingdom. Wang et al (2022) found that sex, literacy rate , flu prediction history and trust in Government play a significant role in determining the vaccination rate which definitely giving the justification of disassociation of municipalty's size with vaccination rate in our findings. In their observation prior acceptance of Influenza vaccination give the urge of accepting the Covid vaccination. Ye (2023) found some distinguishing results as of huge gap between the vaccine uptake rate in Republican and Democratic country. The Republican country was spotted with lower vaccination rate than

Democratic country which triggers our study to find the differences in Eastern and Western part of Poland.

Methodology

Initially for the first five questions we have grouped the population using demographic characteristics , urbanisation, geographical locations, and in each group we studied meticulously the vaccination percentage using linear regression, scatter plots, box plots. For the purpose of solving the question 6. We first made the adjacency lists of the municipalities and then we observed vaccination percentage of each municipality along with its neighbour. To this end, we calculated the standard deviation of the vaccination percentage in each neighbourhood and plotted this standard deviation for different municipalities.

Research Data:

Following empirical research approach, research data is collected from secondary research sources. Under this approach percentage of vaccinated population is considered as dependent variable tested against multiple independent variables including but not limited to only demographical (total population, sex, age) and geographical characteristics (partition based on vistula river and traditional partition) The information about dependent variable is taken from Polish Ministry of Health website. The open access data is taken for the economic year 2020. While we collected information about independent variables for the same duration (2020) from the open-access database of Data Bank of Statistics Poland.

Research Questions:

- Does the size of municipalities/cities impact vaccination rate?
- Do we see a division between eastern and western Poland based on partitions or Vistula river as borders?
- Does age impact vaccination rate?
- Is there a significant relationship between vaccination rate and political views?

- Does neighbourhood affect vaccination response?

Research Hypothesis:

- Urbanization has significant impact on vaccination rate.
- Demographic profiles of residents has association with vaccination response.
- Political views has influence on vaccination rate.

Data Analysis:

Results

Correlation from data_municipalities.cs between percent_vaccinated and population_total are found below. The correlation results suggest a weak positive correlation of 0.216 between total population and percentage of vaccinated population. However, in urban areas we noticed a moderately positive correlation about 0.317. In rural areas, 0.138 weak positive correlation suggests a positive but weak association between total population and vaccination rate.

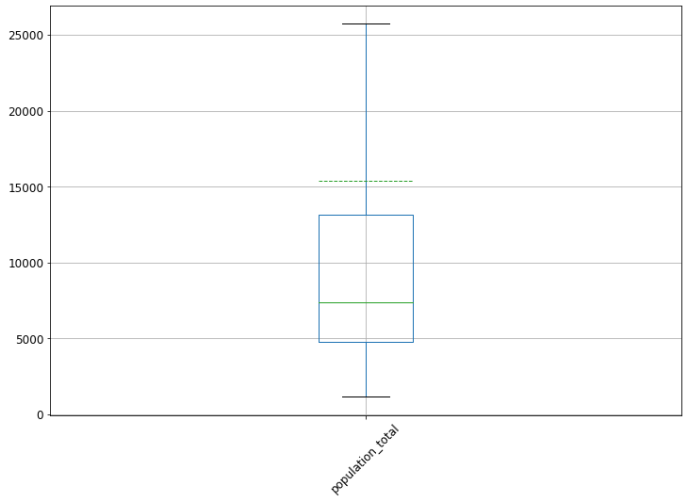
Case	Value
Whole data set	0.21579442766689
Municipality_type = Urban	0.3166442285868626
Municipality_type = Rural	0.13785192850484262
Municipality_type = Mixed	0.31238127451789033

All above cases R squared and Adj R squared of OLS test results are as below

Case	R-squared	Adj. R-squared:
Whole data set	0.047	0.046
Municipality_type = Urban	0.100	0.097
Municipality_type = Rural	0.019	0.018

Municipality_type = Mixed	0.098	0.096

In overall model, only 4.7% (0.047 R^2) of percent_vaccinated can be explained by population_total. Somehow, in subcategories, total_population in urban areas explains 10% (0.100 R^2) of variance in percent_vaccinated. When population_total in all municipilities of rural areas explains around 1.9% (0.019 R^2) variance in percent_vaccinated.

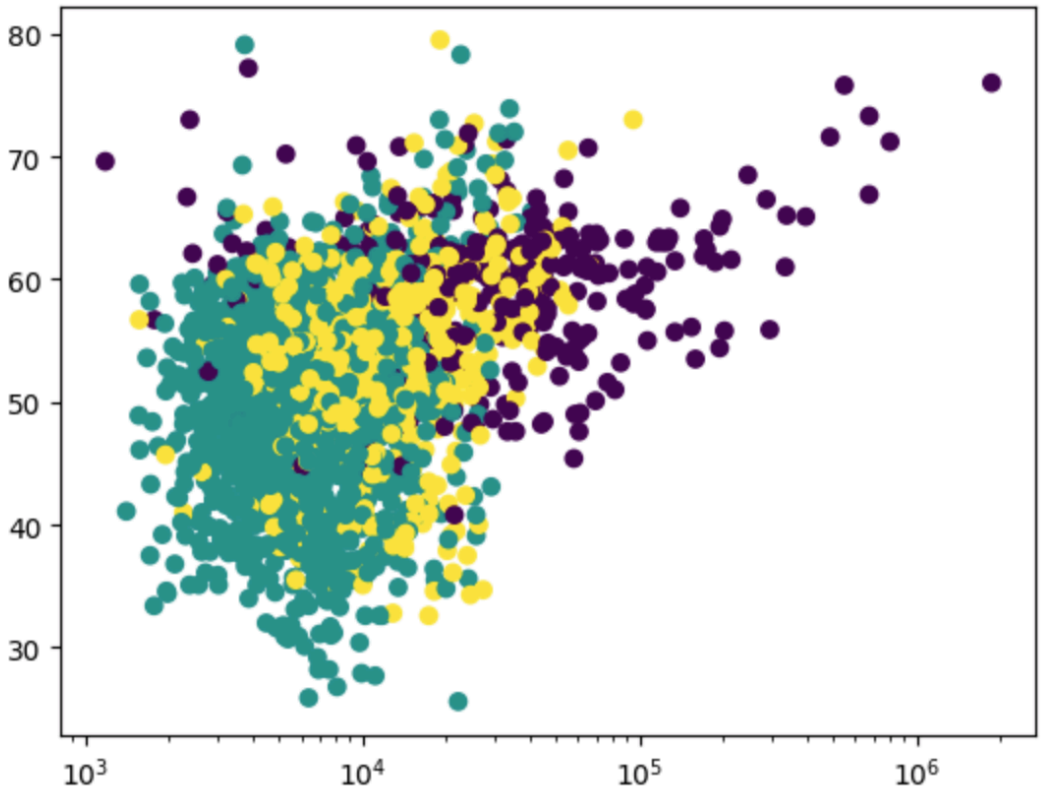


Boxplot of size. Roughly 90% of municipalities have less than 27000 population. Rest are mostly urbanised municipalities with high population.

After considering to remove outlier effect (below Q1 - 1.5 * IQR and above Q3 + 1.5 * IQR), result are below

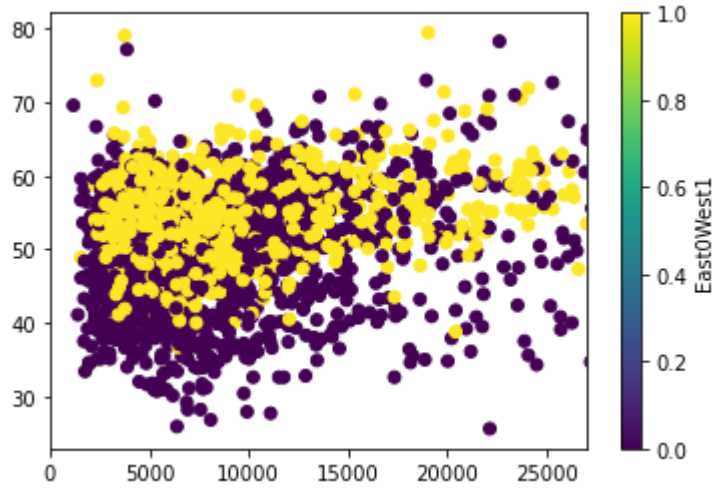
Case	R-squared	Adj. R-squared:
Whole data set	0.033	0.032

As we learnt from data population seems to exponential growing, added further analysis on log scale population for OLS and result are as below
(X-axis -> population vs Y-axis -> percent of vaccination)

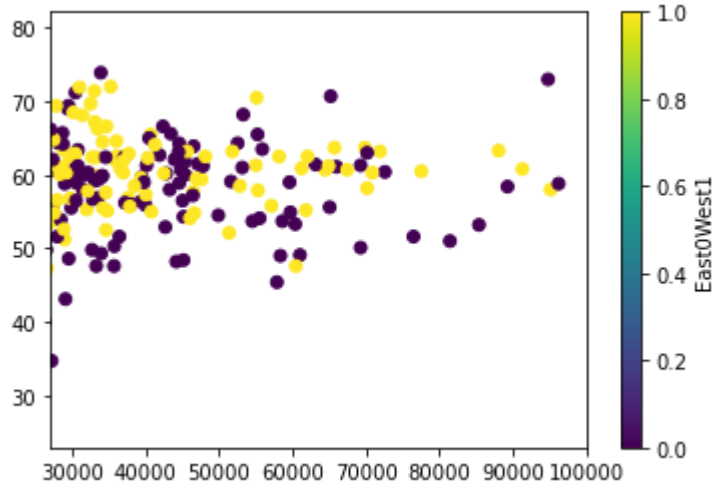


Case	R-squared	Adj. R-squared:
Whole data set	0.111	0.111

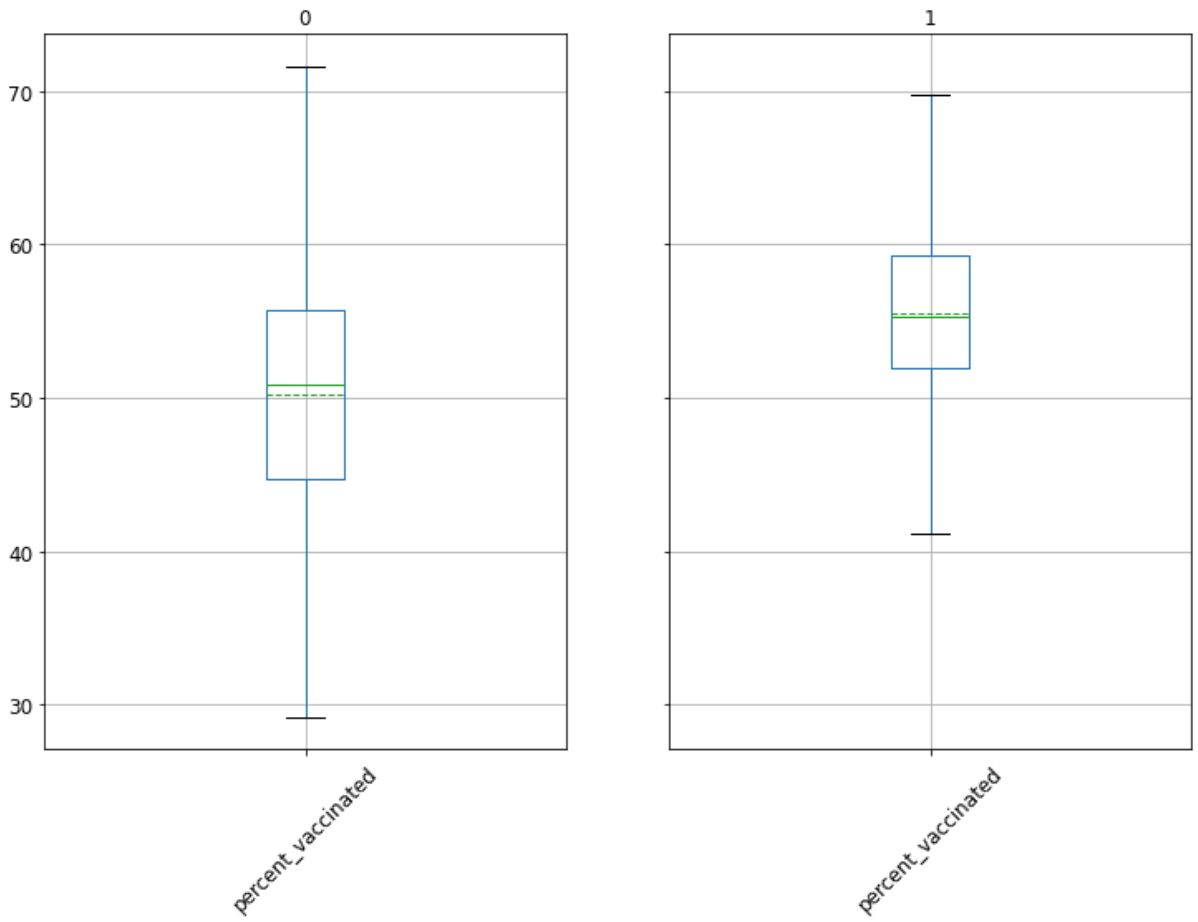
Question 2. (East West)



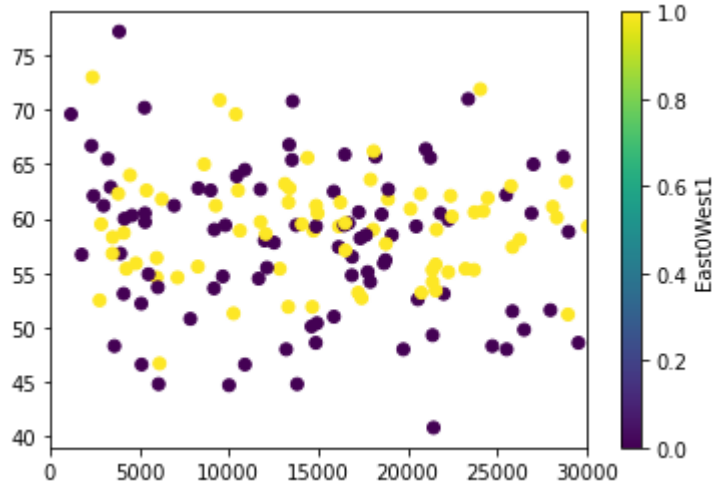
Vaccination rate vs population with population less than 27000. Yellow is West, Brown is East.. West areas have a higher rate of vaccination.



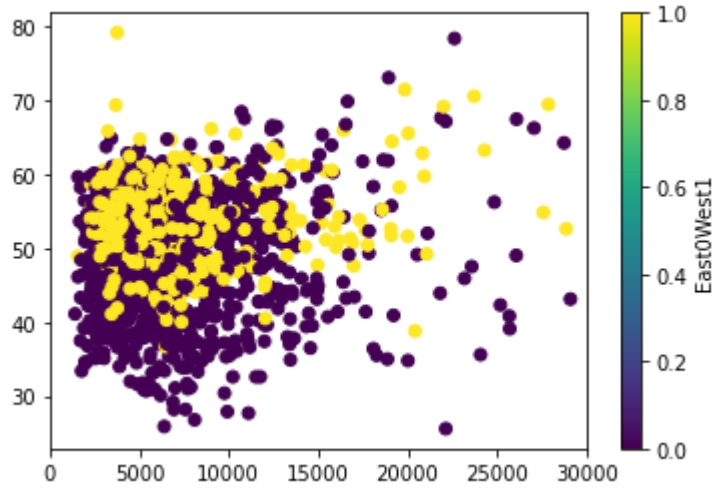
Vaccination rate vs population with population more than 27000. Yellow is West, Brown is East.. West areas have a higher rate of vaccination.



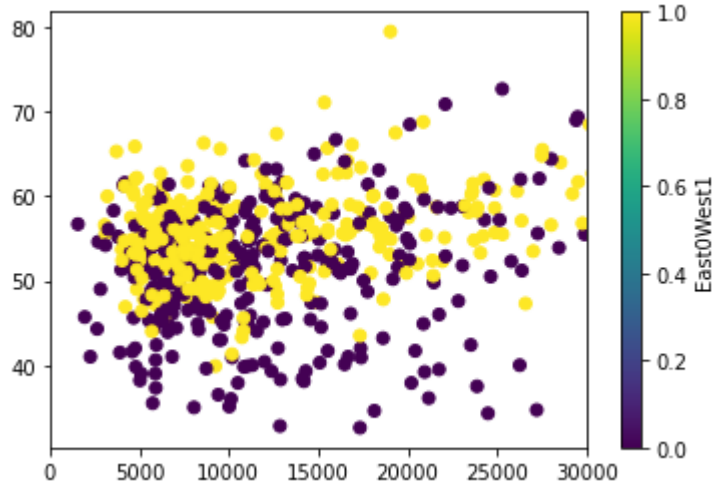
Boxplot of vaccination percent of East(left) and West(right). The West is higher.



Vaccination rate vs population with population less than 27000 in urban municipalities. Yellow is West, Brown is East.. There is not much East-West difference in Urban areas.



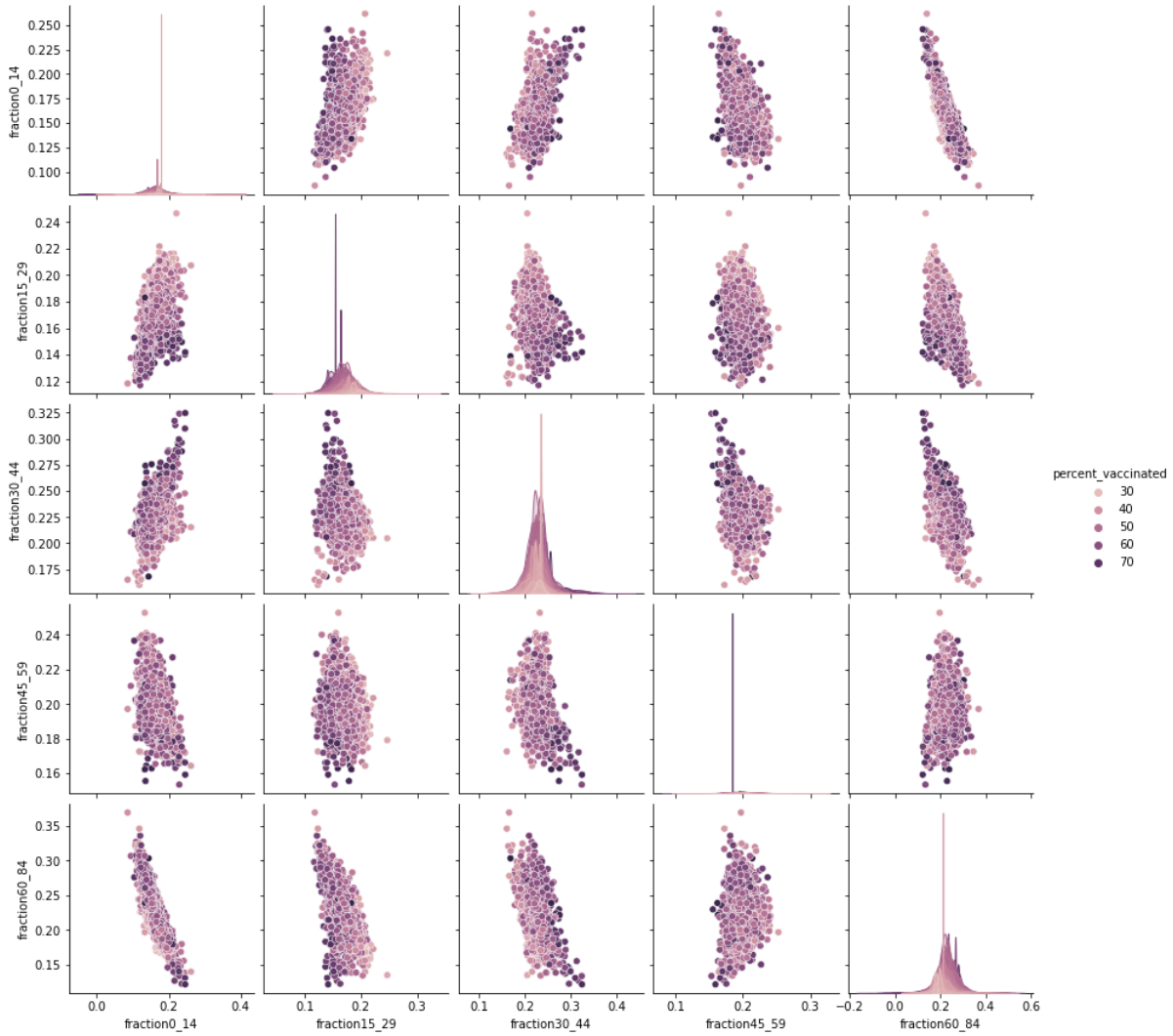
Vaccination rate vs population with population less than 27000 in rural municipalities. Yellow is West, Brown is East.. Vaccination rate is higher in western rural areas.



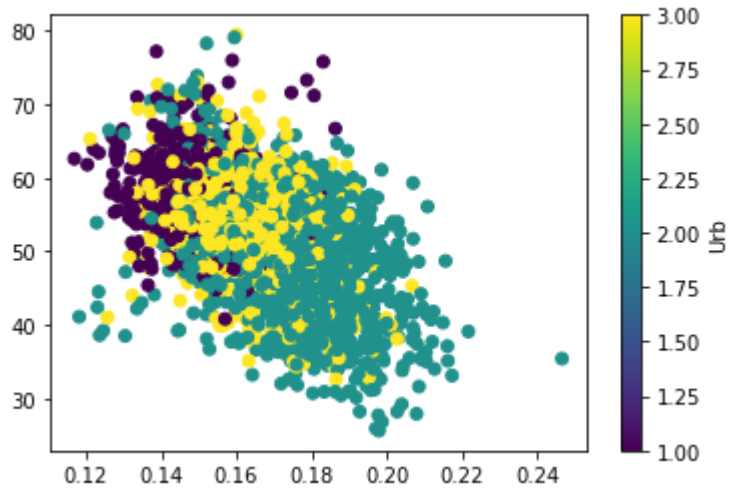
Vaccination rate vs population with population less than 27000 in mixed municipalities. Yellow is West, Brown is East.. There is not much East-West difference in mixed areas.

Question 3. (Demography)

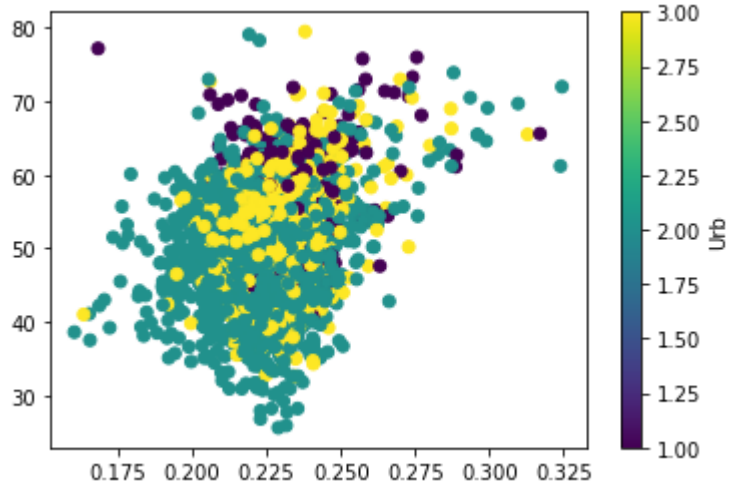
We grouped population into age groups of 0-14, 15-29, 30-44, 45-59, 60-84



Pairplot where darker colour indicates higher rate of vaccination. Municipalities with higher fraction of 15-29 age group are less vaccinated. Municipalities with a higher fraction of 30-44 age group are more vaccinated. We show more details below.



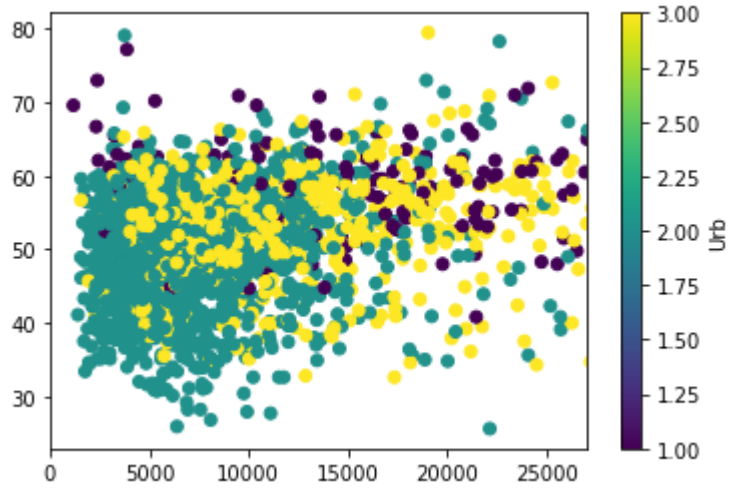
Vaccination rate vs fraction of 15-29 aged people. Brown is urban, green rural, yellow mixed.



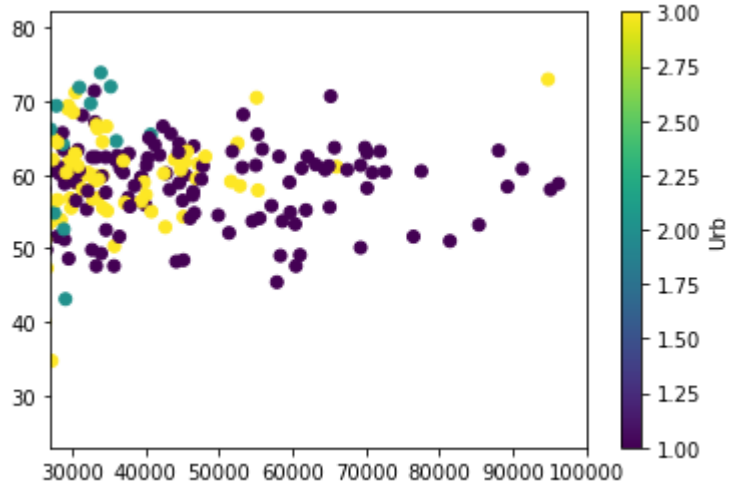
Vaccination rate vs fraction of 30-44 aged people. Brown is urban, green rural, yellow is mixed.

This trend is coming from both male and females. More details are in the code.

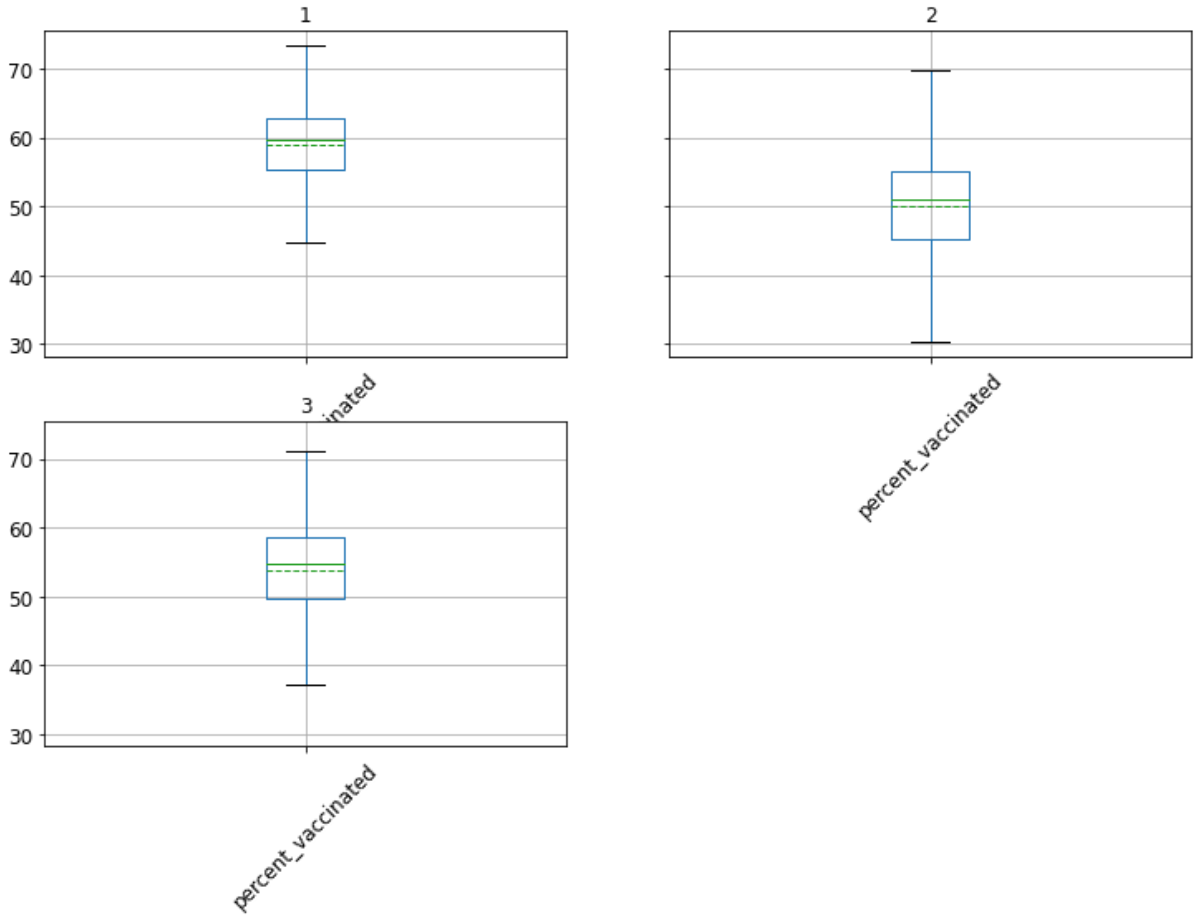
Question 4. (Urbanisation)



Vaccination rate vs population with population less than 27000. Brown is urban, green rural, yellow mixed. Urban areas have a higher rate of vaccination.

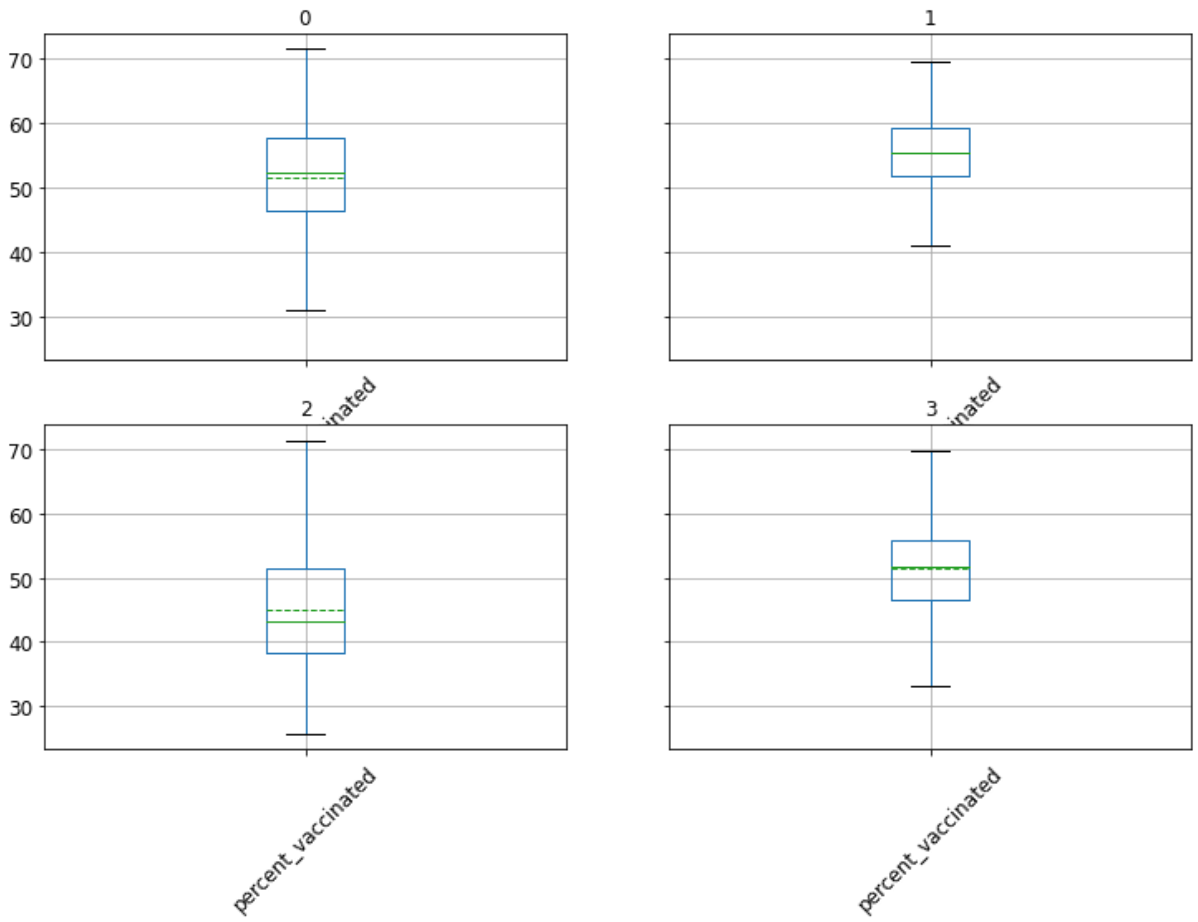


Vaccination rate vs population with population more than 27000. Blue is urban, green rural, yellow mixed. Urban areas have a higher rate of vaccination.

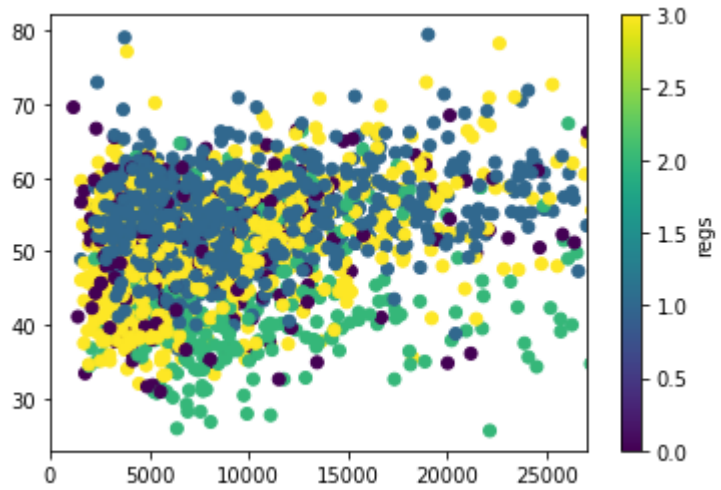


Boxplot of vaccination rate for different urbanisation. Poland is doing best in urban areas.

Question 5. (political view)



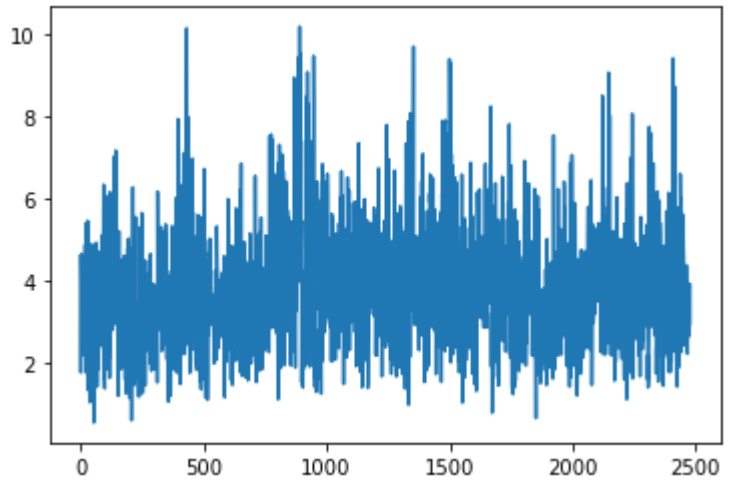
Boxplot for rate of vaccination. 1 is prussian, 2 is austrian, 3 is russian. People from regions that were historically under Prussian influence have higher rates of vaccination. This trend is shown below also



Vaccination rate vs population size. Colour codes can be read from the bar.

Question 6.(Contagion)

For a municipality, we took the standard deviation of vaccination percentages of the municipality itself and its neighbours. We plotted this standard deviation for each municipality and got the following:



This shows most of the time standard deviation is not high. Thus most municipalities have a similar vaccination percentage as their neighbour. So, We indicate that the propensity to vaccination spreads like a contagion.

Conclusion:

This study sets its aims to seek whether there is a direct association and influence of the size of the municipality on the vaccination rate in Poland following some precedent analysis of different authors in different countries. The outcome of this analysis appeared with some observations. Firstly, there is an inadequate integrated impact of the size of the municipality on the vaccine uptake rate in Poland. This disassociation might indicate the presence of some other exogenous factors such as educational status, the willingness of acceptance of vaccination, efficient regulation of Government, political disparity, socioeconomic status as well as the extent of urbanization as advocated by earlier studies in this area. It is quite an interesting observation that the population of urban areas and the western part of Poland is more inclined towards acceptance of vaccination reflecting the need for robust policy implications in rural areas. Secondly, the population of the age group of 15-29 years is reluctant and unwilling to get the vaccine. This phenomenon can be accompanied by the fact of lack of awareness among the new generation mostly in rural areas which is quite justified by the study of Ma and Monnat(2021) which gives the view of highly likelihood to take vaccines in the young generation of urban areas. On the other hand, the age group of 30-44 years is more likely to get vaccinated because of their emerging health consciousness. The sex factor is not exempted from this trend as well. In this investigation, it can be noticeable that the areas of the Western part (mostly Prussian) of Poland are highly susceptible to vaccination which might point out some different political arrangements and development significantly in the rural areas. Malik et al (2022) has also advocated that geographical and demographic disparity are the crucial factors for determining the rate of vaccination which is quite aligned with our findings.In the Prussian region (mostly in Wroclow), the municipalities shows the highest vaccination rate which may adhere to the fact that political views, arrangements, awareness programs, development, and high reliability on Government robust policies are responsible for generating more willingness among the people. Wang et al (2022) also gave the empirical evidence that the trust on Government policies play a pivotal for generating the willingness to uptake vaccine which gives justifiable reasoning of our findings in the Prussian region. Thus it can be concluded that this study lays out some crucial and influential factors for vaccination rate for policy implications.

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