# Geospatial Analysis of COVID-19 Vaccination: A Neighbourhood Level Analysis in Ireland

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## Background

The COVID-19 pandemic has demonstrated the important role vaccination plays in managing an infectious disease outbreak globally. There are several factors that might affect vaccination uptake, such as vaccine center accessibility, urban-rural differences, and demographic variables. However, the influence of spatial determinants has not been widely studied and this has potential to aid public health policy making during healthcare emergencies.[1]

## Objectives of Project

- Explore spatial and demographic patterns associated with COVID-19 vaccination rates in **166 Local Electoral Areas (LEAs)** in Ireland.
- Examine differences in vaccination rates across LEAs over time, with a focus on potential variations between urban and rural areas.
- Evaluate accessibility to vaccination centres, including initial vaccination centres (preliminary vaccine dose centres), GPs, and pharmacies.
- Investigate potential associations between demographic characteristics in LEAs and vaccination rates.
- Assess the applicability of non-linear logistic growth models to describe trends in vaccination uptake over time.
- Identify and describe spatial and demographic disparities in vaccination rates, if present.

## Data Sources

Data on centers offering COVID-19 vaccines are of three types:

1. Initial Vaccination Centers for COVID-19[2]
2. GPs[3]
3. Pharmacies[4]

- They were **scraped** using **rvest** in **R** and **selenium** on **Python (for dynamic webpages)**. They were all **geocoded** to obtain longitudes and latitudes using **Google Maps API**
- **LEA vaccination rates** are in table **CDC47 in Central Statistics Office website (CSO)**[5]
- **LEA Boundary files** were taken from **Ordnance Survey Ireland(OSI)** [6]
- *LEA Boundary files were linked to the CDC47 dataset* by processing the LEA names to be same on both files and then using **merge** function on R to combine them on the LEA names.

## GitHub

The code and datasets for this project can be viewed at our GitHub repository here: https://github.com/Siva-1247/HDS_Project_2425_SN.git

## Early Results

Figure 1, and Figure 3represent an exploratory analysis of Primary Course Vaccination Rates, with the former highlighting vaccination rates by LEA in *January 2022* with the initial vaccination centers represented by dots and the latter depicting vaccination trends over time on a monthly basis. Additionally, Figure 3provides a more detailed breakdown, distinguishing vaccination rates between urban and rural areas for each month.

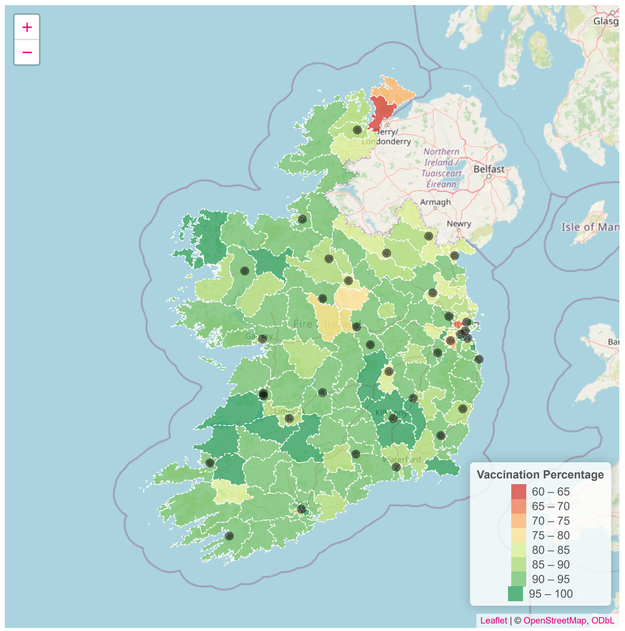


Figure 1: LEA wise Primary Course Vaccination Rates in January 2022 with Initial Vaccination Centers Marked

The centroids of the 166 LEAs were calculated and the distance of these centroids to the initial vaccination centers were calculated using *sf* and *geodist packages*. The *Geodesic* method which gives highly accurate pairwise distance between two coordinates based on the WGS84 ellipsoid was used. The below Figure 2 depicts the distance of top 10 LEAs when ordered alphabetically to all the initial vaccination centers.

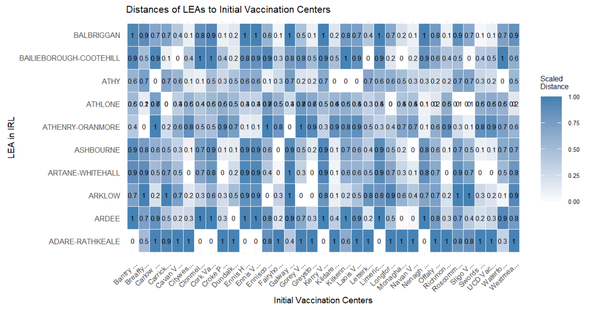


Figure 2: Distance to Initial Vaccination Centers from 10 LEA centroids

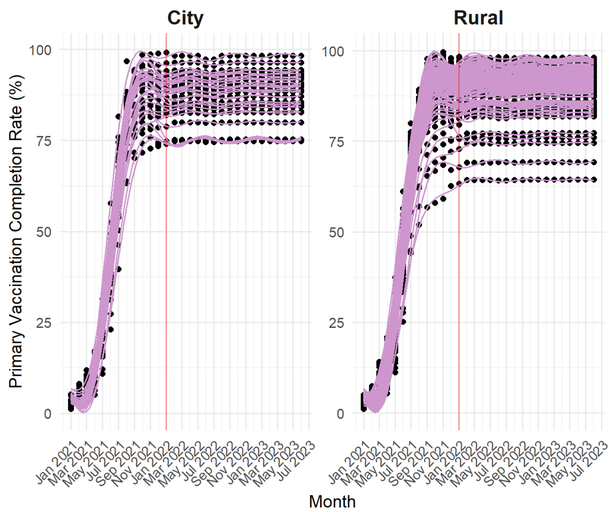


Figure 3: Primary Vaccination Course Completion Over Time (2021 January - 2023 June)

Figure 4 is a scatter plot of primary course vaccination rates to minimum distance to initial vaccination center for each of the 166 LEAs in January 2022.

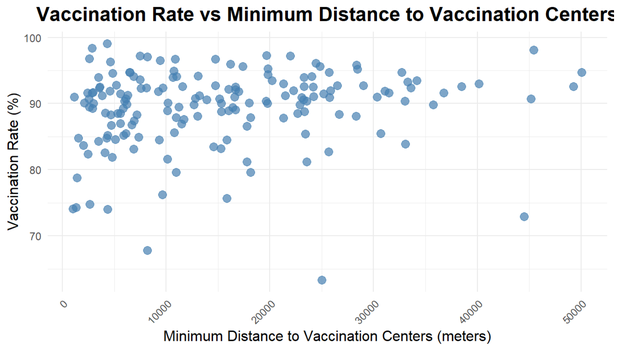


Figure 4: Primary Course Vaccination Rate vs Minimun distance to initial vaccination centers

## Next Project Steps

*Geospatial Analysis:* Identify and analyze variables that influence accessibility to vaccination centers. It can be done using routing APIs (e.g., Google Maps API, OpenStreetMap) to estimate travel times by car, public transport, or walking. Spatial clustering can help identify regions with high or low vaccination center accessibility

*Demographic Analysis:* Identify and extract local area level demographic summaries and transform compositional demographic variables by log-ratio transformations for modelling.

*Model Development:* Analyze models such as generalized linear mixed models and non-linear mixed models (potentially within a Bayesian framework) to analyze vaccination uptake rates[7]

In the presence of spatial autocorrelation, spatial regression models can also be analysed.

## References

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