# EY Tecathon 2021
# Prototype

srivastava.kartikeya02@gmail.com

# Team Dracarians


1. Kartikeya Srivastava
   6383749101
   srivastava.kartikeya02@gmail.com
2. Yenumula HarshaVardhan Reddy
   6281812257
   nani000018@gmail.com
3. Tejas Chintala
   79951 06794
   tejas.chintala@gmail.com


**Problem Statement:**

Prioritize vaccine delivery and Monitor vaccine efficacy using AI/ML

# Problem Definition

- Several vaccines for SARS-CoV-2 are expected to be available in 2021.
- Initial supply is likely to be limited, and will require a judicious vaccination strategy until supply is unrestricted.
- Hence phased allocation of the vaccine is to be implemented. Implying a priority order is to be followed.
- After the vaccination program begins, monitoring the efficacy of the vaccine is of prime importance.
- Determining what percent of the population is to be vaccinated to reach herd immunity is the challenge.

# Solution: Priority Population

Identify and map priority populations and determine sub-allocations of vaccine for distribution within the state.

The priority can determined based on the following factors:

1. Geographical Location (Zone=Red/Green/Orange)
2. Occupation
3. Comorbidities
4. Age group

We divide the process in three phases based on the availability of vaccine:

1. Phase 1- Scarce supply of vaccine
2. Phase 2- Limited supply of vaccine
3. Phase 3- Sufficient/Unlimited supply of vaccines

# Solution: Priority Population

**Phase 1:  Scarce availability of vaccine**

Initial efforts focus on reaching critical populations.

- **High-risk health** workers and **first responders**.
- People of all ages with **comorbid and underlying conditions** that put them at significantly higher risk.
- **Older adults** living in congregate or overcrowded settings

# Solution: Priority Population

**Phase 2:  Limited supply of vaccine**

- The focus is on ensuring access to vaccine for members of Phase 1 critical populations not yet vaccinated and extend efforts to reach Phase 2 critical populations
- Phase 2 critical population-
    1. Critical risk workers.
    2. Teachers and school staff.
    3. People with 1 significant comorbid condition.
    4. People and staff in homeless shelters or group homes .
    5. Incarcerated / detained people and staff.

# Solution: Priority Population

Phase 3:  Sufficient/Unlimited supply of vaccines

- Young adults
- Children
- Workers in industries and occupations important to the functioning of society and at increased risk of exposure not included in Phase 1 or 2
- Social/employment groups unable to social distance (examples: detention facilities, dormitories, low income persons in dense urban neighbourhoods, homeless people and those living in informal settlements or urban slums, certain occupations e.g. mining)

# Solution: Priority Population

**High-risk health workers:**

Hospitals, physician and other health practitioner offices, outpatient care centers, home healthcare services, pharmacies and drug stores, and nursing and residential care facilities and homes.

**First Responders:**

Police, Fire protection services, Other ambulatory health care services.

**Significant comorbid conditions:**

Obesity (BMI ≥ 30 kg/m2), diabetes mellitus, COPD, heart disease, chronic kidney disease, and any (1+) condition

**Congregate settings:**

Nursing residents, Residential care residents, Crowded households with adults over 65.

**Critical risk workers:**

Workers in dentist offices, medical and diagnostic laboratories, food and beverage manufacturing facilities and stores, gas stations, cosmetic and beauty supply stores, optical goods stores, other health and personal care stores, transportation industries .

EY

# Solution: Priority Population

We used Exploratory Data Analysis in Python along with visualizations from Tableau to come to a conclusion which state needs critical attention.

The whole project is uploaded in the following github repository:

HarshaVardhanReddy18/EY_TECKATHON (github.com)

Also the following dashboards were created on Tableau:

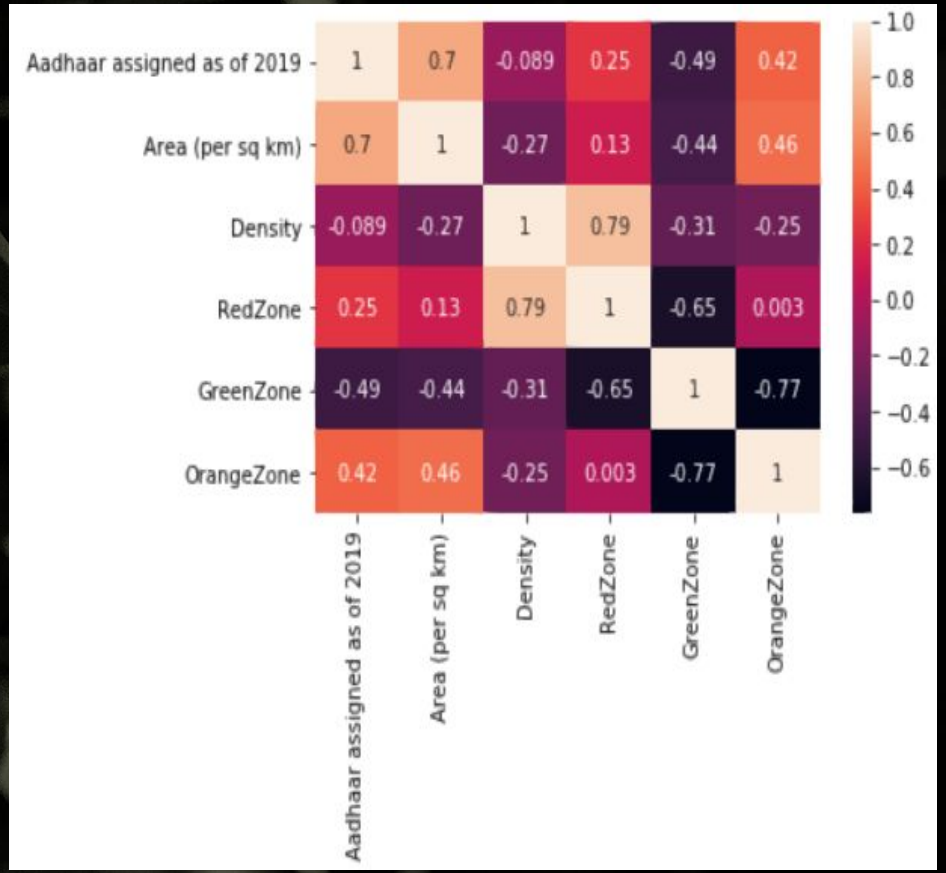
https://public.tableau.com/profile/tejas.chintala8584#!/vizhome/CovidAnalysis_16098441140550/ZonesperState
https://public.tableau.com/profile/tejas.chintala8584#!/vizhome/CovidAnalysis_16098441140550/PopulationVSRedZone
https://public.tableau.com/profile/tejas.chintala8584#!/vizhome/CovidAnalysis_16098441140550/PopulationVSGreenZone

# Solution: Priority Population

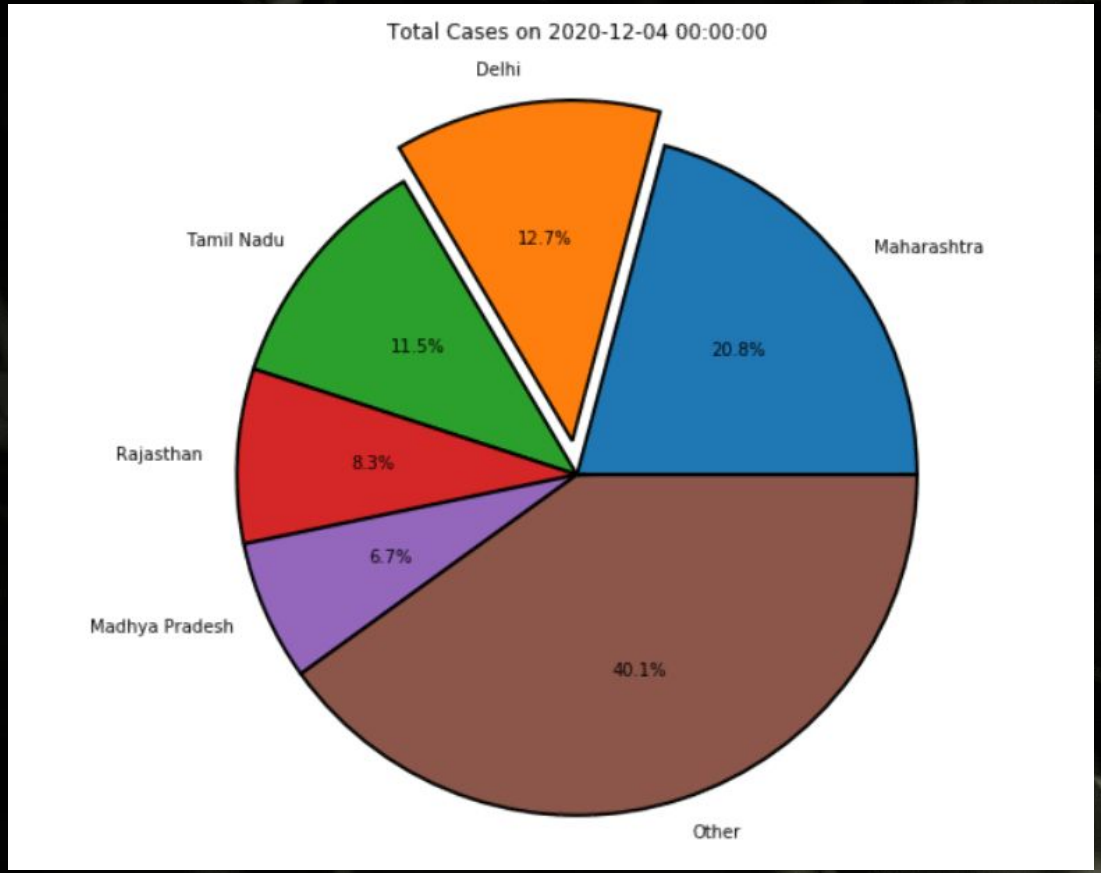
The following table demonstrates the indian states being compared on the basis of the count of their respective red, green, orange zones.

| | State | Aadhaar assigned as of 2019 | Area (per sq km) | Density | RedZone | GreenZone | OrangeZone |
|---|---|---|---|---|---|---|---|
| 0 | Delhi | 21763471 | 1483 | 14675 | 100 | 0 | 0 |
| 1 | Haryana | 28941133 | 44212 | 654 | 9 | 9 | 81 |
| 2 | Kerala | 36475649 | 38852 | 938 | 14 | 14 | 71 |
| 3 | Himachal Pradesh | 7560770 | 55673 | 135 | 0 | 50 | 50 |
| 4 | Punjab | 30355185 | 50362 | 602 | 18 | 18 | 63 |

# Visualizations

# Visualizations



# Solution: Efficacy Monitoring

- Challenge: If and when herd immunity can be achieved.

- Herd immunity is defined as a level of population immunity at which disease spreading will decline and stop even after all preventive measures have been relaxed. If all preventive measures are relaxed when the immunity level from infection is below the herd immunity level, then a second wave of infection may start once restrictions are lifted.

- We used a deterministic mathematical model and a simple equation of epidemic response with limited supply to calculate what minimum Percent of population has to be vaccinated to reach herd immunity.

# Solution: Efficacy Monitoring

The classical herd immunity level hC is defined as

$$hC = 1 - 1/R0$$

where R0 is the basic reproduction number, defined as the average number of new infections caused by a typical infected individual during the early stage of an outbreak in a fully susceptible population.

If the vaccine is not perfect,instead reduces susceptibility by a fraction E (so E = 1 corresponds to 100% efficacy), then the critical vaccination coverage is given by

$$vc = (E^{-1})(1 - 1/R0)$$

implying that a bigger fraction needs to be vaccinated if the vaccine is not perfect.

# Solution: Efficacy Monitoring

We tested varied vaccine efficacy of 38%, 50%, 60%, 70%, 80%, 90% and 95%. These estimates were selected based on published efficacy of vaccine candidates from their phase 3 trials and the remaining values to reflect a plausible efficacy range of forthcoming vaccine

| VE | Population vaccine coverage required for herd immunity |
|---|---|
| 95% | 63% |
| 90% | 66% |
| 80% | 75% |
| 70% | 86% |
| 60% | 100% |
| 50% | (Not achievable) |

# Solution: Efficacy Monitoring

- With a vaccine efficacy (VE) of 90%, vaccinating 66% of the total population will provide herd immunity and reduce the R0 to less than 1.
- A minimum VE of 85% is required to achieve herd immunity at 70% population coverage.
- A VE of 80% will require 75% of the population to be vaccinated, and VE of 60% will require 100% of the population to be vaccinated to achieve herd immunity.
- The required vaccine coverage for varying VE, and that efficacy below 60% cannot achieve herd immunity.

# Solution: Vaccine Administration & Allocation

- A Strategic National Stockpile shall be created which initially keeps all the vaccines.
- It then gets transferred to State Stockpiles for further distribution.
- An online platform to be created that provides a nationwide system for tracking vaccine administration and for notifying clients of the need for further dose of the vaccine.
- Inventory management is given utmost priority.
- Provide a statewide system for volunteer management and tracking.
- Provide oversight of provider enrollment, tracking, and vaccine location.
- Collaborate with Local Health Authorities to conduct a nationwide vaccination campaign

# Discussion & Scope

- This project ultimately leads to the development of an application that has carefully considered prioritization and alerts the authorities on areas where the allocation of vaccine is critical.

- The application shall register all the local distributors and shall keep track of the stockpile they possess to avoid misuse thus tracking  the flow of vaccine across India and its districts.

- Further can be improved to determine the exact percentage of population to be vaccinated in a particular district to reach herd immunity. (exact clinical efficacy value of the vaccine to be used needed).