COVID-19 VACCINATION

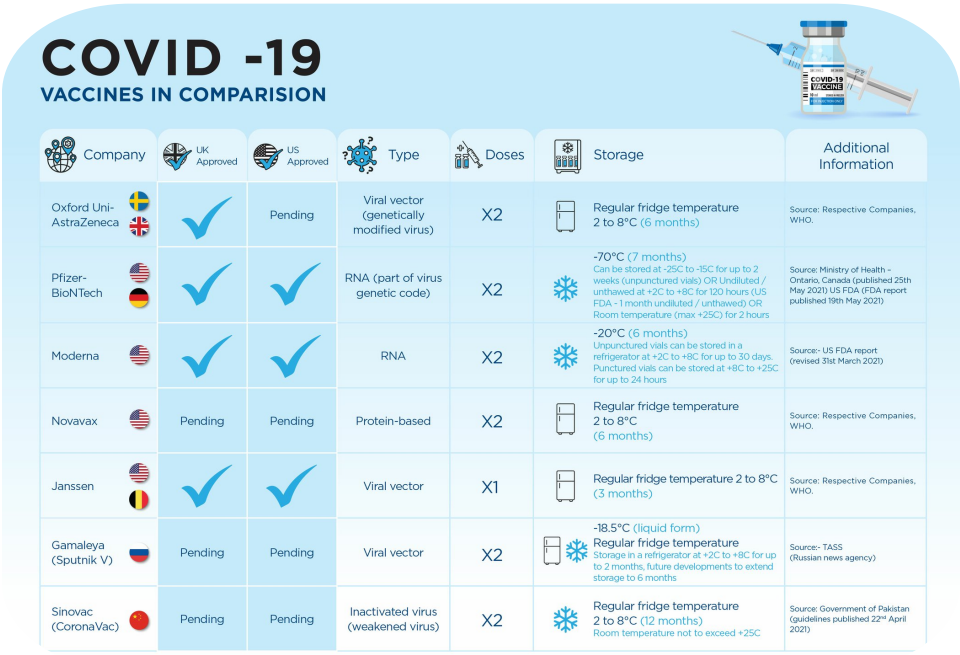
A GUIDE FOR POLICY MAKERS

INCREASING COVID-19 VACCINATION AVAILABILITY AND REDUCING HEALTH INEQUALITIES IN VACCINE UPTAKE

Vaccination Around the World

The progress in vaccination was paramount during the pandemic since the primary motivation for vaccination is to prevent infection.

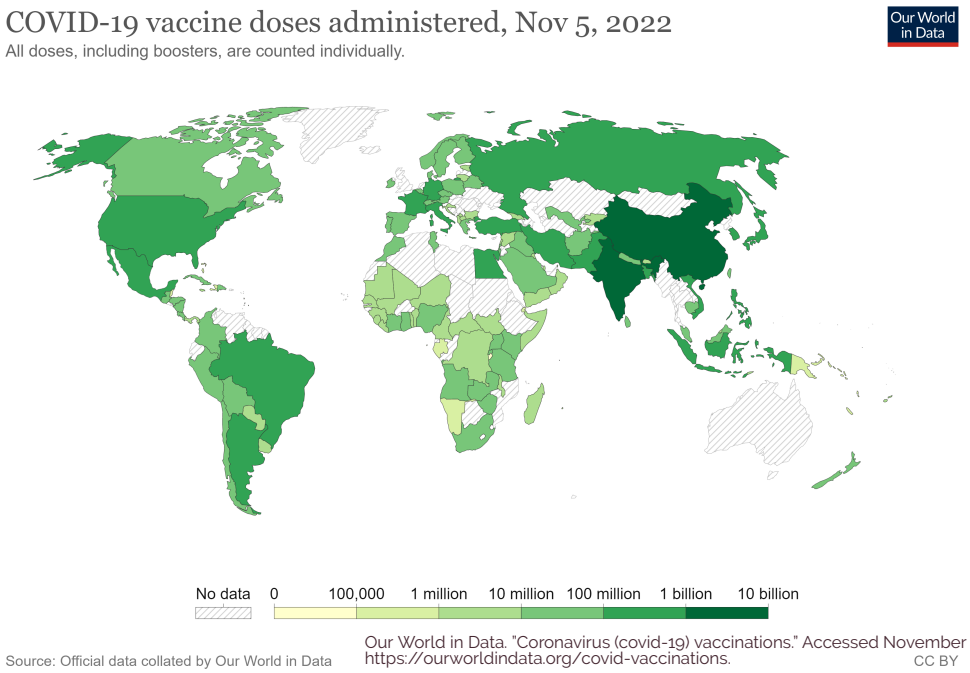
> There are only a few countries manufacturing vaccines. Health officials highly stress that it should be over everywhere for the pandemic to be over anywhere. Therefore, the manufactured vaccines are distributed to other countries.



European Pharmaceutical Manufacturer. "What's needed to protect covid-19 vaccines during transport" Accessed November 6, 2022, 2022. URL https://pharmaceuticalmanufacturer.media/pharmaceutical-industry-insights/pharmaceutical-logistics-distribution/what-s-needed-to-protect-covid-19-vaccines-during-transport/.

Even though vaccines were practical cures, there was highly unfair vaccine distribution across countries.

Some countries are prosperous in increasing the availability and access to vaccination.
However, there are still some countries that are struggling to increase the number of people who get vaccinated.
In many countries, vaccine availability remains scarce, and vaccination rates remain low.

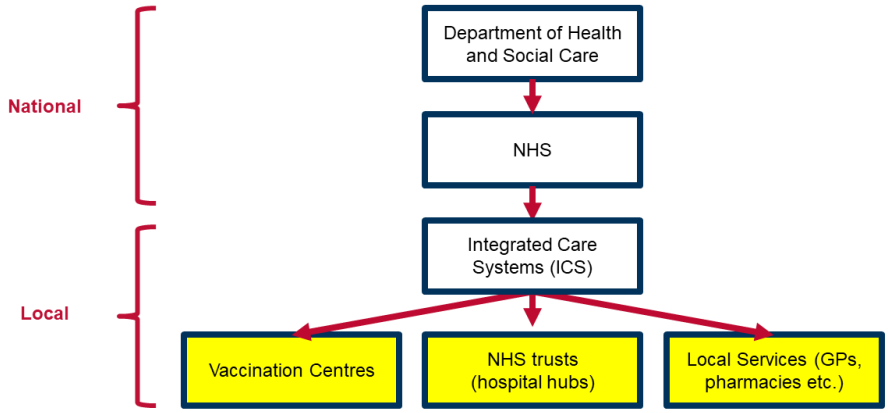


Our World in Data. "Coronavirus (covid-19) vaccinations." Accessed November 6, 2022, 2022. URL https://ourworldindata.org/covid-vaccinations.

The UK Vaccination Rollout Strategy

IN *THE UK, NATIONAL AND LOCAL LEVEL SERVICES ARE INTEGRATED INTO THE COVID-19 VACCINE PROGRAM.*

Department of Health and Social Care assigns the operational delivery of COVID-19 vaccines to NHS (National Healthcare Service). NHS is responsible for enabling delivery models and observing their performance while assuring equality in access to COVID-19 vaccines.



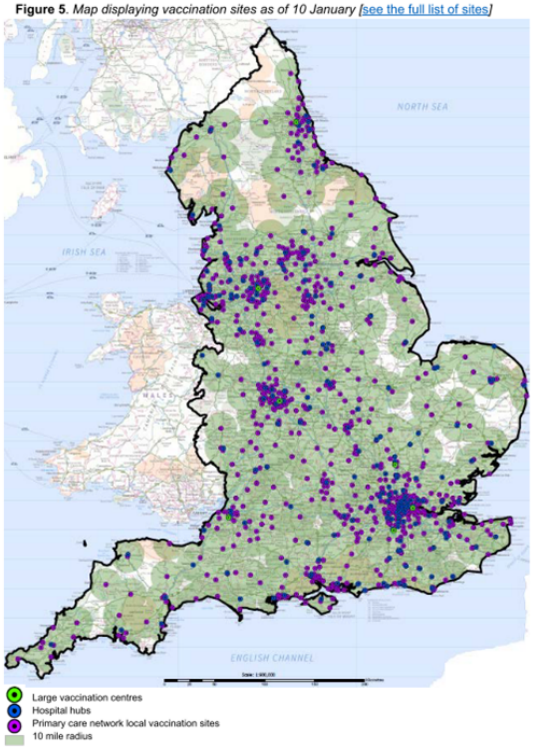
G. Davies. The rollout of the Covid-19 vaccination programme in England, 2022.

Hospitals and pharmacies are permanent centers managed by NHS trust and Local services, respectively. ***Mass vaccination centers, drive-throughs, and walk-in vaccination centers are temporary centers*** managed by both NHS trust and Local services.

Local services manage ***mobile services for a vulnerable part of the community,*** including elderly people, ethnic minority areas, and disadvantaged groups.

Department of Health & Social Care. "Policy paper UK COVID-19 vaccines delivery plan" Accessed November 6, 2022, 2021. URL https://www.gov.uk/government/publications/uk-covid-19-vaccines-delivery-plan/uk-covid-19-vaccines-delivery-plan

Figure 5. *Map displaying vaccination sites as of 10 January [see the full list of sites]*



96% of the population in the UK is within 10 miles of a vaccine service

In order to increase this level even more, they aimed to increase the number of active hospital hubs, local vaccination service sites and large vaccination centers while providing mobile vaccination units for highly rural areas.

Turkey Vaccination Strategies

In Turkey, vaccination is first implemented in hospitals and family health centers. It is also implemented in nursing homes, rehabilitation centers, protection houses, and there is a Home Health Services system for specific groups. In order to increase accessibility to vaccination, on-site vaccination started in shopping malls, high-speed train stations, airports (such as Esenboga), bus stations, industrial zones, large military units, and factories. Those on-site vaccination sites aim to provide convenience for employees who cannot visit health institutions due to working hours

Anadolu Ajansı. "Esenbo˘ga Havalimanı'nda Kovid-19 a¸sısı yapılmaya ba¸slandı." Accessed November 6, 2022. 2022a. URL https://www.aa.com.tr/tr/koronavirus/esenboga-havalimaninda-kovid-19-asisi-yapilmaya-baslandi/2288622.

Anadolu Ajansı. "Yenikapı Marmaray ˙Istasyonu'nda Kovid-19 a¸sı uygulanmasına ba¸slandı yapılmaya ba¸slandı." Accessed November 6, 2022, 2022b. URL https://www.aa.com.tr/tr/koronavirus/yenikapi-marmaray-istasyonunda-kovid-19-asi-uygulanmasina-baslandi/2292363.

TRT Haber. "Alı¸sveri¸s merkezinde ¸calı¸sanlara ve m˙u¸sterilere a¸sı." Accessed November 6, 2022, 2022. URL https://www.trthaber.com/haber/guncel/alisveris-merkezinde-calisanlara-ve-musterilere-asi-590234.html.

Success Stories

Bahçelievler Case

Bursa Case

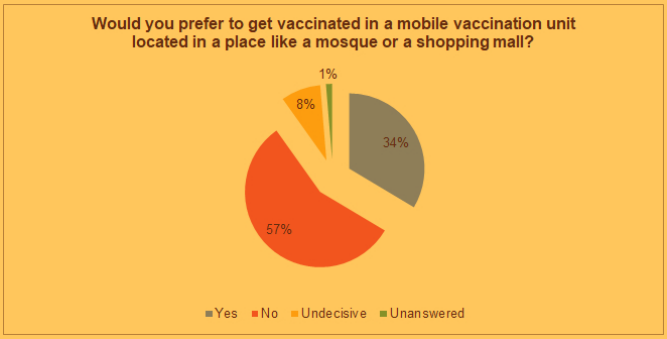
The half-mobile vaccination points are located. By those applications, the citizens can be vaccinated in the most crowded places of the districts. According to news, in one week, approximately 2,500 citizens received their first dose of vaccines in those mobile units.

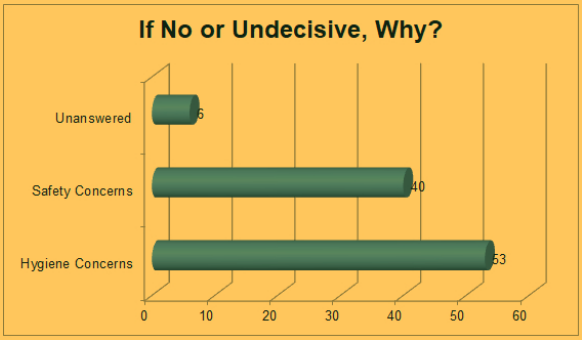
INTERVIEW WITH POLICYMAKERS AND HEALTH WORKERS:

Policymakers and health workers ensure that at each vaccination center, there are healthcare teams, including doctors, nurses, and health officials. In this way, they provide credit and safety of mobile units for the people to get vaccinated. Moreover, as a part of safety issues, they ensure that vaccines are stored in proper cold-chain conditions. There are arranged resting areas arranged by the municipalities for patients. First aid kits are also available for emergencies to increase safety.

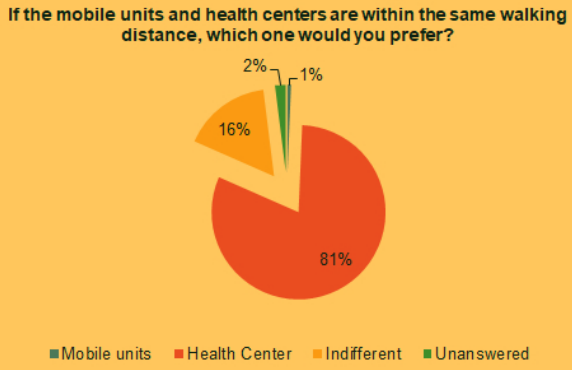
Survey

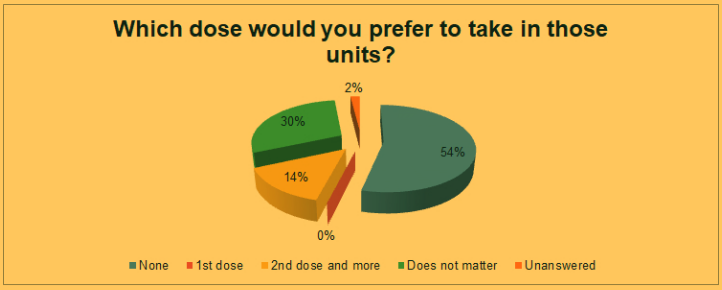
The extensive scale survey is used to get a more comprehensive range of people's perspectives on mobile vaccination. Participants were asked whether they would prefer to get vaccinated in a half-mobile vaccination unit located in mosques or shopping malls. The questions were asked to understand their reliance on mobile health units. 152 people are included in the survey.





Based on the results, we have observed that 57% of the participants do not prefer mobile units. When the reasons are analyzed, it is observed that it is mainly due to hygiene and safety concerns. Participants do not think those locations are sterile enough and are concerned about the cold chain for vaccination. Moreover, regarding safety issues, participants are mainly concerned about the difficulty in accessibility to a hospital in the case of an emergency.





Those who mostly prefer vaccination at hospitals rather than mobile units have safety concerns. Those who prefer vaccination in mobile units highlight that there is health personnel and mainly stated that the dosage does not matter. However, a remarkable percentage of people (14%) still stated that they would not take their first dosage even though they would accept the vaccination in mobile units.

ISSUES & SUGGESTIONS *on Mobile Vaccination*

A hygienic and sterile environment is suggested and shown as the primary concern.

The perception of people towards the quality of the health team and their equipment in mobile units should be improved. Including a better-equipped team and full-fledged medical devices can enhance the credit of mobile units.

In an emergency, means to access a health center by ambulance are strongly suggested to increase the reliability of mobile units.

A scientific Approach : Problem Definition

Our aims:
Improve social welfare and prevent the spread of COVID-19 through effective vaccination.
Improve the cost-effectiveness of deploying limited vaccines to the vast public while promoting health equity by increasing the accessibility to vaccines from disadvantaged social groups.

In order to achieve those goals, we wanted to improve the operational dynamics of mobile vaccination units. The mobile units are allowed to depart from the fixed centers and serve some locations. After achieving a certain vaccination level at a location, they can move to another location.
There are 2 cases: half-mobile services, and temporarily fixed centers with half-mobile services.

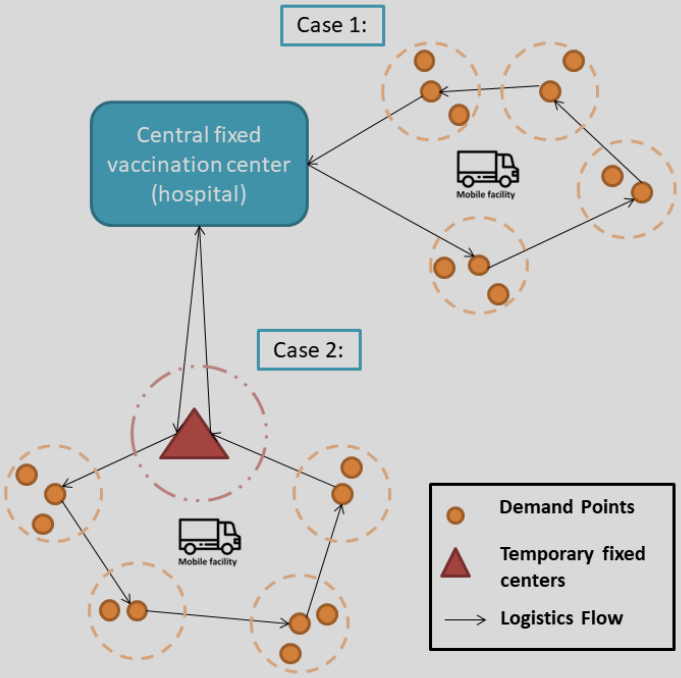
Problem Definition

Case 1 refers to the half-mobile services. A predefined number of mobile vaccination centers depart from the central vaccination center. Those mobile vaccination units visit and stay at specific locations. The vaccination potential denotes the number of people vaccinated hourly at those locations. If a mobile unit stays in a location for more than a specific time, the vaccination potential is expected to diminish. Moreover, people in the neighborhood of a visited district can walk on for vaccination. However, the willingness of people in those districts to reach mobile centers may decrease. Also, those mobile units have a time limit due to working hours, and they are expected to return to the central hospital.

We also consider Case 2, which is an extended version of Case 1 with temporarily fixed centers and diminishing vaccination potential of those centers. Case 2 is very similar to Case 1. Rather than one central hospital for mobile units to depart, Case 2 includes temporarily fixed centers that also allow mobile units to depart. Also similar to Case 1, it includes diminishing vaccination potential for mobile units and temporarily fixed centers.

Main Decisions and Decision Criteria

In Case 1, the main decisions are
• the locations visited among candidate visiting points,
• the length of stay of the mobile vaccination vehicles, and
• the tours of mobile vaccination vehicles.
The decision criteria were selected to maximize total vaccination collection and minimize maximum walking distance. The minimization of maximum walking distance is selected for the convenience of people in the neighborhood of a visited location.
In Case 2, the main decisions are
the same as in Case 1. However, there is also a decision:
• the locations of temporarily fixed vaccination centers.
The decision criteria were selected to maximize total vaccination collection and minimize the total distance traveled by mobile units.



Operational Research Literature

OR Literature on Case 1

The Selective Routing Problem complies with the characteristics of Case 1 for determining the tours of mobile vaccination centers. However, unlike Selective Routing Problems, Case 1 selects a subset of nodes to serve and maximizes the number of people vaccinated with coverage characteristics and diminishing vaccination potentials.
Furthermore, the Covering Tour Problem also complies with our aim of increasing the availability of vaccines by coverage.
Regardless, unlike the Covering Tour Problem, the focus is on maximizing the number of people vaccinated. It also requires a decision regarding the duration and nodes to serve.
Therefore, we adopt an extension of the Covering Tour and Selective Vehicle Routing approaches and combine it with coverage and time-dependent vaccination potential.

OR Literature on Case 2

The Selective Location Routing Problem complies with the characteristics of our problem in Case 2 for determining the locations of fixed centers and the tours of mobile vaccination centers.
Nevertheless, Case 2 has coverage characteristics and diminishing vaccination potentials for both fixed and mobile vaccination centers to allow the availability of vaccination to more districts.
We need more than a simple variant of the Selective Location Routing Problem to cover all features of our problem.
Hence, we adopt an extension of the Selective Location Routing approaches and combine it with coverage and time-dependent vaccination potential.

A General Guideline for Vaccination Implementation

Practical actions should be taken at the national level to endeavor the global health problem. It is important to increase the accessibility and availability of COVID-19 vaccines to be protected from the virus. There was highly unfair vaccine coverage across countries. Implementing different and effective vaccination strategies is essential to increase availability and reduce health inequalities in vaccine uptake.
We conducted interviews with individuals from Turkey and the UK to understand the current vaccination system dynamics. As a result, mobile vaccination centers appear to be a successful means of increasing the availability and accessibility of vaccines. We proposed a mobile vaccination system based on the best practices in the UK and Turkey. Then, we used the mathematical models to implement mobile vaccination strategies through a case study. We constructed a general guideline for implementing vaccines to reduce health inequality by combining the model results and interviews.

Step 1: Implementation of vaccines to fixed centers

Strategically, the number of fixed centers should be increased. Significantly, the initial fixed center locations should be chosen as hospitals, health centers, pharmacies, and primary care units. Those locations should be explicitly chosen due to safety and hygiene issues. However, the capacity of hospitals and health centers in a district may run short due to intensity. Therefore, new fixed vaccination centers are required for mass vaccination.

Step 2: Implementation of vaccines to functional fixed centers

Vaccination should be implemented in crowded areas such as shopping halls, stations, and industrial zones for people working during the day. Similar conditions in health institutions should be prepared in those locations, such as waiting rooms, to observe and interfere in urgent cases. There can be more functional fixed locations, such as walk-in or drive-through sites. The walk-in sites benefit people who do not prefer or cannot travel long distances to health centers. In contrast, drive-through sites benefit people who have a car. Similar to other mass vaccination centers, safe and sterile conditions should be satisfied.

Step 3: Implementation of vaccines to mobile centers

The fixed centers may only be able to cover some parts of the community. Even when the number of those fixed sites is increased, older people, ethnic minority areas, and disadvantaged groups may not be able to reach those fixed centers. A different vaccination strategy should be considered for those vulnerable parts of the community. For this purpose, mobile vaccination units are observed to be efficient in practice.

According to the practical and theoretical results, cooperating with mobile and fixed centers would provide much more extensive coverage of people. Moreover, mobile units are supplementary to fixed centers. The vaccination rates can be increased drastically with the supplement of the mobile unit. Therefore, implementing vaccines according to the guideline will increase vaccine availability and reduce health inequality.