# Blockchain for vaccine tracking

## Documentation Report

Submitted by

| | |
|---|---|
| Team ID | **NM2023TMID03767** |
| Team Lead | **Suruthika P** |
| Team Member 01 | **Haritha T** |
| Team Member 02 | **Harini M** |
| Team Member 03 | **Susithura E** |
| Team member 04 | **Vanathi R** |

# INDEX

# 1. INTRODUCTION

Vaccine tracking is a critical component of public health and healthcare systems worldwide. In an era defined by the ongoing battle against infectious diseases and the development of life-saving vaccines, monitoring and managing the distribution and administration of vaccines is of paramount importance. This process involves the meticulous documentation of vaccine doses, their sources, and the individuals who receive them, as well as the tracking of adverse events and the assessment of vaccination coverage. With the global response to the COVID-19 pandemic underscoring the significance of vaccine distribution and tracking, this system has never been more vital in safeguarding public health and creating a safer, healthier world for all. This introduction sets the stage for exploring the essential aspects of vaccine tracking, its benefits, and its role in our collective journey towards a disease-free future.

## 1.1 PROJECT OVERVIEW

The Vaccine Tracking System is a critical solution designed to streamline the management of vaccine distribution and administration, especially in the context of public health emergencies and routine vaccination programs. This project aims to create a robust, user-friendly platform that offers real-

time tracking and reporting capabilities for vaccines from manufacturer to patient. Here is an overview of the key components and functionalities:

Develop an intuitive dashboard for authorized users, including healthcare providers, government agencies, and vaccine manufacturers.

**Vaccine Inventory Management:**

Implement a system for manufacturers to upload vaccine details, production dates, and batch numbers.

Enable healthcare facilities to manage and track their vaccine inventory, including stock levels, expiration dates, and restocking notifications.

**Supply Chain Tracking:**

Establish a real-time tracking system for vaccines in transit, with GPS-enabled tags and sensors to monitor temperature and humidity conditions.

Enable stakeholders to track the movement of vaccines from manufacturers to distribution centers and healthcare facilities.

**Patient Registration and Scheduling:**

Develop a secure patient registration system for capturing demographic information and vaccination history.

Allow healthcare providers to schedule vaccine appointments and send reminders to patients.

**Vaccination Records and Reporting:**

Create a centralized database for storing and managing vaccination records.

Generate comprehensive reports on vaccination coverage, adverse events, and other critical data for public health analysis.

**Security and Compliance**:

Implement robust security measures to protect sensitive patient data and vaccine information.

Ensure compliance with data privacy regulations and healthcare standards.

**Mobile Accessibility:**

Develop a mobile application for healthcare providers to record vaccine administration on-site and access patient information securely.

**Integration with Public Health Systems:**

Enable seamless integration with public health agencies' systems for data sharing and reporting.

**Scalability and Sustainability:**

Design the system to accommodate growth and evolving vaccination needs.

Develop a plan for ongoing maintenance and updates.

**Expected Outcomes:**

Improved vaccine distribution efficiency.

Enhanced patient experience with streamlined scheduling and reminders.

Timely tracking and monitoring of vaccine supply chain.

Comprehensive data for informed public health decisions.

Greater transparency in vaccine availability and administration.

**Project Stakeholders:**

Government Health Agencies

Vaccine Manufacturers

Healthcare Providers

Patients

System Administrators

The Vaccine Tracking System will contribute to public health efforts by ensuring that vaccines reach the right people at the right time while maintaining the integrity of the supply chain and protecting patient data..

## 1.2 PURPOSE

**Monitoring Vaccine Uptake:**

Tracking vaccines helps health authorities and governments monitor the rate at which vaccines are administered to the population. This information can help identify areas or populations that may be falling behind in vaccination rates, allowing for targeted efforts to increase coverage.

**Vaccine Safety Monitoring:**

After vaccines are approved and distributed, ongoing monitoring helps identify and investigate any potential adverse effects or safety concerns. This allows for rapid response to any safety issues and can provide important data to inform regulatory decisions.

**Disease Surveillance**:

Tracking vaccine coverage and effectiveness can help health authorities monitor the prevalence of vaccine-preventable diseases. This information is critical for understanding disease trends and responding to outbreaks.

**Resource Allocation**:

Vaccine tracking can inform decisions about resource allocation, such as the distribution of vaccines to areas with the greatest need or planning for future vaccine procurement.

**Research and Development**:

Data from vaccine tracking can be used for research and development purposes, such as evaluating the long-term effectiveness of vaccines, improving vaccine formulations, and designing new vaccines.

**Public Health Planning**:

It helps public health agencies plan and implement vaccination campaigns, ensuring that vaccines are distributed to those who need them most and that vaccination programs are efficient and cost-effective.

**Individual and Community Health:**

Tracking vaccines can provide individuals with their vaccination history, which is useful for personal health management and for ensuring that they are up to date on recommended vaccines. Additionally, it helps create a collective immunity in communities, protecting those who cannot be vaccinated for medical reasons.

**Compliance and Accountability:**

Vaccine tracking can help ensure that healthcare providers and institutions adhere to vaccination guidelines and record-keeping requirements, promoting transparency and accountability.

**Global Health:**

Tracking vaccines is crucial for international health organizations and governments to assess global vaccination coverage and address vaccine-preventable diseases on a global scale.

**Emergency Response:**

In cases of disease outbreaks or public health emergencies, vaccine tracking can help authorities quickly identify vulnerable populations and target vaccination efforts to contain the spread of the disease.

# 2 LITERATURE SURVEY

A literature survey on vaccine tracking encompasses a comprehensive examination of research and developments in the field of vaccine monitoring and management. This critical area of public health has witnessed significant advancements in recent years, driven by the imperative need for efficient and transparent vaccine distribution. Several studies have focused on utilizing cutting-edge technologies, such as blockchain and RFID, to enhance the traceability of vaccines throughout the supply chain, ensuring their authenticity and preventing counterfeiting. Additionally, research has explored the integration of data analytics and machine learning for predictive modeling of vaccine demand, thereby aiding in optimized allocation and reducing wastage. Moreover, there is an increasing body of literature addressing the ethical and privacy concerns surrounding vaccine tracking, highlighting the

importance of striking a balance between public health goals and individual rights. Furthermore, international collaboration and standardization efforts, as observed in the Global Vaccine Alliance (Gavi) and the World Health Organization (WHO), have played a pivotal role in harmonizing tracking systems across borders. Overall, this literature survey reveals a multidisciplinary approach to vaccine tracking, with a focus on technological innovations, policy implications, and ethical considerations that collectively contribute to the global effort to improve vaccine distribution and coverage.

## 2.1 EXISTING PROBLEM

Existing problems in vaccine tracking include data accuracy and completeness, data fragmentation, data privacy and security concerns, vaccine supply chain issues, adverse event reporting challenges, accessibility and equity issues, vaccine hesitancy, technical obstacles, international coordination complexities, and the need for long-term monitoring. These challenges can hinder efficient vaccine distribution and monitoring efforts.

## *2.2 REFERENCE*

| Title | Year | Authors |
|---|---|---|
| *" Chain Management" Vaccine Logistics and Cold* | ***2016*** | ***Prashant Yadav, Anne Snowdon, Margaret C. Kruk*** |

## 2.3 PROBLEM STATEMENT DEFINITION

"Efficiently tracking the distribution, administration, and monitoring of vaccines across a healthcare system to ensure accurate and timely delivery, reduce vaccine wastage, enhance vaccine coverage, and maintain proper storage conditions, while safeguarding data privacy and security."

# 3 IDEATION & PROPOSED SOLUTION

Vaccine tracking is crucial for ensuring the effective distribution, administration, and monitoring of vaccines, especially

in scenarios like mass immunization campaigns, global health crises, and routine vaccinations. Below, I'll outline an ideation process and propose a solution for vaccine tracking:

# Ideation:

## Understanding the Problem:

Before proposing a solution, it's essential to understand the problem thoroughly. In this case, the primary issues are tracking vaccine supply, distribution, administration, and monitoring vaccine coverage.

## Key Stakeholders:

Identify the key stakeholders involved, including healthcare providers, public health agencies, vaccine manufacturers, and recipients.

## Technology and Infrastructure:

Assess the existing technological infrastructure in the target region. Consider whether internet connectivity is reliable and whether there's access to smartphones and computers.

**Data Privacy and Security**:

Prioritize data privacy and security, especially when dealing with sensitive medical information.

**Scalability:**

Ensure that the solution can scale up or down based on the size of the population and the number of vaccines being administered.

# Proposed Solution:

## Vaccine Management System:

Create a comprehensive Vaccine Management System (VMS) that integrates the following components:

- **Inventory Tracking**: Implement a barcode or RFID system to track vaccine shipments, storage, and distribution. Each vaccine vial should have a unique identifier.

- **Vaccine Distribution Software:** Develop software that allows for real-time tracking of vaccine shipments and their status. This can be integrated with GPS technology to monitor vaccine movement.

- **Vaccination Records System**: Create an electronic health record system where healthcare providers can input vaccine administration data, including the recipient's information, date, and location.

- **Reporting and Analytics**: Use data analytics to generate reports and insights on vaccine distribution, coverage, and any adverse events. Dashboards can help health authorities make informed decisions.

## Mobile Applications:

Develop user-friendly mobile apps for both healthcare providers and vaccine recipients:

- **Provider App**: Healthcare workers can use this app to scan vaccine vials, record vaccine administration, and access patient information.

- **Recipient App**: Individuals can use this app to schedule appointments, receive reminders, and access their vaccination records. This app should also provide educational materials about vaccines.

## Data Interoperability:

Ensure that the VMS and mobile apps can communicate with each other and with existing electronic health record systems to avoid duplicating efforts and data entry.

## Blockchain Technology:

Consider implementing blockchain for secure and immutable record-keeping. This can enhance data security and integrity, especially for critical information like vaccination records.

## SMS and IVR (Interactive Voice Response):

In regions with limited internet access, use SMS and IVR systems to send reminders, collect feedback, and provide information to vaccine recipients.

## Community Engagement:

Engage community leaders and influencers to promote vaccine awareness and encourage participation. Use social media, webinars, and community events to reach the population.

## Data Privacy and Security:

Implement strong data privacy and security protocols to protect individuals' sensitive health information.

## Feedback Mechanism:

Create a feedback mechanism for vaccine recipients to report adverse events or concerns, fostering transparency and trust.

## Scalability and Training:

Ensure that the system is easily scalable and provide training to healthcare workers and administrators.

**Continuous Improvement**:

Regularly evaluate the system's performance, collect feedback from users, and make continuous improvements to enhance its effectiveness.

**Global Collaboration**:

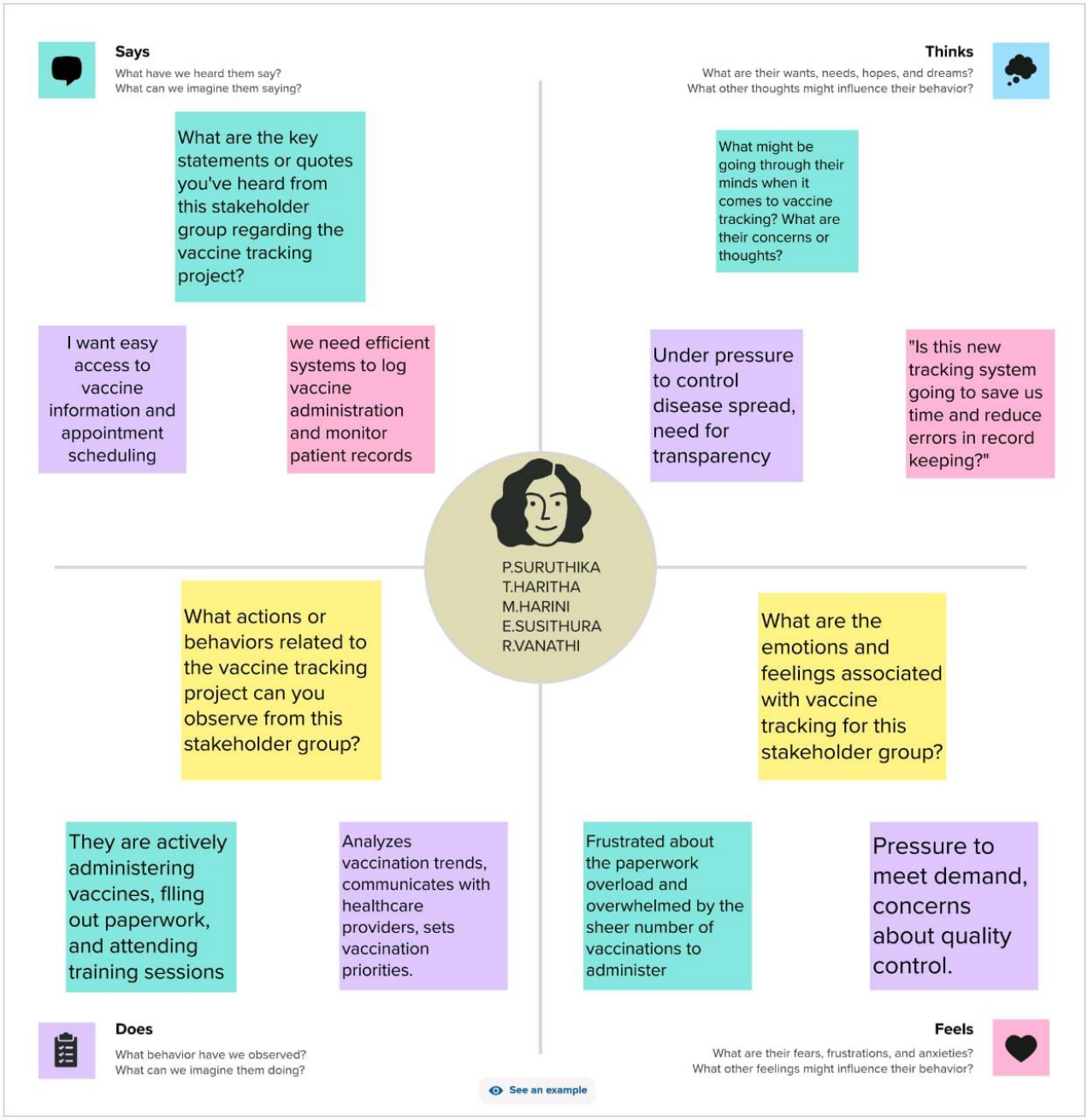
Collaborate with global health organizations to ensure the interoperability of systems and data sharing across borders, especially in the context of international travel and pandemics.

**Legislation and Regulations:**

Ensure compliance with local and international laws and regulation related to data protection, healthcare standards, and vaccine administration

## 3.1 EMPATHY MAP CANVAS

An empathy map is a visual tool used to understand and empathize with users' experiences, thoughts, feelings, and needs. It helps project teams gain deeper insights into their users' perspectives. The map




typically includes sections for what users see, hear, think and feel, say and do, and their pains and gains. By considering these aspects, teams can develop a more profound understanding of user behavior and create products or solutions tailored to users' genuine needs and emotions.

# 3.2 **IDEATION & BRAINSTORMING**

Ideation and brainstorming are creative techniques used to generate a diverse range of ideas for solving a problem or exploring new opportunities. During ideation, participants engage in a free-flowing, non-judgmental exchange of ideas. By encouraging open thinking and collaborative input, diverse concepts emerge. Brainstorming sessions often involve structured activities or discussions, sparking creativity and innovation within a team. These processes are essential for generating innovative solutions and fostering a collaborative, creative environment.

Template

# Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

**10 minutes** to prepare
**1 hour** to collaborate
**2-8 people** recommended

## Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

10 minutes

A **Team gathering**
Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

B **Set the goal**
Think about the problem you'll be focusing on solving in the brainstorming session.

C **Learn how to use the facilitation tools**
Use the Facilitation Superpowers to run a happy and productive session.

Open article →

## 1 Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

5 minutes

The challenge of efficiently distributing, administering, and monitoring vaccines

### Key rules of brainstorming

To run an smooth and productive session

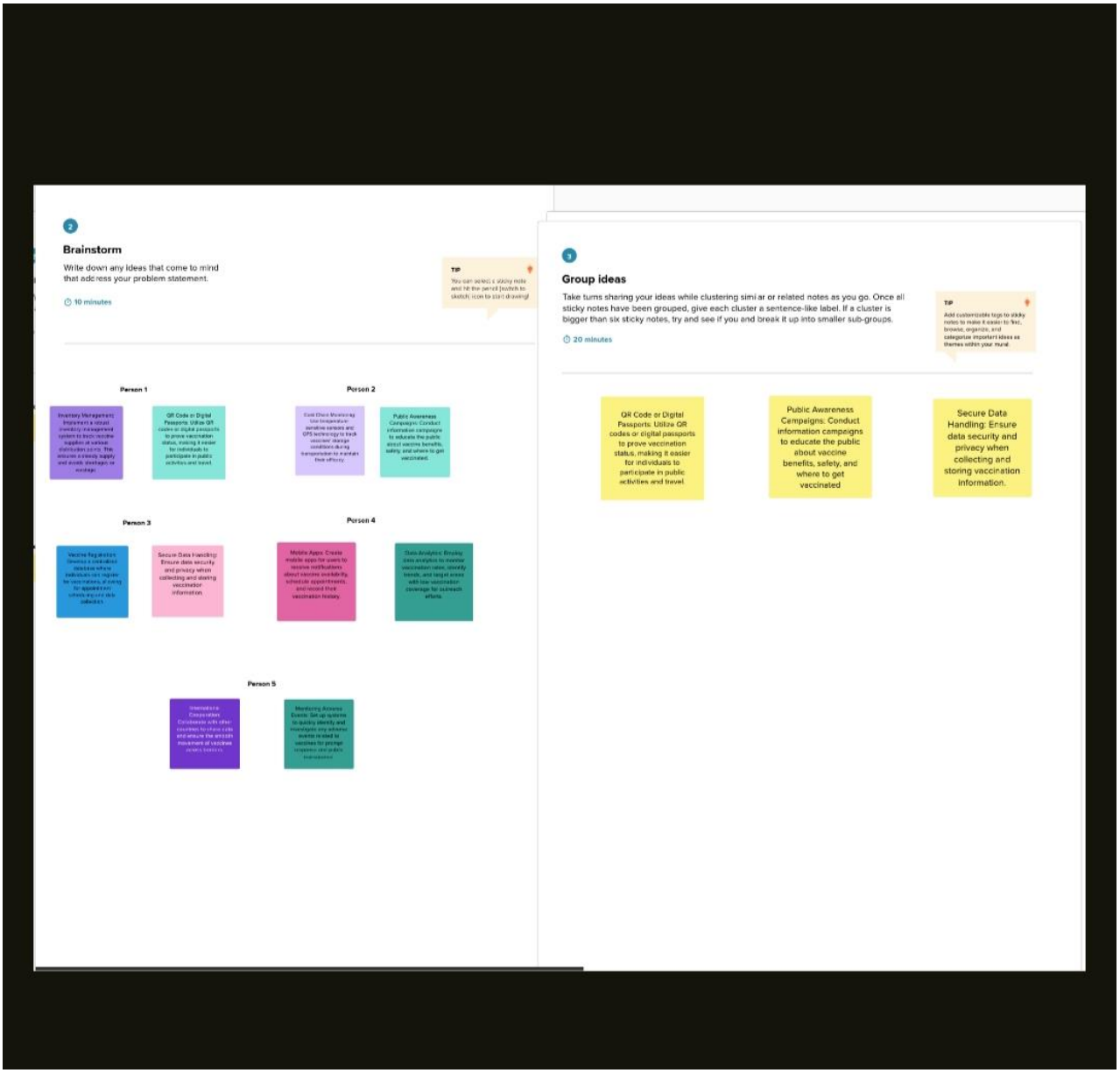
- Stay in topic.
- Encourage wild ideas.
- Defer judgment.
- Listen to others.
- Go for volume.
- If possible, be visual.

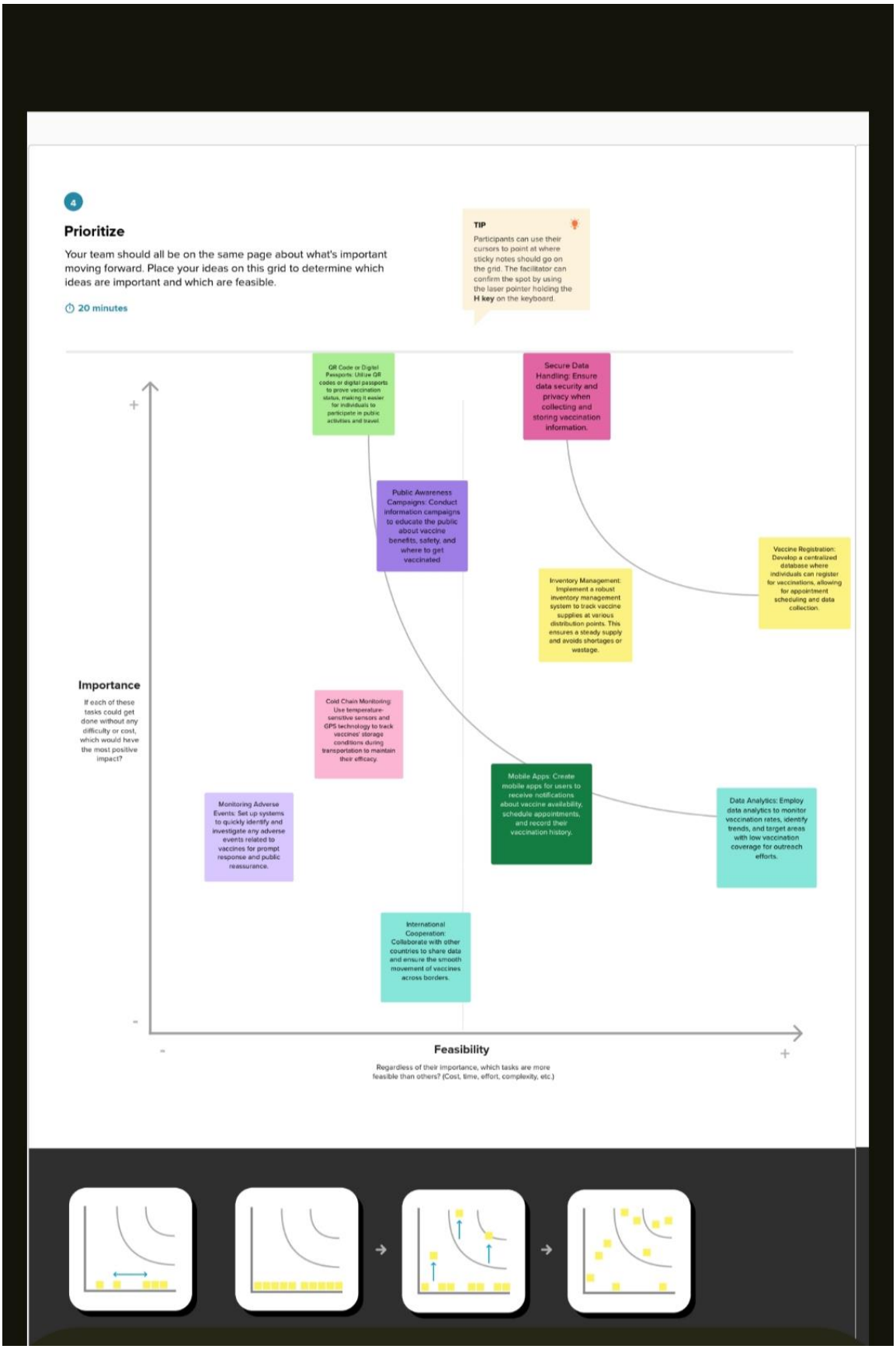
**Need some inspiration?**

See a finished version of this template to kickstart your work.

Open example →

# Idea listing




4
Prioritize
Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.
20 minutes
TIP
Participants can use their cursors to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the H key on the keyboard.
QR Code or Digital Passports: Utilize QR codes or digital passports to prove vaccination status, making it easier for individuals to participate in public activities and travel.
Secure Data Handling: Ensure data security and privacy when collecting and storing vaccination information.
Public Awareness Campaigns: Conduct information campaigns to educate the public about vaccine benefits, safety, and where to get vaccinated
Vaccine Registration: Develop a centralized database where individuals can register for vaccinations, allowing for appointment scheduling and data collection.
Inventory Management: Implement a robust inventory management system to track vaccine supplies at various distribution points. This ensures a steady supply and avoids shortages or wastage.
Importance
If each of these tasks could get done without any difficulty or cost, which would have the most positive impact?
Cold Chain Monitoring: Use temperature-sensitive sensors and GPS technology to track vaccines' storage conditions during transportation to maintain their efficacy.
Mobile Apps: Create mobile apps for users to receive notifications about vaccine availability, schedule appointments, and record their vaccination history.
Data Analytics: Employ data analytics to monitor vaccination rates, identify trends, and target areas with low vaccination coverage for outreach efforts.
Monitoring Adverse Events: Set up systems to quickly identify and investigate any adverse events related to vaccines for prompt response and public reassurance.
International Cooperation: Collaborate with other countries to share data and ensure the smooth movement of vaccines across borders.
+
-
-
+
Feasibility
Regardless of their importance, which tasks are more feasible than others? (Cost, time, effort, complexity, etc.)

# 4 REQUIREMENT ANALYSIS

Requirement analysis is a critical phase in the software development lifecycle where project teams gather, document, and analyze the needs and expectations of stakeholders. This process forms the foundation for designing and developing a system that fulfills these requirements effectively. It involves understanding the project's scope, objectives, and constraints, as well as the functional and non-functional requirements

.

## 4.1 .FUNCTIONAL REQUIREMENTS

Functional requirements for a vaccine tracking system are essential to ensure the system's effectiveness in monitoring and managing vaccines. Here are some key functional requirements for a vaccine tracking system:

**User Authentication and Authorization:**

The system should provide user authentication to ensure only authorized personnel can access and update vaccine data.

Role-based access control should be implemented to restrict access based on user roles (e.g., healthcare professionals, administrators, auditors).

**Vaccine Registration**:

The system should allow for the registration of new vaccines, including details such as vaccine name, manufacturer, lot number, and expiration date.

It should support the ability to specify vaccine categories (e.g., pediatric, adult, COVID-19).

**Vaccine Inventory Management:**

Track vaccine inventory levels in real-time, including the current stock, incoming shipments, and doses administered.

Alert administrators when vaccine stock levels reach predefined thresholds to prevent shortages.

**Dose Administration:**

Record the administration of vaccine doses to patients, capturing details like the patient's name, date of administration, and healthcare provider.

Verify and document the type of vaccine administered (e.g., first dose, second dose) for multi-dose vaccines.

**Batch and Lot Tracking:**

Enable tracking of vaccine batches and lots to quickly identify and manage recalled or expired vaccines.

Record information about the supplier, manufacturing date, and expiration date for each batch.

**Storage Conditions Monitoring:**

Monitor and record the temperature and storage conditions of vaccines to ensure they remain within the recommended range.

Generate alerts and notifications for temperature excursions or storage issues.

**Expiry Date Tracking:**

Notify users when vaccines are approaching their expiration dates, allowing for proactive removal or replacement.

Archive expired vaccines to maintain a complete historical record.

**Reporting and Analytics**:

Generate reports on vaccine inventory, usage, wastage, and compliance with vaccination schedules.

Provide data analytics tools to analyze trends, identify vaccine utilization patterns, and forecast future needs.

**Integration with Health Records:**

Integrate with electronic health record (EHR) systems to maintain patient vaccination history and facilitate data sharing with healthcare providers.

Support standard data exchange formats (e.g., HL7, FHIR) for interoperability.

**Security and Data Protection:**

Implement data encryption, data backup, and disaster recovery measures to ensure the security and integrity of vaccine data.

Comply with data protection regulations and privacy laws (e.g., HIPAA, GDPR).

**Audit Trail:**

Maintain a detailed audit trail of all vaccine-related activities, including user actions, date, and time stamps for accountability and traceability.

**Mobile Access:**

Provide a mobile application for healthcare professionals to record vaccine administration and access vaccine information on the go.

**Barcode/QR Code Scanning:**

Support barcode or QR code scanning to streamline vaccine identification and tracking processes.

**Notifications and Alerts:**

Send alerts and notifications to relevant personnel for critical events, such as temperature excursions, recalls, or low inventory levels.

**Compliance Tracking:**

Ensure compliance with regulatory requirements and guidelines related to vaccine storage, administration, and reporting.

These functional requirements are crucial for an effective vaccine tracking system to ensure the safety, quality, and availability of vaccines while meeting regulatory and reporting obligations. The specific requirements may vary based on the organization's needs and the type of vaccines being tracked

## 4.2 NON-FUNCTIONAL REQUIREMENTS

Non-functional requirements define system qualities, constraints, and limitations. These requirements focus on aspects like performance, security, usability, and compliance. For this project, non-functional requirements might include:

- **Performance:** The system should handle a specific number of simultaneous users and transactions without significant performance degradation, ensuring real-time access to patient records.

- **Security:** The platform should adhere to industry-standard security practices, ensuring data confidentiality, integrity, and availability. It should protect against common cybersecurity threats such as DDoS attacks and unauthorized access attempts.
- **Usability:** The user interface should be user-friendly and accessible, catering to users with varying technical expertise. It should minimize the learning curve and provide clear instructions for system usage.
- **Compliance:** The system must comply with healthcare data regulations and standards, such as HIPAA (Health Insurance Portability and Accountability Act) in the United States or GDPR (General Data Protection Regulation) in Europe. Compliance ensures the legal and ethical handling of patient data.
- **Scalability:** The system should be scalable, allowing for future expansion in terms of users, patient records, and functionalities. It should handle increased loads without compromising performance or data integrity.

# 5 PROJECT DESIGN

**Project Initiation:**

- Define the project scope, objectives, and deliverables.
- Establish a project team with members from various relevant departments (e.g., healthcare, IT, logistics, government agencies).
- Secure necessary funding and resources.

**Requirements Gathering**:

- Identify key stakeholders and gather their requirements.
- Analyze the legal and regulatory requirements for vaccine tracking.
- Determine the technology and infrastructure needed for the project.

**System Design:**

- Develop a high-level system architecture.
- Design the user interfaces for data entry and reporting.
- Define data structures and data flow diagrams for vaccine tracking.
- Select and procure necessary hardware and software.

**Development and Implementation:**

- Build the vaccine tracking system according to the design.
- Implement the system in phases, starting with a pilot program.
- Ensure integration with existing healthcare systems, if applicable.

- Train users on system operation and data entry.

**Data Collection and Integration**:

- Establish data collection points at vaccination centers and distribution hubs.
- Implement data integration protocols to ensure real-time data exchange.
- Implement barcode or QR code scanning for vaccine vials and patient records.

**Inventory Management:**

- Develop features for tracking vaccine inventory levels and expiration dates.
- Implement automatic reordering and alerts for low inventory.

**Vaccine Distribution:**

- Create a route optimization algorithm for vaccine distribution.
- Implement GPS tracking for vaccine shipment vehicles.
- Monitor temperature and storage conditions during transportation.

**Vaccine Administration:**

- Record and verify patient information during vaccination.
- Ensure the secure and real-time update of administered doses.
- Implement patient reminders for follow-up doses.

**Reporting and Analytics**:

- Develop reporting tools to generate real-time dashboards and reports.
- Analyze data for vaccine coverage, adverse events, and other critical metrics.

**Security and Compliance:**

- Implement robust security measures to protect sensitive data.
- Ensure compliance with healthcare data privacy regulations (e.g., HIPAA).
- Conduct regular security audits and vulnerability assessments.

**Testing and Quality Assurance:**

- Test the system thoroughly to identify and rectify any issues.
- Ensure data accuracy and system reliability.

**Scale-up and Rollout:**

- Expand the system to cover larger regions or the entire population.
- Monitor system performance and address scalability issues as needed.

**User Training and Support:**

- Provide ongoing training and support to users.
- Maintain a helpdesk for issue resolution.

**Monitoring and Evaluation:**

- Continuously monitor the system's performance and effectiveness.
- Collect feedback from users and stakeholders for improvements.

**Documentation and Knowledge Transfer:**

- Document all processes, configurations, and procedures.
- Ensure knowledge transfer to future administrators and maintainers.

**Project Closure:**

- Conduct a project review and evaluation.
- Ensure that all project objectives have been met.
- Handover the system to the relevant authorities for long-term operation.

Remember that vaccine tracking is a critical public health initiative, and the system should prioritize data security, accuracy, and compliance with healthcare regulations. Regular updates and improvements should be part of the long-term plan to adapt to changing vaccine needs and technologies

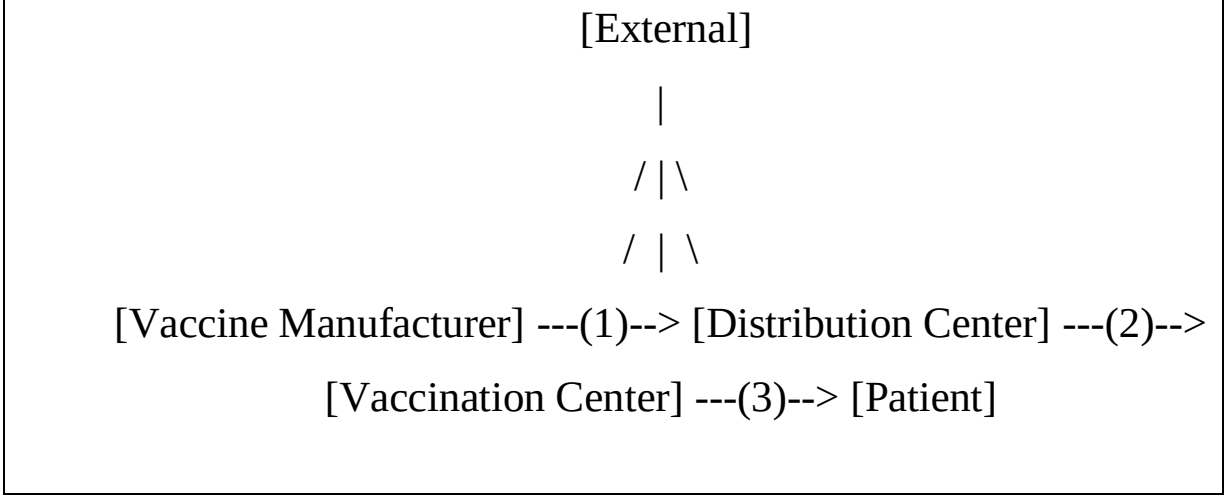
## 5.1 DATA FLOW DIAGRAMS

A Data Flow Diagram (DFD) for vaccine tracking can help illustrate the flow of information in a system that tracks the distribution, administration, and monitoring of vaccines. Here's a simplified DFD for vaccine tracking:

**Level 0 DFD:**

The Level 0 DFD represents the overall system and its major components.

| Scss | Copy code |
|---|---|




**Description of the main components:**

- **Vaccine Manufacturer**: This is where vaccines are produced. They send vaccines to distribution centers.

- **Distribution Center:** The distribution center receives vaccines from manufacturers and then distributes them to various vaccination centers.

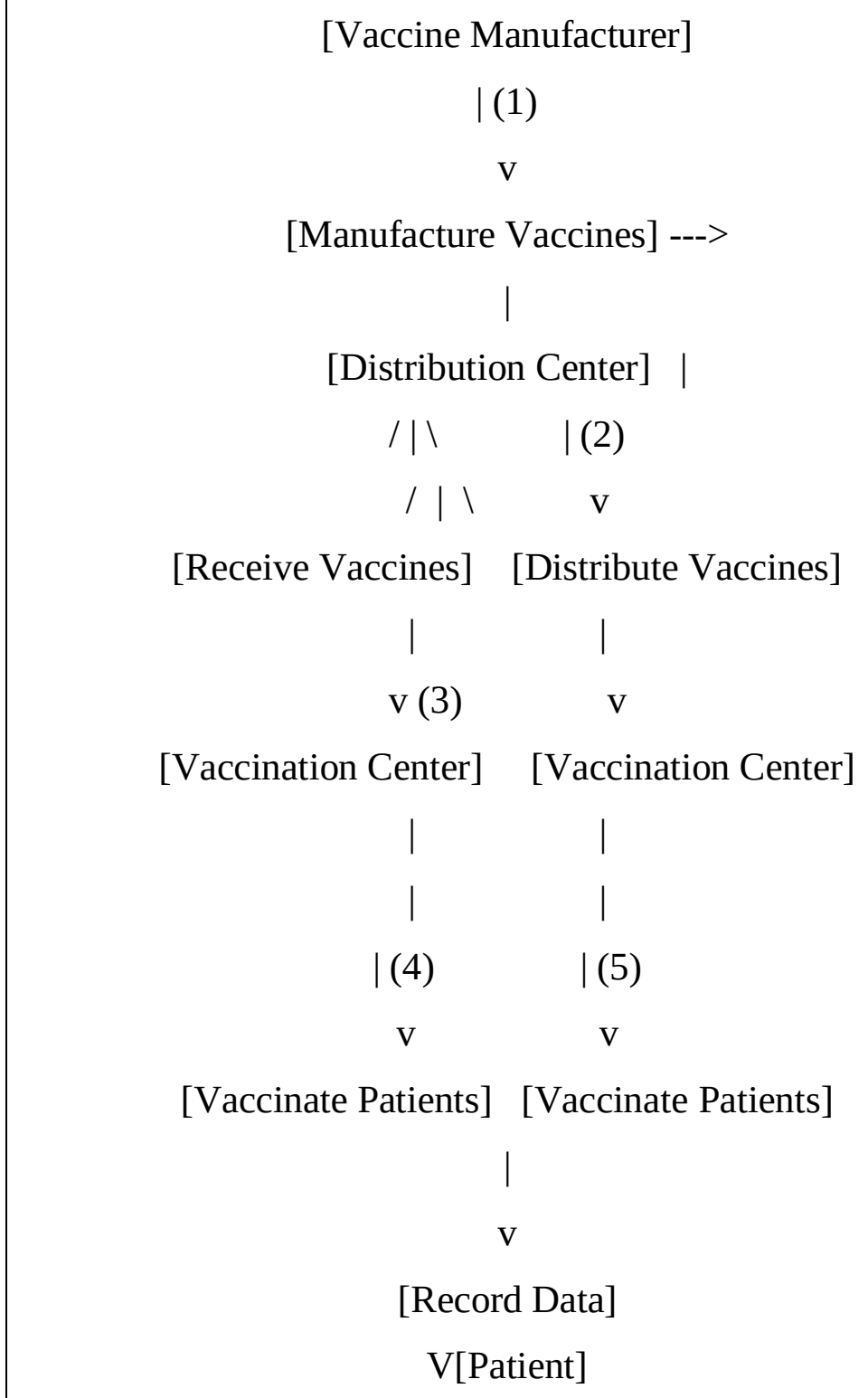
- **Vaccination Center**: These are the locations where vaccines are administered to patients. They also record patient information and vaccine details.

- **Patient:** The individuals receiving the vaccine. Patient information and vaccination status are recorded.

**Level 1 DFD**:

Now, let's expand the DFD for more details within each component.

Scss Copy code



**Description of the Level 1 components:**

- **Vaccine Manufacturer**: The manufacturer produces vaccines.

- **Distribution Center**: The distribution center receives vaccines from manufacturers and distributes them to multiple vaccination centers.

- **Vaccination Center**: These centers receive vaccines from the distribution center and administer them to patients. They also record vaccination data.

- **Vaccinate Patients**: This process involves the actual administration of vaccines to patients at vaccination centers.

- **Record Data**: Vaccination centers record patient information, vaccine details, and vaccination status. This data may be shared with other entities like public health agencies for tracking and reporting.

- **Patient:** Individuals who receive vaccines. Patient data is recorded by the vaccination centers.

This DFD illustrates the flow of information and vaccines from the manufacturer to patients through various intermediaries in the vaccine tracking system. It shows the major processes and data flows within the system. Depending on the complexity and specific requirements of the system, you can create more detailed DFDs or add additional processes and data stores as needed.

## 5.2 SOLUTION ARCHITECTURE

Creating a solution architecture for vaccine tracking is crucial for ensuring the efficient and secure distribution and monitoring of vaccines, especially in situations like pandemics. Such an architecture should encompass various components to cover the entire lifecycle of vaccines, from production and storage to distribution and administration. Below is a high-level overview of a solution architecture for vaccine tracking:

**1. Data Collection and Integration:**

- Vaccine Manufacturers: Collect data from vaccine manufacturers to track production, expiration dates, and batch details.

- Healthcare Providers: Integrate with healthcare providers to gather information on vaccine administration.
- Supply Chain: Connect with supply chain partners to monitor the movement of vaccines from production to distribution centers.

**2. Data Storage:**

Maintain a centralized database to store all vaccine-related data securely, ensuring data integrity and compliance with data protection regulations.

**3. IoT and Sensor Integration:**

Use Internet of Things (IoT) devices and sensors to monitor vaccine storage conditions, such as temperature, humidity, and light exposure.

**4. Blockchain Technology:**

Implement a blockchain-based ledger system for transparent and immutable recording of vaccine-related data, ensuring data integrity and traceability.

**5. Vaccine Information System (VIS):**

Develop a Vaccine Information System to manage vaccine administration, including patient records, vaccination schedules, and adverse event monitoring.

**6. Mobile and Web Applications**:Create user-friendly mobile and web applications for healthcare providers, patients, and other stakeholders to input and access vaccine-related data.

**7. QR Code or RFID Tagging:**

Assign QR codes or RFID tags to each vaccine dose to enable quick and accurate tracking and verification.

**8. Machine Learning and AI:**

Utilize machine learning and AI algorithms for demand forecasting, route optimization, and anomaly detection in the supply chain.

**9. Security and Access Control**:

Implement robust security measures to protect sensitive vaccine data from unauthorized access, including encryption, access controls, and audit trails.

**10. Real-Time Monitoring and Alerts:**

Set up real-time monitoring systems that trigger alerts for temperature deviations, vaccine shortages, or any anomalies in the supply chain.

**11. Reporting and Analytics:**

Develop reporting and analytics tools to provide insights into vaccine distribution, administration rates, and inventory levels.

**12. Regulatory Compliance**:

Ensure compliance with regulatory requirements and standards for vaccine tracking and reporting.

**13. Data Sharing and Interoperability:**Establish interoperability standards to enable data sharing between different systems, agencies, and healthcare providers while maintaining data privacy and security.

**14. Geographic Information System (GIS):**Integrate GIS for geospatial analysis to optimize vaccine distribution routes and identify vaccination deserts.

**15. Disaster Recovery and Redundancy:**Implement robust disaster recovery and redundancy mechanisms to ensure the system's availability in case of system failures or disasters.

**16. User Training and Support:**Provide training and support for users to ensure the efficient use of the tracking system.

**17. Public Communication:**Create a public-facing platform to disseminate vaccine-related information, including availability, safety, and administration locations.

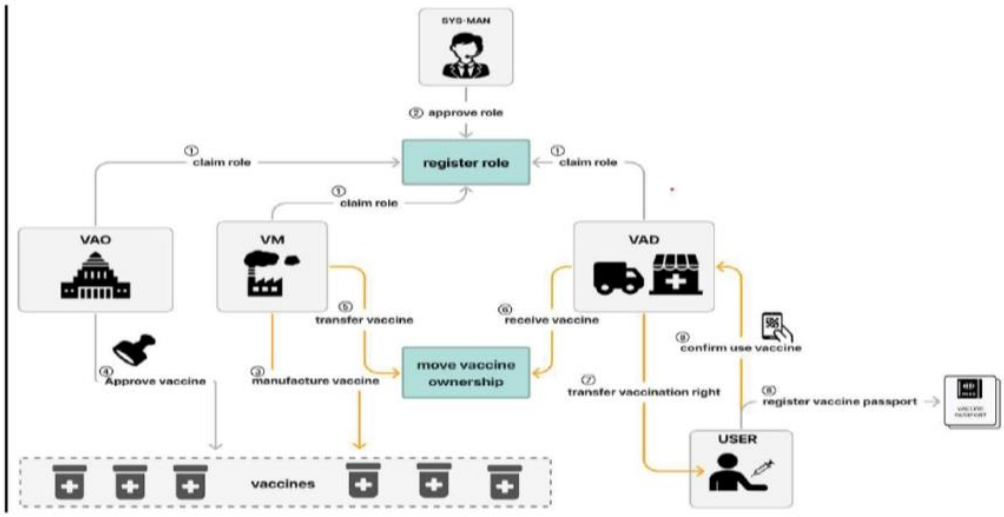
**18. Audit and Compliance Logging:**

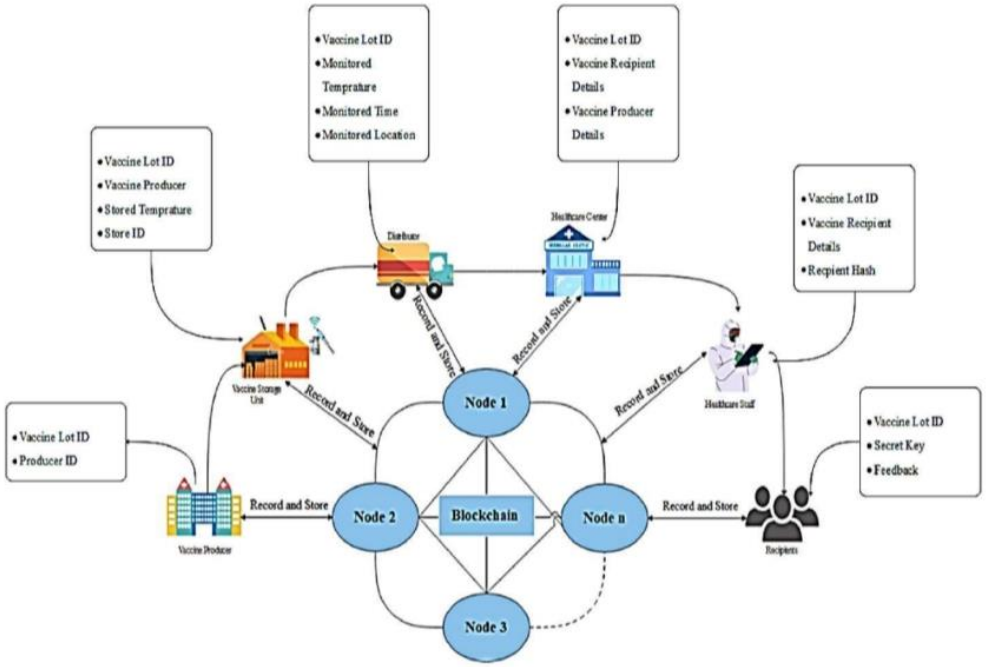
Maintain detailed logs of all transactions and changes to vaccine data to meet audit and compliance requirements.

This solution architecture aims to provide end-to-end visibility and control over the vaccine supply chain, ensuring the safe and efficient distribution and administration of vaccines while maintaining data

security and compliance. The specific implementation may vary depending on the scale, resources, and requirements of the vaccine tracking system

**Example - Solution Architecture Diagram:**



# 6 PROJECT PLANNING & SCHEDULING

Planning and scheduling a vaccine tracking project is essential for its successful implementation. Below is a step-by-step guide to help you create a project plan and schedule for vaccine tracking. Please note that this is a simplified outline, and the specific requirements and tasks may vary depending on the scale and complexity of your project.

**1. Define Project Objectives and Scope:**

Clearly define the goals and objectives of the vaccine tracking project.Determine the scope of the project, including the type of vaccines to be tracked, geographic areas, and populations to be covered.

**2. Stakeholder Identification:**Identify all the stakeholders involved, such as government agencies, healthcare providers, pharmaceutical companies, and end-users.

**3. Project Team Formation:**Assemble a project team with the necessary skills and expertise, including project manager, developers, data analysts, and subject matter experts.

**4. Requirements Gathering:**Document the specific requirements for the vaccine tracking system, including data collection, reporting, and user interface.

**5. Technology Stack Selection:**Choose the appropriate technology stack for the project, considering factors like scalability, security, and data management.

**6. Data Collection and Integration**:Develop data collection methods, including APIs and data sources from healthcare providers and vaccination centers.

**7. System Design:**Create a system architecture and database design.

Develop wireframes and prototypes for the user interface.

**8. Development and Testing:**

- Start development of the vaccine tracking system.
    - Conduct thorough testing to ensure data accuracy and system reliability.

**9. Data Security and Compliance:**

- Implement security measures to protect sensitive vaccine data.
    - Ensure compliance with relevant data privacy and healthcare regulations.

**10. Deployment:**

- Deploy the system in a controlled environment for initial testing.
- Fine-tune the system based on user feedback and performance metrics.

**11. User Training and Documentation:**

- Provide training to users and healthcare providers on how to use the vaccine tracking system.
  Create documentation for reference.

**12. Rollout and Adoption:**

- Gradually roll out the system to a wider user base.
- Monitor adoption and address any issues that arise.

**13. Data Analysis and Reporting**:

- Develop reporting tools to analyze vaccine distribution and utilization.
- Generate regular reports for stakeholders.

**14. Ongoing Maintenance and Support:** Establish a system for ongoing maintenance, updates, and user support.

**15. Monitoring and Evaluation:**

- Continuously monitor the system's performance and user feedback.
- Evaluate the project's success in achieving its objectives.

**16. Risk Management:** Identify potential risks and develop mitigation plans.

**17. Timeline and Schedule**: Create a detailed project schedule with specific timelines for each phase and milestone. Here's a simplified example:

Project Initiation: 2 weeks

Requirements Gathering: 3 weeks

System Design: 4 weeks

Development and Testing: 12 weeks

Deployment and User Training: 6 weeks

Rollout and Adoption: 10 weeks

Data Analysis and Reporting: Ongoing

Ongoing Maintenance and Support: Ongoing

Make sure to allocate buffer time for unforeseen delays and changes.

**18. Communication Plan:** Establish a communication plan to keep stakeholders informed of the project's progress and any changes.

**19. Budget and Resource Allocation**: Determine the project budget and allocate resources accordingly.

**20. Project Review and Documentation**:

- Conduct regular project reviews to assess progress and make necessary adjustments.
- Document all project activities, decisions, and outcomes.

## 6.1 TECHNICAL ARCHITECTURE

Tracking vaccines, especially in the context of public health and healthcare systems, requires a robust technical architecture to ensure the secure and efficient management of vaccine-related data. Below is an outline of a technical architecture for vaccine tracking:

**Data Collection and Entry**:

- **Vaccine Administration**: Healthcare providers and facilities should use electronic health record (EHR) systems or specialized vaccine tracking software to record vaccine administrations. This data includes patient information, vaccine type, date of administration, and lot numbers.
- **Batch and Inventory Management**: Track the receipt, storage, and distribution of vaccine batches. Barcode scanning or RFID technology can be used to automate this process.

**Data Storage:**

- Centralized Database: Store vaccine-related data in a secure and centralized database. Use industry-standard security protocols and encryption to protect patient information.
- Cloud-Based or On-Premises: Choose between a cloud-based or on-premises database solution, depending on scalability and security requirements.

**Interoperability:**

- Health Information Exchange (HIE): Ensure interoperability with regional or national health information exchange systems, allowing healthcare providers and public health agencies to share and access vaccine data.
- Standardized Data Formats: Use standardized formats like HL7 or FHIR for data exchange between systems.

**User Access and Authentication:**

Implement robust user access control and authentication mechanisms to restrict access to authorized personnel only.

Use role-based access controls (RBAC) to define what different users can do within the system.

**Vaccine Tracking System:**

Develop or implement a specialized vaccine tracking system that offers features like real-time tracking, alerts for vaccine inventory levels, and batch expiration notifications.

Provide an intuitive user interface for healthcare providers to input and access data.

**Integration with External Systems:**

Integrate with vaccine manufacturers and suppliers to receive real-time updates on vaccine availability and recalls.

Integrate with state or national immunization registries to maintain a comprehensive record of vaccinations.

**Data Analytics:**

- Utilize data analytics and reporting tools to monitor vaccine coverage, identify trends, and generate reports for public health decision-making.
- Implement business intelligence tools to extract meaningful insights from the collected data.

**Data Security and Privacy:**

Adhere to strict data security and privacy regulations such as HIPAA (in the United States) and GDPR (in the European Union).

Implement data encryption, regular security audits, and access control measures.

**Mobile Applications:**

Develop mobile apps for healthcare providers to access and update vaccine records in real-time, particularly in the case of field vaccinations.

**Scalability and Redundancy:**

- Ensure the system can scale to handle increased demand, especially during vaccination campaigns.
- Implement redundancy and disaster recovery plans to ensure continuous operation.

**User Training and Support**:

- Provide comprehensive training for healthcare providers and system administrators.
- Offer technical support to address issues and ensure the smooth operation of the vaccine tracking system.

**Regulatory Compliance:**

Stay current with regulatory requirements related to vaccine tracking and reporting, and update the system accordingly.

**Auditing and Logging:**

Maintain detailed audit logs to track changes to vaccine data and user actions for accountability and troubleshooting

## 6.2 SPRINT PLANNING & ESTIMATION

Sprint planning is a meeting held at the beginning of each sprint in Agile development. During this session, the team discusses and prioritizes the tasks to be completed in the upcoming sprint. It involves selecting user stories from the product backlog, breaking them down into smaller tasks, estimating the effort required, and defining the sprint goals. Sprint planning ensures a clear direction for the team, aligning everyone on what needs to be accomplished within the sprint.

**Estimation:**

Estimation in Agile involves predicting how much effort a task or user story will require. It's typically done using story points or time-based estimates like hours or days. Team members collectively estimate the complexity and effort of tasks during sprint planning. Estimation helps teams understand the workload, plan capacity, and make informed decisions on what can be achieved within a sprint. It

provides a basis for prioritization and ensures a realistic approach to task completion within the given timeframe.

## 6.3 SPRINT DELIVERY SCHEDULE

- **Regular Intervals:** Sprints occur at regular intervals, with a consistent duration agreed upon by the team.

- **Sprint Goals:** Each sprint begins with sprint planning, where specific goals and tasks are defined based on the prioritized backlog items.

- **Development Phase:** During the sprint, the team works on the planned tasks, ensuring they align with the sprint goals.

- **Daily Stand ups:** Daily standup meetings are conducted to track progress, discuss challenges, and make necessary adjustments.

- **Sprint Review:** At the end of the sprint, a sprint review meeting is held to showcase the completed work to stakeholders and gather feedback.

- **Sprint Retrospective:** A retrospective meeting allows the team to reflect on the sprint, identify areas for improvement, and plan for the next sprint.

- **Delivery:** The completed and tested user stories, features, or bug fixes are delivered to stakeholders and may be deployed to production, depending on the project's release schedule.

- **Next Sprint Planning:** Following the sprint review and retrospective, the team conducts sprint planning for the next sprint, defining new goals and tasks based on updated priorities.

# 7. CODING & SOLUTIONING

Coding refers to the process of translating a software design into a functional program using programming languages like JavaScript, Python, or Java. It involves writing code, debugging, and optimizing algorithms to create a solution for a specific problem or requirement.

Solution involves designing a comprehensive solution strategy before coding. It includes problem analysis, architectural

design, selecting appropriate technologies, and planning for scalability and security. Solution ensures that the software addresses the problem effectively and aligns with the project's goals.

## some code examples in Python to help you get started.

**Components of a Vaccine Tracking System:**

- **User Interface:** A user-friendly interface for data entry, reporting, and monitoring.
- **Database:** A database to store information about vaccines, healthcare providers, patients, and vaccination records.
- **Barcode Scanning:** Barcode or QR code scanning to identify and track vaccine doses.
- **Vaccine Inventory Management:** Keep track of vaccine stock levels, expiry dates, and restocking alerts.
- **Patient Information:** Store patient details, vaccination history, and eligibility criteria.

- **Authentication and Authorization:** Secure access control to ensure only authorized personnel can update and view records.

- **Reporting and Analytics**: Generate reports and analytics on vaccination coverage, adverse events, and more.

**Here's a simple Python example to create a command-line-based vaccine tracking system:**

1**. Database Setup:**

You can use a lightweight database like SQ Lite for this example.

```
python
Copy code
import sqlite3

# Connect to the database
conn = sqlite3.connect ( 'vaccine_tracking.db' )
c = conn.cursor()

# Create tables for vaccines, providers, patients, and vaccination records
c.execute('''
    CREATE TABLE IF NOT EXISTS vaccines (
        id INTEGER PRIMARY KEY,
        name TEXT,
        stock_quantity INTEGER,
        expiry_date DATE
    )
''')

c.execute('''
    CREATE TABLE IF NOT EXISTS providers (
        id INTEGER PRIMARY KEY,
```

```
        name TEXT
    )
''')

c.execute('''
    CREATE TABLE IF NOT EXISTS patients (
        id INTEGER PRIMARY KEY,
        name TEXT,
        dob DATE
    )
''')

c.execute('''
    CREATE TABLE IF NOT EXISTS vaccination_records (
        id INTEGER PRIMARY KEY,
        vaccine_id INTEGER,
        provider_id INTEGER,
        patient_id INTEGER,
        date DATE,
        FOREIGN KEY (vaccine_id) REFERENCES vaccines (id),
        FOREIGN KEY (provider_id) REFERENCES providers (id),
        FOREIGN KEY (patient_id) REFERENCES patients (id)
```

```
    )
''')

conn.commit()
```

**2. Data Entry (Adding a Vaccine):**

```
python
Copy code
def add_vaccine(name, stock_quantity, expiry_date):
    c.execute('INSERT INTO vaccines (name, stock_quantity, expiry_date)
VALUES (?, ?, ?)', (name, stock_quantity, expiry_date))
    conn.commit()

# Example usage
add_vaccine("COVID-19 Vaccine", 1000, "2023-12-31")
```

**3. Data Entry (Vaccination Record):**

```
 python
 Copy code
def  record_vaccinati       c.execute('INSERT  INTO  vaccination_records
(vaccine_id, provider_id, patient_id, date) VALUES (?, ?, ?, ?)',
            (vaccine_id, provider_id, patient_id, date))
   conn.commit()

# Example usage
record_vaccination(1, 1, 1, "2023-10-29")
 on(vaccine_id, provider_id, patient_id, date):
```

**4. Data Retrieval:**

You can write functions to retrieve data as needed, such as querying vaccine stock or patient vaccination history.

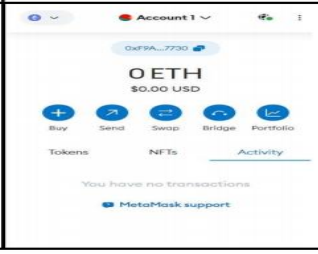
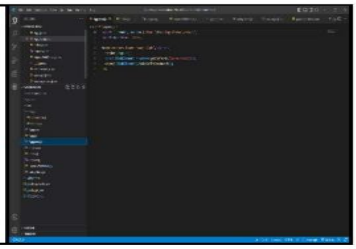
**5. Reporting and Analytics:**

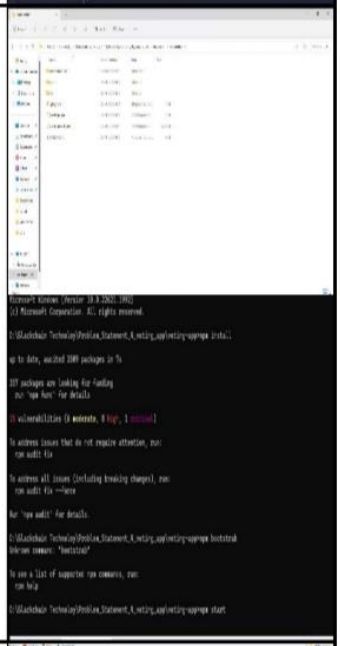
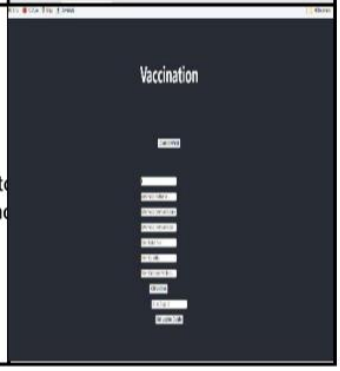
You can use libraries like Matplotlib or Pandas for data visualization and analysis.

This is a simplified example. In a real-world application, you should consider security, scalability, and integration with external systems. Additionally, you may want to implement barcode scanning and a web-based interface for a more comprehensive solution.

# 8 PERFORMANCE TESTING

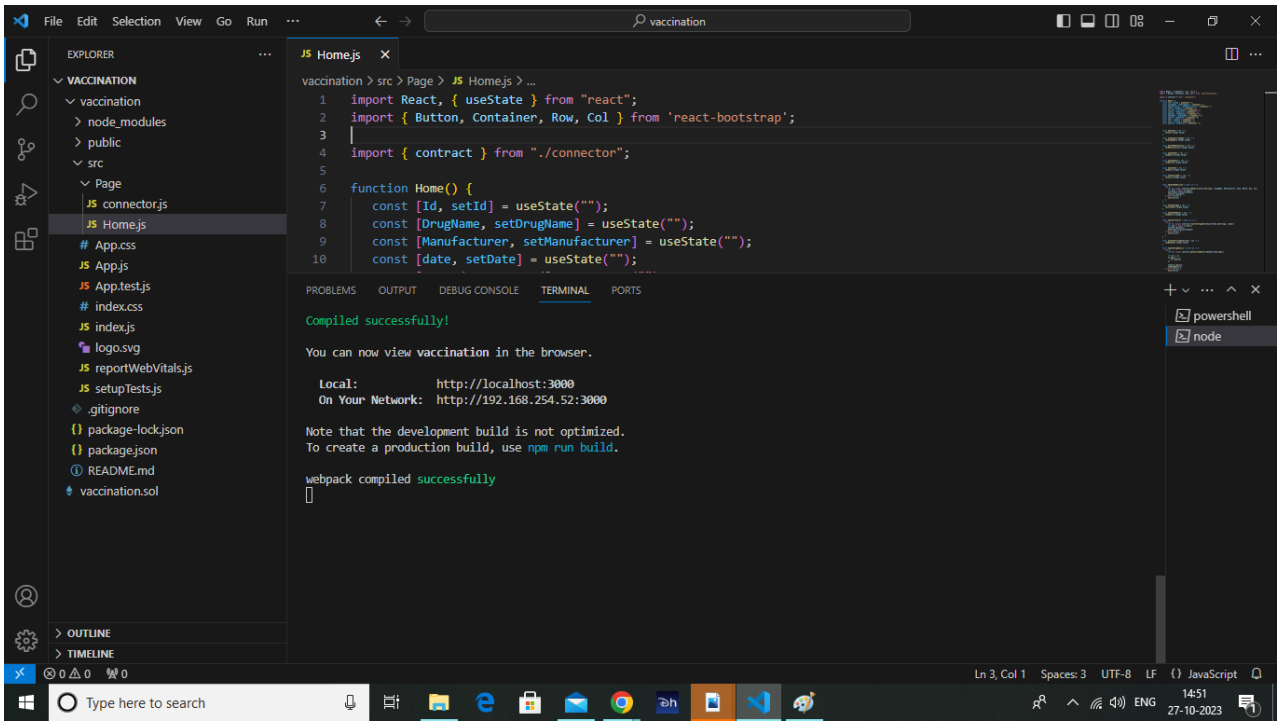
## 8.1 PERFORMANCE METRICS

| S.No. | Parameter | Values | Screenshot |
|---|---|---|---|
| 1. | Information gathering | Setup all the Prerequisite: |   |
| 2. | Extract the zip files | Open to vs code |  |

| | | | |
|---|---|---|---|
| 3. | Remix Ide platform<br><br>explorting | Deploy the smart contract code<br><br>Deploy and run the transaction. By selecting the environment - inject the MetaMask. |  |
| 4 | Open file explorer | Open the extracted file and click on the folder.<br><br>Open src, and search for utiles.<br><br>Open cmd enter commands<br><br>1.npm install<br><br>2.npm bootstrap<br><br>3. npm start |  |
| 5 | {LOCALHOST IP ADDRESS | copy the address and open it t chrome so you can see the front en of your project. |  |

# 9 RESULT

## 9.1 OUTPUT SCREENSHOTS



# 10 ADVANTAGES & DISADVANTAGES

**Advantages :**

- **Efficient Resource Allocation**: Tracking vaccines helps ensure that vaccines are distributed to areas and populations where they are most needed. This prevents wastage and maximizes the impact of vaccination campaigns.

- **Safety Monitoring**: Continuous tracking allows for the prompt identification of adverse events or side effects associated with vaccines. This is crucial for ensuring vaccine safety and can lead to the rapid investigation and management of any potential concerns.

- **Epidemiological Surveillance**: Vaccine tracking can provide real-time data on vaccine coverage and effectiveness, enabling health authorities to monitor the spread of vaccine-preventable diseases and respond with targeted interventions when outbreaks occur.

- **Public Trust:** Transparent vaccine tracking and reporting mechanisms can enhance public trust in vaccination programs. People are more likely to get vaccinated when they have confidence in the safety and effectiveness of vaccines.

- **Inventory Management**: Vaccine tracking helps healthcare providers and agencies manage vaccine inventories more effectively, reducing the risk of running out of vaccines or having excessive amounts in stock.

- **Data-Driven Decision-Making**: Data collected through vaccine tracking can inform policy decisions and public health strategies. This allows for evidence-based planning and adjustments to vaccination programs.

- **Real-Time Alerts**: Tracking systems can provide alerts for healthcare providers and authorities when vaccine coverage falls below acceptable thresholds or when there are potential outbreaks. This enables rapid response to emerging health threats.

- **Research Opportunities**: The data collected through vaccine tracking can support research on vaccine effectiveness, safety,

and long-term outcomes. This research can lead to improvements in vaccine development and policy.

- **International Cooperation**: Vaccine tracking is crucial for international coordination in the event of pandemics or the need for global vaccination campaigns. It ensures equitable distribution and effective deployment of vaccines on a global scale.

- **Cost Savings:** By preventing disease outbreaks through effective vaccination, vaccine tracking can lead to substantial cost savings in terms of healthcare expenses and productivity losses.

- **Equity and Access:** Tracking helps identify underserved populations and areas with limited access to vaccines, allowing for targeted efforts to ensure that everyone, regardless of location or socioeconomic status, has access to immunization.

- **Documentation and Accountability**: Maintaining a record of vaccinations administered and outcomes can help hold healthcare providers and health systems accountable for their

actions, ensuring that vaccines are administered correctly and that data is accurately recorded**.**

## Disadvantages of the Whole Project:

- **Privacy Concerns:** Vaccine tracking systems often involve collecting and storing personal and medical information, which can raise privacy concerns. There is a risk that sensitive data could be mishandled, accessed by unauthorized individuals, or even exploited for nefarious purposes.

- **Data Security**: Maintaining the security of vaccine tracking systems is essential, as they contain valuable personal and medical information. Any breach or cyberattack on these systems could compromise the confidentiality and integrity of the data.

- **Misuse of Information:** There is the potential for vaccine tracking data to be misused, such as for discrimination, targeting specific populations, or other unethical purposes. This can lead to social and ethical issues.

- **Access Barriers:** Implementing and maintaining a vaccine tracking system may not be feasible in all regions, especially in low-resource or remote areas. This can create disparities in access to healthcare services and vaccines.

- **Reliability and Accuracy:** The effectiveness of vaccine tracking systems relies on the accuracy of data input and maintenance. Human error or system glitches can lead to incorrect records, potentially impacting patient care and public health decisions.

- **Resistance and Opposition:** Some individuals may be hesitant or resistant to the idea of vaccine tracking due to concerns about government overreach, surveillance, or invasion of privacy. This resistance can lead to challenges in implementing such systems.

- **Costs and Resources**: Developing and maintaining a vaccine tracking system can be costly, both in terms of financial resources and personnel. This cost may deter some healthcare facilities or regions from implementing or upgrading their tracking systems.

- **Data Fragmentation**: In some cases, different regions or healthcare providers may use separate tracking systems or software, which can result in fragmented data. This fragmentation can hinder the seamless sharing of vaccine information between various healthcare entities and government agencies.

It's important to weigh these disadvantages against the benefits of vaccine tracking, such as improved vaccine safety, efficient distribution, and public health monitoring, to make informed decisions about implementing and using such systems. Efforts to address privacy concerns, ensure data security, and maintain transparency can help mitigate some of these disadvantages.

# 11 CONCLUSION

**The ability to monitor and trace the distribution and administration of vaccines is essential for several reasons:**

- **Safety and Efficacy**: Tracking vaccines helps ensure that they are administered correctly and are safe for individuals. This

reduces the risk of adverse reactions and ensures that vaccines achieve their intended purpose of preventing diseases.

- **Outbreak Management**: In the event of disease outbreaks, having a comprehensive record of vaccine distribution and administration allows for swift and targeted responses to control the spread of infectious diseases.

- **Resource Allocation:** Vaccine tracking data can inform decision-makers on where vaccines are needed most, helping to allocate resources efficiently and reach underserved populations.

- **Research and Development:** Data collected through vaccine tracking can also be invaluable for research purposes. It can provide insights into vaccine effectiveness, long-term immunity, and potential areas for improvement in vaccine development.

- **Public Trust**: Transparency and accountability in vaccine distribution build trust among the public. By providing clear information on the vaccination process and its outcomes, vaccine tracking can help address vaccine hesitancy and misinformation.

To ensure the success of vaccine tracking efforts, it is important for governments, healthcare organizations, and the private sector to invest in robust data infrastructure, secure data management practices, and clear communication with the public. As technology continues to advance, including the use of blockchain and digital health records, we can expect

even more efficient and secure methods for vaccine tracking to emerge, further enhancing the global effort to combat infectious diseases. Ultimately, vaccine tracking plays a crucial role in safeguarding public health and the well-being of communities worldwide

# 12 FUTURE SCOPE

In light of the global COVID-19 pandemic and the growing importance of vaccination campaigns. Here are some key areas where the future of vaccine tracking holds promise:

- **Enhanced Vaccine Distribution**: Vaccine tracking systems can optimize the distribution of vaccines to ensure efficient and equitable delivery. This is crucial not only for managing pandemics but also for routine immunization programs.

- **Supply Chain Management**: Effective vaccine tracking can help manage the supply chain more efficiently, reducing wastage and ensuring vaccines are stored and transported under the right conditions, such as temperature control.

- **Immunization Registries**: National and global immunization registries can be established to track who has been vaccinated and against what diseases. This information can be invaluable

for public health planning, outbreak management, and ensuring people receive the right booster shots.

- **Vaccine Passport Systems**: These systems can provide secure digital proof of vaccination, allowing individuals to travel and access services without the risk of spreading infectious diseases.

- **Data Analytics**: Analyzing vaccine tracking data can provide insights into disease prevalence and vaccine coverage, helping authorities make data-driven decisions and respond to emerging health threats.

- **Pharmacovigilance**: Continuous monitoring of vaccine recipients can help Identify and respond to adverse reactions quickly, ensuring the safety of vaccines.

- **Research and Development**: Vaccine tracking data can inform research on vaccine efficacy, safety, and long-term impact, helping improve future vaccine development.

- **Emerging Technologies**: Innovations in technology, such as block chain and AI, can enhance the security and efficiency of vaccine tracking systems.

- **Global Collaboration**: Vaccine tracking can be used for international cooperation in disease control, allowing countries to share data and resources to combat pandemics more effectively.

- **Public Education**: Vaccine tracking systems can be used to educate the public about the importance of vaccination and the safety of vaccines.

- **Remote Monitoring**: Remote tracking of vaccines can be vital in reaching underserved or remote populations, ensuring they also benefit from vaccination programs.

- **Data Privacy and Security**: Developing robust privacy and security measures is crucial to protect individuals' health information in vaccine tracking systems.

It's important to note that vaccine tracking must be implemented carefully to balance public health benefits with privacy concerns and ethical considerations. Additionally, the success of vaccine tracking systems depends on collaboration between governments, healthcare providers, technology companies, and other stakeholders. As the technology and infrastructure for vaccine tracking continue to evolve, it will play a critical role in safeguarding public health and controlling the spread of infectious diseases.

# 12 APPENDIX

An appendix for vaccine tracking is a useful tool to organize and maintain records of vaccinations, ensuring easy access to important information when needed. Here's a sample structure for creating an appendix for vaccine tracking:

**Title: Vaccine Tracking Appendix**

**Table of Contents:**



**1. Personal Information:**

- Full Name
- Date of Birth
- Gender
- Contact Information
- Blood Type (optional)

**2. Childhood Vaccinations**:

- List of vaccines received during childhood
- Vaccination dates
- Healthcare provider information
- Vaccine record card or number (if applicable)

**3. Adult Vaccinations**:

- List of vaccines received in adulthood
- Vaccination dates

- Healthcare provider information
- Vaccine record card or number (if applicable)

**4. COVID-19 Vaccination**:

- COVID-19 vaccine(s) received
- Dates of COVID-19 vaccine doses
- Vaccine manufacturer (e.g., Pfizer, Moderna, Johnson & Johnson)
- Location of vaccination
- Vaccine lot number

**5. Travel Vaccinations**:

- List of vaccinations received for travel
- Destination and purpose of travel
- Dates of travel vaccinations
- Healthcare provider information
- Any recommended booster shots

6**. Vaccine History Summary:**

- A summary of all vaccinations, categorized by type (e.g., routine, travel, COVID-19)
- Dates of vaccinations
- Healthcare provider information
- Any adverse reactions or side effects (if applicable)

***Additional Tips:***

- Include a section for any vaccine exemptions or medical contraindications, if applicable.
- Attach copies of official vaccine record cards, documents, or medical records to provide physical proof of vaccinations.
- Keep this appendix in a secure and easily accessible location, both digitally and in print, to ensure you can quickly retrieve your vaccination history when required for school, work, travel, or medical appointments.

Remember to keep this vaccine tracking appendix updated as you receive new vaccinations or booster shots to maintain an accurate and complete record of your immunization history.

# 13 SOURCE CODE

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract Vaccination {
    address public owner;

    constructor() {
        owner = msg.sender;
    }

    modifier onlyOwner() {
```

```
        require(msg.sender == owner, "Only the owner can perform
this action");
        _;
    }

    struct Vaccine {
        string vaccineName;
        string manufacturer;
        uint256 manufacturingDate;
        string batchNumber;
        uint256 quantity;
        address customerAddress;
    }

    mapping(uint256 => Vaccine) public vaccines;
    uint256 public vaccineCount;

    event VaccineAdded(uint256 indexed vaccineId, string
vaccineName, string manufacturer, uint256 manufacturingDate,
string batchNumber, address customerAddress);

    function addVaccine(uint256 vaccineId, string memory
_vaccineName, string memory _manufacturer, uint256
_manufacturingDate, string memory _batchNumber,uint256 _qty,
address _customerAddress) external onlyOwner {


        vaccines[vaccineId] = Vaccine(_vaccineName, _manufacturer,
_manufacturingDate, _batchNumber, _qty, _customerAddress);
        vaccineCount++;
```

```
        emit VaccineAdded(vaccineId, _vaccineName, _manufacturer,
    _manufacturingDate, _batchNumber, _customerAddress);
        }

        function getVaccineDetails(uint256 _vaccineId) external view
    returns (string memory, string memory, uint256, string
    memory,uint256, address) {

            Vaccine memory vaccine = vaccines[_vaccineId];
            return (vaccine.vaccineName, vaccine.manufacturer,
    vaccine.manufacturingDate, vaccine.batchNumber,
    vaccine.quantity, vaccine.customerAddress);
        }
}
```