

Digital Strategies for Vaccine Distribution and Administration

How cloud, artificial intelligence (AI), and machine learning (ML) technologies can improve the vaccine experience for citizens in COVID-19 and beyond

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Abstract

The COVID-19 pandemic has put an enormous burden on public health, healthcare agencies, and organizations across the world. Experts from the Department of Health and Human Services (HHS) are leading vaccine development, while experts from the Department of Defense (DoD) have partnered with the Centers for Disease Control and Prevention (CDC) and other parts of HHS to coordinate supply, production, and distribution of vaccines.¹ However, successful rollout of the national vaccination program requires close collaboration among federal, state, and local healthcare entities for information dissemination and scheduling to the public. Additionally, there are a number of challenges for state and local agencies in communicating with the public on vaccination, rollout strategy, eligibility, and campaign management. These challenges include tracking patient and vaccine data, vaccine supply and demand logistics, and more broadly, data sharing across healthcare entities for the entire vaccine lifecycle.

This whitepaper outlines some of these challenges and provides an approach to address these challenges using the Amazon Web Services (AWS) Cloud, digital communication, and cognitive intelligence technologies.

Introduction

The White House paper “National Strategy for the COVID-19 response and pandemic preparedness”² outlines seven major goals, of which mounting a safe, effective, and comprehensive vaccine campaign is a critical goal to ensure citizens can get vaccinated quickly and effectively. According to the data provided by the CDC as of this publication date, the United States is administering an average of 1.58 million COVID-19 vaccine doses per day based on a moving 7-day average.³

The United States has vaccinated 44.22% of the adult population as of May 2021,⁴ with an overarching goal to provide at least one shot to 70% of the U.S. adult population by July. Efforts to ramp up vaccine administration are well underway by the federal, state, and local governments, healthcare providers, and vaccination sites through increasing walk-in vaccinations at local pharmacies, mobilizing community-based organizations for outreach and increasing shipments to rural health clinics.⁵ Vaccine administration volumes continue to increase, and trends are moving in a positive direction.⁶ The CDC provided guidance on Vaccine Administration and Management Systems⁷ for supporting the planning and creation of COVID-19 vaccination clinics. However, as thousands of vaccination sites pop up across the nation to meet the demand, healthcare organizations and individual citizens are faced with increasing complexity of coordination that can get in the way of mass vaccination goals.

This whitepaper explores the key challenges, as well as the AWS services, that can be leveraged by public health departments and healthcare providers to increase the velocity of their mass vaccination efforts while improving citizen experience.

Challenges with vaccine distribution and administration

Given the context of limited COVID-19 vaccine supply during the first few months of global vaccination programs, phased deployment of priority groups in many countries will take place by different criteria. The federal, state, and local department of health, as well as academic medical centers, hospitals, and clinics are challenged by the interim arrangements for vaccine distribution. Some of these interim challenges will continue to exist for the foreseeable future. This section outlines the challenges with vaccine planning, communication, and administration.

Citizen education, outreach, and engagement

According to polls conducted by Gallup,⁸ the Kaiser Family Foundation (KFF) at the Pew Research Center, vaccine acceptance rates will rise from about 50% in the summer of 2021 to more than 60%, and in one poll, to 73%.⁹ Still, large pockets of skepticism and resistance to vaccination remain. About half of the people surveyed in the KFF poll say they don't have enough information about the vaccine's side effects or effectiveness, with higher shares of younger, Black, and Hispanic adults citing these information needs.¹⁰ Citizens continue to have many inquiries pertaining to vaccine safety and efficacy. These questions are often directed to overburdened health systems. Handling these communications at scale is a major challenge for public and private healthcare agencies and organizations.

Reaching 70% of the U.S. adult population requires state, local, and large health care providers to manage vaccine campaigns at a population-level scale. Having a multi-pronged engagement approach that provides information and education to help address citizens' questions and address hesitancy is necessary for continued adoption. Public health and provider systems are charged as the main sources of health information, and can serve as conduits for timely, accurate, and up-to-date information regarding COVID-19 vaccinations. Deploying technology solutions to maximize and automate citizen outreach and education utilizing web, voice, or chat can reduce the manual burden placed on our public health system and encourage vaccination acceptance, especially in communities where gaps in information sharing exist.

AWS has a number of services to address the citizen outreach, engagement, and communication challenges, including [Amazon Lex](#), [Amazon Connect](#), and [Amazon Pinpoint](#). These services are discussed in detail in the [Digital strategy framework](#) section of this document.

Access to vaccinations

As larger populations become eligible for vaccination, state and local departments of health are challenged with the task of deploying a coordinated approach for communicating vaccine eligibility criteria and creating visibility on appointment availability to maximize vaccination rates.¹¹

In some cases, health care systems are taking the lead in communication as they leverage their existing relationships with patients. Outreach to patients comes with its own set of challenges. Health systems need to aggregate clinical and demographic patient data to stratify which patients are eligible based on state criteria, develop scalable outreach and communication mechanisms for these populations, and implement operations that can efficiently meet the demand of incoming calls.

This decentralized approach leads to frustrated citizens who make multiple phone calls and navigate various websites in search of appointments. Citizens eligible to receive vaccinations are facing challenges including a shortage of appointment availability, technical barriers, an information void, and transportation issues. Caretakers of elderly and dependents eligible for vaccines report they are spending hours looking for available appointments, adding themselves to waiting lists, and in some cases, driving hundreds of miles for the vaccine.¹² Inbound calls to public health, health systems, and retail pharmacies are sharply on the rise, and in some cases, crashing call centers due to overwhelming demand.¹³ [Amazon Connect](#) can help address this challenge.

Instead of navigating multiple websites to find available appointments, AWS has proposed a reference solution that can be used to find out vaccine appointment availability across all providers. Providers are publishing APIs with the available appointments at all their locations across all the states. Using the information published by these APIs, a centralized data store can be created so that the availability information can be provided to the general public via various channels such as websites, voice, SMS, and chatbots.

Ideally, future APIs will enable the consumer to directly schedule their vaccination from a centralized system that has access to all available appointments. The current proposed APIs are limited to vaccine appointment availability. Although this does make it easier for the consumer to target which websites they visit to schedule a vaccine appointment, the end user still has to visit multiple sites and enter the same information repeatedly before finalizing an appointment. Additional APIs to enable registration and scheduling of the actual appointment will provide a much friendlier end user experience.

Vaccine data interoperability

Data exchange and digital communication strategies are essential components to a coordinated approach for national scale vaccination. Technology systems across state and local public health jurisdictions vary widely. Some are utilized by vaccine administration sites, but in some instances, vaccination sites and providers implement their own technology. Health systems and clinics typically leverage Electronic Health Record (EHR) systems to meet these functional requirements and adapt their workflow to capture the necessary data elements. Vaccine administration technology is leveraged to schedule vaccine appointments, capture administrative and billing data, track vaccine lot numbers, manage inventory, document side effects, supply operational metrics, and provide patients with access to their vaccine data. Interoperability of vaccination data between vaccine administration technology and EHRs across independent health settings is largely inconsistent across the industry.

While mechanisms exist for data exchange, each technology owner is required to ensure appropriate configuration and implementation has occurred between their system and other systems, including state or jurisdictional immunization information systems (IIS). IIS serves as the conduit for state immunization data into federal systems. Each state manages their IIS independently, and leverages different technology solutions to meet their immunization tracking needs. The Center for Medicare and Medicaid Services (CMS) provides policies on this interoperability.¹⁴ As a starting point for clinical data interoperability, the Fast Healthcare Interoperability Resources (FHIR) specification enables this interoperability and electronic data exchange. [FHIR Works on AWS](#) is an open-source software toolkit that can be used to create a FHIR interface over existing healthcare applications and data.

Health data repository for vaccine and immunization

Managing immunization information at scale for millions of citizens results in tens of millions of electronic health records that may come in disparate formats, such as images or FHIR / HL-7 messages. This data may be used by health systems and public health agencies for vaccine efficacy, research, and targeted outreach. The vast amount of information coming in requires highly scalable and flexible data lakes to store and process data that is format agnostic. Additionally, vaccine inventory management and tracking the status of vaccinations for large populations requires databases that can provide high scalability and optimal performance. AWS has a number of services, including [Amazon S3](#), [Amazon DynamoDB](#), [AWS Lake Formation](#), [AWS HealthLake](#), and [AWS Glue](#) to address these challenges.

Transparency in reporting outcomes and tracking program operations

Public health and private healthcare organizations that deal with immunization systems are often faced with operational challenges, including budget and enrollment model forecasting, fraud, waste, and abuse. As vaccination rates increase, transparency in reporting of outcomes and operational metrics are essential to maintaining trust with the public, as well as identifying targeted gaps for outreach efforts. To achieve these objectives, organizations can analyze data at scale and develop dashboards that provide deep insights to public and program leadership into operations and outcomes. AWS has number of services, including [Amazon Kinesis Data Analytics](#), [Amazon EMR](#), and [Amazon Athena](#) to address these challenges.

Digital communication use cases

This section outlines a few use cases that demonstrate how cloud digital strategy helps modernize COVID-19 vaccine distribution and communication processes.

Automated experience for COVID-19 vaccine FAQs

Regulatory guidance¹⁵ and answers to FAQs¹⁶ have been published by a number of trusted sources across government, academia,¹⁷ and industries. Organizations can augment this content with answers to questions specific to their populations, and deliver it through multiple self-service channels powered by conversational artificial intelligence (AI). One solution can be integrating [QnABot](#) with the [Amazon Kendra](#) service, a powerful, intelligent search engine powered by machine learning (ML). There are two ways to take advantage of Amazon Kendra's natural language processing model to enhance QnABot's ability to understand human questions:

- Use Amazon Kendra's FAQ queries to match users' questions to the answers in the QnABot knowledge base. Kendra's machine learning models can handle many variations in how users phrase their questions, and this can reduce the amount of tuning needed for QnABot to find the right answer from your knowledge base.
- Use Amazon Kendra's document index as a fallback source of answers when a question / answer is not found in QnABot's knowledge base.

For example, AWS built a natural language questions and answers platform using Amazon Kendra to query the [COVID-19 Open Research Dataset](#) (CORD-19).¹⁸

Targeted campaign management for (pre) registration processes

Targeted campaigns via email and SMS text messages can be leveraged to proactively communicate with citizens and patients regarding COVID-19 vaccine availability. Enabling citizens or patients to pre-register for notifications and alerts creates a channel for timely and regular updates that can encourage eligible patients to schedule their vaccinations, while reducing calls from patients that are currently ineligible. Email and SMS text messages can also be used to target outreach to populations experiencing gaps or lag in immunizations. This can serve as a mechanism to build citizen or patient trust, reduce customer anxiety, and improve information flow.

In a pre-registration scenario, candidates are provided a link to a web form where eligibility and pre-registration data is collected (name, email, phone number, age, occupation). Citizens can choose an authorization option for enrollment to receive an SMS text or email. If authorized, the eligibility criteria is evaluated on a daily basis. Once a citizen is eligible, SMS text messages and/or email will be auto-generated based on the data collected. This process can be managed through [Amazon PinPoint](#).

Digital strategy framework

The vaccine information system data flow from the National Governors Association depicts anticipated vaccine distribution and administration processes.¹⁹

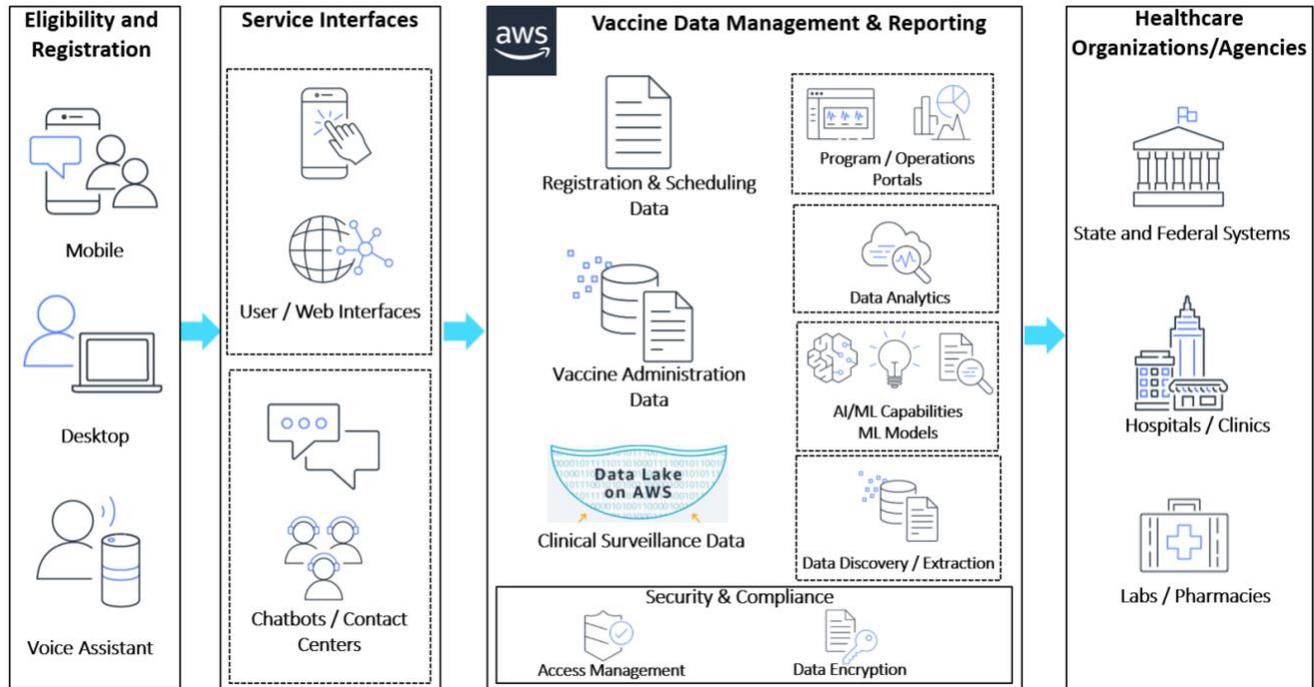
- Vaccine distribution systems need to facilitate vaccine allocation, ordering, distribution to vaccine administration sites, inventory management, and tracking.
- Vaccine administration systems need to facilitate scheduling and reminders, and subsequent documentation and reporting for a full end-to-end view of vaccine efforts.

Working with public health agencies and health systems, these systems have been consistent in identifying what the anticipated high-level workflow should look like as mass vaccination deployments expand. Agencies and organizations tasked with vaccine management seek mobile-responsive pre-registration, scheduling, notification, analytics, and in some cases, pre-payment functions that are patient-facing via the omnichannel.

High-level architecture

The following figure provides a high-level architecture that includes cloud, AI, and ML technologies to modernize vaccination communication, administration, and

management. Note that constituents can use multiple modes of communication that fit their needs, including mobile, voice assistant, web clients, or in-person registration. Cloud capabilities outlined in this diagram can help with vaccine data management and reporting for all these communication channels.



High-level architecture for digital strategy framework

Cloud digital communication enablers

Conversational AI and cognitive intelligence

AWS services and solutions can add conversational AI and cognitive intelligence capabilities to healthcare providers and public health agencies, which can automate tedious and manual processes to improve customer experience. Deploying chatbots on websites, mobile apps, and social media can facilitate proactive communication with targeted segments of patient populations or the general public. These chatbots can effectively handle responses to targeted vaccine-related questions, such as eligibility and scheduling. The [QnABot](#) is one example of such a chatbot. The following AWS services can enable the conversational AI:

- [Amazon Lex](#) is the key building block enabling the conversational interfaces for chatbots using voice and text. Amazon Lex leverages the advanced deep learning functionalities for automatic speech recognition (ASR) and natural language understanding (NLU). Using Amazon Lex, customers can engage user interactions through pre-defined utterances, recognize the intent of users, and capture user responses in pre-defined slots throughout the conversational interactions. Amazon Lex is built upon the same deep learning technologies that power Amazon Alexa.
- [Amazon Alexa](#) is a cloud-based voice service that powers devices like Amazon Echo and Echo Show, as well as third-party devices. Healthcare organizations can use several natural language understanding tools, machine learning algorithms, and skill-building kits to build customized Alexa skills for natural voice experiences that allow customers to easily ask questions in a conversational way. In Fall 2019, Alexa Health and Wellness opened applications for their [HIPAA-eligible skills program](#), allowing organizations to build Alexa skills that can specifically handle protected health information. With [Alexa HIPAA-eligible healthcare skills](#), healthcare organizations can connect to their customers and provide them with a hands-free way to manage their healthcare needs at home, including tracking provider appointments, accessing their daily care plan, or managing medications. Healthcare providers can develop their own self-service Alexa skills for COVID-19-related use cases. For example, the Mayo Clinic released an Alexa skill for users called “Mayo Clinic Answers” which offers the latest information about COVID-19 symptoms and research. Mayo Clinic also launched an Alexa skill that helps customers to perform a COVID-19 self-assessment to determine whether they should seek a testing center or order a home test kit for COVID-19.
- **Managed AI Services** offer ready-to-use intelligence using pre-trained machine learning models. The most relevant ones include but are not limited to [Amazon Translate](#), [Amazon Transcribe Medical](#), [Amazon Comprehend Medical](#), and [Amazon HealthLake](#). Amazon Translate automates language translation in real time, and enables [multilingual Chatbot](#) for COVID-19 vaccine communication. An AWS partner has successfully delivered a hands-free voice assistant through automatic speech recognition and comprehension [for Houston Methodist hospital systems](#).

Omnichannel digital front door

Modernization of omnichannel communication capabilities will enable public and private health systems to reduce the overhead required to manage vaccination campaigns, and provide flexibility with the changing requirements across various states. Services such as Amazon Connect and Amazon Pinpoint can be utilized in digital user engagement

vaccine campaigns to both reduce the friction experienced by patients seeking vaccination, and streamline business operations for related call centers.

- [Amazon Connect](#) is an easy-to-use omnichannel cloud contact center that helps users provide superior customer service at a lower cost. Although Amazon Connect provides full-fledged call center solutions, it can also be plugged in to the customer's existing call center system using inbound and transfer contact flows. Once added as an extension, Amazon Connect can provide an automated chatbot experience using Amazon Lex and audio recording capabilities via [Amazon Kinesis Video Streams](#). The voice recordings stored in [Amazon Simple Storage Service](#) (Amazon S3) can be further analyzed using AWS-managed AI services for transcription and comprehension of the conversations.
- [Amazon Pinpoint](#) is a flexible and scalable outreach communications service. Users can connect with customers over channels such as email, SMS, notification push, or voice. Customers can segment their target audience and personalize outreach schedules with the right content. Amazon Pinpoint provides visibility on delivery and campaign metrics, which can be used to measure the success of their communications. One of the key components in COVID-19 vaccine management systems is to communicate with the target audience through multi-channel means, such as SMS message or email, to notify and remind them of the vaccination dates and other information. This AWS blog post outlines [how to use Chatbot campaigns to check in COVID-19 patients remotely](#). Similar chatbots can be used to check in people who are scheduled to receive COVID-19 vaccines.

Data storage and interoperability

As outlined previously, managing immunization information at scale is a major challenge. The AWS Cloud can help address this challenge through flexible and scalable storage and databases. The [AWS Data Lake solution](#) automatically crawls data sources, identifies data formats, and then suggests schemas and transformations, so organizations don't have to spend time hand-coding data flows. For example, if a user uploads a series of EHRs to Amazon S3, [AWS Glue](#), a fully managed extract, transform, and load (ETL) tool, can scan these documents to identify the schema and data types present in the files. This metadata is then stored in a catalog to be used in subsequent transforms and queries.

[Amazon HealthLake](#), currently in preview as of the date of this publication, is a HIPAA-eligible service that enables healthcare providers, health insurance companies, and pharmaceutical companies to store, transform, query, and analyze health data at scale.

The [AWS Lake Formation](#) service builds on the existing data lake solution by enabling organizations to set up a secure data lake within days. Once a user defines where their data lake is located, AWS Lake Formation collects and catalogs this data, moves the data into Amazon S3 for secure access, and cleans and classifies the data using ML algorithms.

Some healthcare systems may have interfaces that are proprietary or that conform to older standards, such as Health Level 7 (HL7). These systems can fail to achieve healthcare interoperability. This leads to a situation where data is digitally available, but not generally accessible. Fast Healthcare Interoperability Resources (FHIR), which is an interoperability standard for the electronic exchange of healthcare information, addresses this issue. An open-source project called [FHIR Works on AWS](#) is available to organizations to integrate with their products.

S3 combined with AWS Glue and AWS Lake Formation act as a centralized data lake for storing vaccine-related information from multiple sources with disparate data formats. FHIR provides data interoperability. [Amazon DynamoDB](#), a key-value document database, provides fast access to these documents by storing patient metadata.

Reference workflows

Public Health Solution

The following figure provides a high-level architecture that includes Serverless technologies and business applications to modernize vaccination availability communication. Note that constituents can use multiple modes of communication that fit their needs, including mobile, voice assistant, and web clients. Cloud capabilities outlined in this diagram can help with vaccine availability information for all these communication channels



Reference architecture for a centralized vaccination availability communication system

The following table shows the various AWS services needed to implement this architecture.

Table 1: Objectives within the reference architecture and AWS service mapping

Objective	Services/Options
UI / mobile interfaces	Amazon Amplify Amazon API Gateway (support for data exchange via APIs)
Databases	Amazon DynamoDB (NoSQL database)
Audio / Video, voice, contact centers, SMS, notification	Amazon Connect (contact centers) Amazon Lex (chatbot for self-service) Amazon Pinpoint (SMS notification) Amazon Simple Notification Service (Amazon S3) Amazon Alexa for Business
Security management	Amazon Key Management Service (KMS) AWS Identity and Access Management (IAM)
Micro services / Serverless, orchestration	AWS Lambda AWS Step Functions
Monitoring/Schedule	Amazon CloudWatch

This solution can use [Amazon CloudWatch Events](#) rules to periodically trigger the AWS Step functions state machine, which will run a series of AWS Lambda functions to retrieve available information from providers' APIs and store them in an Amazon DynamoDB table.

To provide vaccine appointment availability information to the general public via voice and chat channels, [Amazon Connect contact flows](#) can be used to provide vaccine appointment availability information based on a provided zip code. When the user calls in or interacts with the chat option, they are requested to provide the zip code of the location for which they want to know vaccine availability. The contact flow triggers an AWS Lambda function, which interacts with the DynamoDB table and responds back with the availability information.

To support users through chat, Amazon Connect provides an out-of-the-box chat user interface that can be added as a chat widget to a website.

For SMS users, a chatbot solution with Amazon Pinpoint and Amazon Lex can be used to provide availability information based on a provided zip code. When the user sends an SMS, they are asked to provide the zip code of the location for which they want to know vaccine availability. Amazon SNS triggers a Lambda function that interacts with the DynamoDB table and responds back with the availability information.

In terms of website interface, [AWS Amplify](#) helps developers to build secure and scalable full-stack cloud applications. [AWS Amplify Console](#) is a tool within Amplify that provides a user interface with a GitHub-based workflow for hosting static sites. Deploy applications by connecting to an existing repository (GitHub, BitBucket Cloud, GitLab, or [AWS CodeCommit](#)) to set up a fully managed, nearly continuous deployment pipeline. Any changes committed to the repository trigger the pipeline to build, test, and deploy the changes to the target environment. It also provides instant content delivery network (CDN) cache invalidation, atomic deploys, password protection, and redirects without the need to manage any servers. When users access the website and input the zip code of the location for which they want to know vaccine availability information, a request is sent to a Lambda function from API Gateway. Lambda functions interact with the DynamoDB table and respond back with the availability information.

Vaccine appointment availability information can be provided to the general public via Alexa Voice. Custom Alexa skills can be hosted with integration to AWS Lambda, which is triggered in response to Alexa voice interactions. The Lambda function interacts with the DynamoDB table, and responds back with the availability information.

Healthcare provider solution

The following workflows can be supported in a healthcare provider system using cloud technologies:

Registration and scheduling

- **(Pre)Registration** — Demographic data collection, prequalification, and screening
- **Scheduling** — Vaccination consent form, date / time / location selection
- **Notifications** — First and second dose appointment reminders via SMS text messages or emails
- **Pre-Payment** — Insurance information submission and options to collect payments

Dispensing and administration

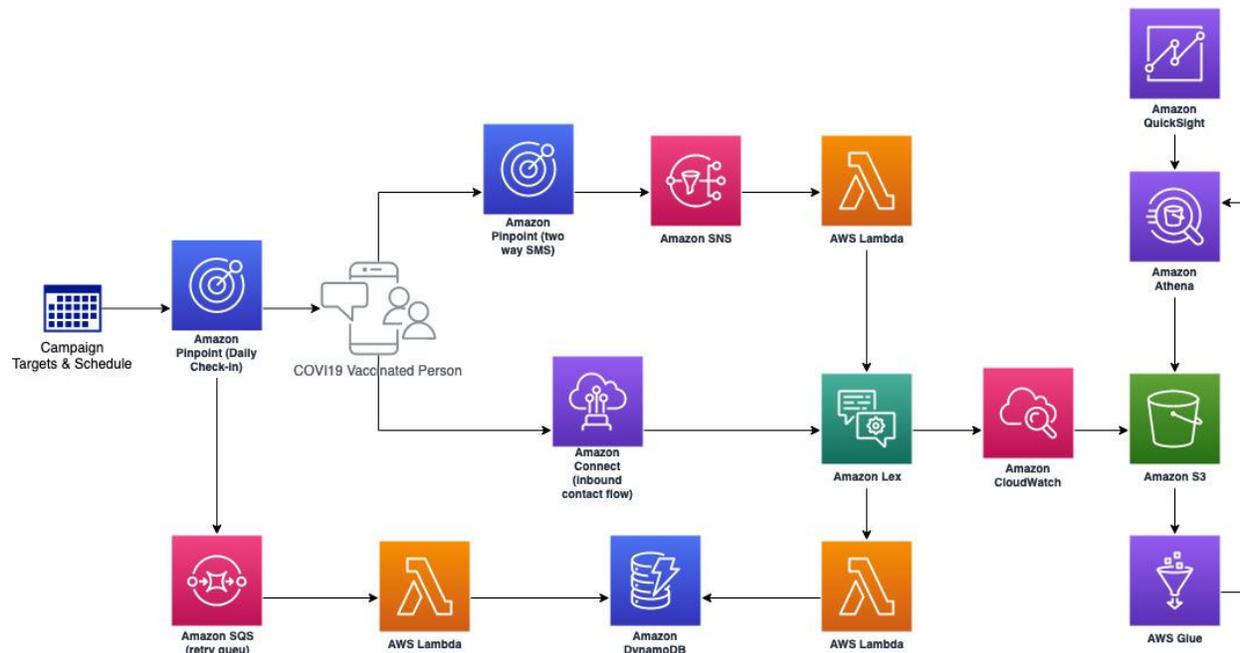
- **Just-in-time registration / walk-in appointment** — Consent form capture and queuing system
- **Vaccine administration** — ID validation plus documentation of lot, vaccination, injection site, and so on.

- **Inventory management** — Inventory monitoring and tracking, identify doses needed for various locations
- **Real-time visibility on dosage information** — Ability to query Internet Information Services (IIS) and / or Immunization (IZ) Gateway

Post vaccination

- **IIS and IZ Gateway integration** — Send vaccination (VX*) message to immunization registry
- **Adverse reaction recording** — 15-30 minutes of observation at administration site, plus post-appointment monitoring
- **Reporting function** — Operational reporting, clinical research, flat file extracts, administrative billing file exports

The following figure outlines a high-level workflow for an omnichannel communication system using the AWS Cloud.



Reference workflow architecture for a COVID-19 vaccine communication system

The following workflow steps explain the user experience and solution benefits:

- Utilize Amazon Pinpoint to segment target population based on when they took COVID vaccine, and schedule a campaign to send them daily notifications to track potential immunization side effects.

- People who received the SMS notification can either call a phone number provided to them or reply back through SMS.
- People can interact with a chatbot designed to collect the side effect symptoms, plus some vital signs, including body temperature, blood pressure, and pulse rate. The bot contains slot types for all the solicited side effect symptoms, plus some common unsolicited symptoms for COVID-19 vaccine that were identified in an NIH clinical trial.¹³
- The collected information is stored in Amazon S3 and can be queried and visualized using Amazon Athena and QuickSight.

Conclusion

Given the rising demand for COVID-19 vaccine, cloud digital strategy will play a critical role for vaccine distribution and administration. [AWS participated](#) in the recent national forum convened by the CDC on COVID-19 vaccine to share and discuss best practices to help advance the goals of the [National Strategy for the COVID-19 Response and Pandemic Preparedness](#). As part of this forum, AWS discussed how cloud digital strategy can help modernize immunization information systems, leverage scalable and reliable call center solutions with AI-enabled assistants, and integrate clinical data platforms for healthcare policy creation. This whitepaper introduced the challenges for public COVID-19 vaccination, proposed a cloud-based framework, and outlined AWS services for AI-enabled omnichannel digital communication to address some of the implementation challenges.

Next steps

Adopting the AWS Cloud can provide you with sustainable advantages for vaccine system modernization. Our customers in the healthcare space include the [Center for Medicare and Medicaid Services](#), [Center for Disease Control](#), [Cerner](#), and [GE Healthcare](#), among others. AWS works together with your team and your chosen member of the AWS Partner Network (APN) to actualize your enterprise cloud computing initiatives. You can reach out to an AWS Partner through the [AWS Partner Network](#). Get started on AI and ML by visiting [Machine Learning on AWS](#), the [AWS Machine Learning Embark Program](#), or the [Amazon Machine Learning Solutions Lab](#).

Contributors

Contributors to this document include:

- Yooli Hardy, Principal Business Development, Academic Medical Center Team
- Srinath Godavarthi, Senior Solutions Architect, AWS WWPS
- Gang Fu, Senior Solutions Architect, Academic Medical Center Team
- Jim Daniel, Public Health Leader, AWS WWPS
- Betsy Baker, Public Health Program Lead, AWS WWPS
- Venkata Kampana, Senior Solutions Architect, AWS WWPS

Further reading

For additional information, see:

- [AWS Healthcare and Life Sciences](#)
- [Amazon COVID-19 Blogs](#)
- [Amazon Machine Learning Blogs](#)

Document revisions

Date	Description
May 21, 2021	Significant updates
April 12 2021	First publication

Notes

¹ [The Operation Warp Speed Strategy for Distributing a COVID-19 Vaccine](#)

² [National Strategy for the COVID-19 Response and Pandemic Preparedness](#)

³ [Covid Data Tracker: COVID-19 Vaccinations in the United States](#)

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- ⁴ [Statistics and Research: Coronavirus \(Covid-19\) Vaccinations](#)
 - ⁵ Office of the Intergovernmental and External Affairs. "President Biden to Announce Goal to Administer at Least One Vaccine Shot to 70% of the U.S. Adult Population by July 4th." Fact sheet. The White House. Washington, D.C. n.d. Email.
 - ⁶ [Covid Data Tracker: Vaccination Trends](#)
 - ⁷ [How CDC Is Making COVID-19 Vaccine Recommendations](#)
 - ⁸ [WebMD: More Americans Willing to Get COVID Vaccine](#)
 - ⁹ [KFF COVID-19 Vaccine Monitor: December 2020](#)
 - ¹⁰ [KFF COVID-19 Vaccine Monitor: January 2021](#)
 - ¹¹ [Covid-19: Critical Vaccine Distribution, Supply Chain, Program Integrity, and Other Challenges Require Focused Federal Attention](#)
 - ¹² [Washington Post: Tipsters, tech-savvy kids, pharmacy hopping: How Americans are landing coronavirus vaccines](#)
 - ¹³ [Call centres: going voice-first in the post-Covid world](#)
 - ¹⁴ [Policies and Technology for Interoperability and Burden Reduction](#)
 - ¹⁵ [How CDC Is Making COVID-19 Vaccine Recommendations](#)
 - ¹⁶ [CDC: Frequently Asked Questions about COVID-19 Vaccination](#)
 - ¹⁷ [New England Journal of Medicine: Covid-19 Vaccine — Frequently Asked Questions](#)
 - ¹⁸ [AWS: COVID-19 Open Research Dataset \(CORD-19\) Search](#)
 - ¹⁹ [National Governors Association: Information Systems and Data Flow for COVID-19 Vaccine Distribution and Administration](#)