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## Web Mapping for Nigeria Covid-19 Testing and Vaccination Site Finder Application

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GIS, Vaccine, Web Mapping*

### ABSTRACT

This study aimed to describe the development and implementation of COVID-19 vaccine and testing center's location finder portal for Nigeria. Names, locations, coordinates, pictures and other relevant information related to the health centers were obtained from the NCDC and the NPHDA. The data was used to create a database which was used to connected to the Google API. The portal contains sections like Nearest Centers, Vaccination Centers, Testing Centers, All Centers, FAQ, Survey and COVID News. The objective of the study is to improve access to COVID-19 testing site, enhance access to COVID-19 vaccination centers across the country and educate Nigerians about COVID-19. The research suggest the active participation of religious and community leaders would improve access and willingness of their subjects to be vaccinated

### INTRODUCTION

Coronavirus Disease (COVID-19) is induced by the acute respiratory syndrome virus 2 (SARS-CoV-2) (WHO, 2020). The occurrence of the novel Coronavirus disease (COVID-19) in Wuhan, China, in December 2019 signaled a change in the global state of affairs (WHO, 2021). These required a shift away from traditional personal gatherings and hygiene practices and toward social distancing and routine hygiene practices (WHO, 2021; Ilesanmi and Afolabi, 2020a Globally, 532,218,120 COVID-19 cases and 6,312,135 COVID-19 deaths had been recorded as of May 31, 2022. The African continent estimated to account for 1.60 % (8,539,262) of cases and 2.72 % (171,598) of deaths worldwide (Worldometer, 2022). As of May 31, 2022, 256,028 cases (<1% of worldwide COVID-19 cases) and 3,143 deaths (<1% of global COVID-19 deaths) had been recorded in Nigeria (Worldometer, 2022).

The advancement of information technology has resulted in the emergence of new trends in the real implementation of cartography (Lisitskiy, 2013, 2014; Kameswara, 2015; Bharathi, 2014). In the last two decades, a new phase in mapping has surfaced (McQuire, 2019). Mobile mapping and web mapping are the most popular methods of cartography development, according to them. Both directions are very popular and continuing to develop, as a result of technological advancement in wireless communication methods, web-technologies, and mobile devices (Kikin, 2014; Mitchel, 2005; Shashidhar, 2014; Michael, 2003; Hemalatha, 2015; Kraak, 2001). Nigeria had more than 109.2 million mobile internet users as of January 2022, the highest number reported in Africa. Meanwhile, Egypt ranked second with over 75.66 million internet users, followed by South Africa with approximately 41.19 million (Joseph, 2022). Moreover, at the commencement of 2022, Nigeria's internet penetration stood at 51.0%. According to Kepios,

internet users in Nigeria increased by 4.8 million (+4.6 percent) between 2021 and 2022. (Datareportal, 2022).

Furthermore, public health campaigns, contact tracing and testing activities are being used to boost case management by detecting COVID-19 cases as quickly as possible (Ilesanmi and Afolabi, 2020b). Testing is an important step in the submergence of COVID-19 (Ilesanmi and Afolabi, 2020c). As a result of the evolving community wide transmission of COVID-19 in Nigeria, increased community testing capacity are required. Testing activities have begun in Nigerian communities, but they have been met with a slew of misconceptions and falsehoods (Ilesanmi and Afolabi, 2020d). COVID-19 is now easily and sustainably spreading in the Nigerian community (Chan, et al., 2019; Chen, et al., 2020). Similarly, Vaccines have been an effective prevention and treatment measure for decades (WHO, 2020a).

According to the BBC (2020), maps have the potential to "go viral" on the Internet, a map depicting international air traffic resurfaced after being removed from its original context, Various news outlets ran headlines like 'New map exposes no nation safe from coronavirus tentacles' and 'Terrifying map uncovers how thousands of Wuhan travelers might have spread coronavirus to 400 cities across the world'. Therefore, there is need for the development of an easy and genuine source of Covid-19 news and update. In addition, accessibility to testing and sampling collection centers is very significant in order to get more people vaccinated and tested effectively to mitigate the widespread of the virus. The portal and app created will aid in the long run support the government's policies in terms of providing vital information regarding the location and address of the nearest center to the citizenry wherever they are in Nigeria. As a result, the purpose of this research was to describe the steps followed to create this site containing all the sampling collection sites and testing centers of the COVID-19 vaccine in Nigeria

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## LITERATURE REVIEW

Coronavirus disease-2019 (COVID-19) is a viral disease that is causing widespread concern in the global public health community. Coronavirus (COV) is a major highly contagious pathogen that attacks the human respiratory system. Coronavirus transmission occurs primarily through direct contact or when an infected patient coughs, sneezes or droplets spread (Chan, et al., 2020). Nigeria, as Africa's most populated nation and the sixth most populous country in the world plays a critical role in international response. Nigeria's epidemic response is being conducted within a setting of an established health-care system that is frail and under-resourced, which is further characterized by security, political, social and economic, problems across the nation. Nonetheless, dealing with epidemics is nothing new in Nigeria. The Ebola in 2014 outbreak alerted the health system, government, and towns and cities to the dangers of highly communicable diseases like COVID-19 and the need for swift, prevention measures (Shuaib, 2014). Furthermore, the establishment of a stronger Nigeria Centre for Disease Control (NCDC) has improved the country's diagnosis, treatment and surveillance ability and improves the health care intervention to the emergence of COVID-19 in Nigeria through May 2020.

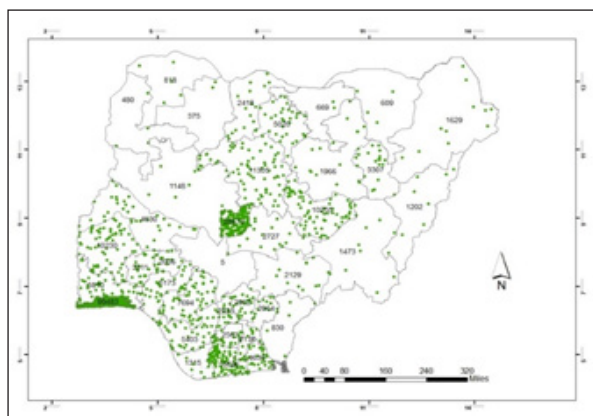
The Federal Ministry of Health validated the first COVID-19 case in Ogun State, Nigeria, on 27th February, 2020, positioning Nigeria as the third country in Africa to acknowledge an imported COVID-19 case after Egypt and Algeria. The index case involved the Italian national who flew to Lagos from Milan, Italy on February 24, 2020, and then decided to drive to his company's location in Ogun State same day. He displayed to the company clinic on February 26, 2020 with signs similar with COVID-19 and was referred to the Infectious Disease Hospital (IDH) in Lagos, where a COVID-19 diagnosis was carried out and validated by real-time reverse transcription polymerase chain reaction (RT-PCR) on February 27, 2020. A total of 216 interactions in Ogun and Lagos States were recognized for a two weeks' follow-up, including the passengers on the February 24 flight, with around 40 of these contacts discovered as high-risk. Two weeks later, an asymptomatic contact of the index case in Ogun State

was identified as the country's second COVID-19 case.

Since then, Nigeria's COVID-19 epidemiology has evolved, with cases identified in all of the nation's states as well as the Federal Capital Territory (FCT). It was acknowledged that Lagos State was the epicenter of the outbreak at first, the FCT and Rivers State have recently joined Lagos State as high-burden states, accounting for 56.58 percent of total cases of COVID-19 in Nigeria by the end of May 2022. According to the Nigerian center for Disease control, the states with highest number of cases as at 31 May, 2022 are; Lagos, 99,483, FCT 28,674 and Rivers state 16,696 (NCDC, 2022). Males seem to be disproportionately affected, taking account for 67.7% of confirmed cases (6,882). A cumulative of 287 deaths have been reported among the proven COVID-19 cases, yielding an identified case fatality ratio (CFR) of about 2.8 percent (NCDC, 2020). The federal government said on 31st May, 2022 that only a total of 18,291,072 Nigerians, representing 16.4% of Nigeria's eligible population, have so far been fully vaccinated against COVID-19 (Joseph, 2022).

Although mobile apps are successfully used for managing chronic diseases (Triantafyllidis et al, 2019), well-designed information systems for collecting, managing, and analyzing data in real-time should be considered when implementing Covid-19 contact tracing (WHO, 2020b). According to Kodali et al. (2020), the majority of users were positive about the Arogya Setu app due to its usefulness and acceptance. Users also expressed a desire for the app to include additional features such as geolocation tracking, timely COVID19 updates and information on red-orange-green zones. Nwawudu et al., (2020) in their research proposed a system which will have five elements in its architectural design. The five architectural elements are: Short Message Service (SMS)-based communications to and from the server via the mobile phones, telephone audio computer-assisted personal interviewing, voice messages, remote access to the database from any Internet-connected computer, and the central database and Web server.

Timmers et al., (2020) successfully implemented and designed a COVID-19 app for individuals, complete with an interactive map displaying data collected via the app. The study successfully demonstrated implementation and use of an app that included COVID-19 education, self-assessment, and a 7-day symptom diary. Generally speaking, app users were pleased with the information provided by the app and valued its functionality. Medina et al. (2020) created an app that integrates a self-monitoring app for patient engagement, tracks symptoms for early detection, and facilitates a comprehensive view of treatment for people with COVID-19. As a COVID-19 counter-cluster measure, Yamamoto et al. (2020) created a health observation app embedded with personal health records. The app significantly reduced the follow-up burden for people who had close contact with proven COVID-19 cases. To our best knowledge, no similar study has been conducted and published in the study area.



**Figure 1:** Covid-19 cases as at 31 May, 2022

Source: NCDC, 2022

## MATERIALS AND METHODS

### Types and sources of data

The table below shows the type and sources of data needed for the study.

### Requirements Analysis and Specification

#### Specification Requirements

The requirements of any project must be well-considered,

structured, and comprehensible. If there is one thing that every project must have in order to avoid failure, it is a reasonable and detailed collection of both the functional and non-functional requirements. Non-functional requirements explain how the system works, whereas functional requirements specify whatever the system should do (Duyne, Hong and Landay, 2018).

**Table 1:** Types and sources of data

S/N	Data Needed	Sources
1	Testing Centers Labs, Public, Private and Sample Collection Sites NITP (NCDC)	National Centre for Disease Control (NCDC)
2	Vaccination Centers Public Private	National Primary Health Care Development Agency (NPHCDA) Federal Ministry of Health (MOH) World Health Organization (WHO)
3	Pictures	Field work, Internet Searches

Source: Authors, 2022

### Requirements Analysis and Specification

#### Specification Requirements

The requirements of any project must be well-considered, structured, and comprehensible. If there is one thing that every project must have in order to avoid failure, it is a reasonable and detailed collection of both the functional and non-functional requirements. Non-functional requirements explain how the system works, whereas functional requirements specify whatever the system should do (Duyne, Hong and Landay, 2018).

#### Functional Requirements

The functional requirements illustrate the system's specific functions. Pertaining to the Software, the system is able to:

1. Add admin (admin that can manipulate the admin dashboard) and ascribe them different levels of authority.
2. Validate admin login details and ensure access to information according to the user's level.
3. Store and retrieve information about covid-19 testing, and vaccination centers.
4. Carry out search functions based on some established criteria.
5. Generate covid-19 statistics and update.

#### Non-Functional Requirements

Non-functional requirements are those that have an impact on the computer as a whole. They are the requirements that are unrelated to the system's functions (Aurum & Wohlin, 2017). Non-functional requirements address system quality issues in specific software and describe various attributes in that system. Non-functional requirements include security, and system reliability, accuracy, usability and performance (Li & Tsai, 2020). Non-functional requirements, on the other hand, are constraints on the system's functions, such as "timing constraints, development process constraints, and standards" (Summerville, 2017). Non-functional requirements are associated with performance, which determines how the system will operate (Wysocki, 2017).

The Nigeria Covid-19 Testing and vaccination site finder (Test&Vax9ja) has the following non-functional requirements:

- i. Performance: The Test&Vax9ja requires a high level of performance. The user can see how the system performs in terms of "response time," "throughput," and "concurrency." Concurrency refers to how many users can access the system at the same time. How many requests can the system accommodate? How quickly the system could handle individual requests.
- ii. Security: A significant non-functional requirement is security. Nobody wants to use a system that isn't secure. The requirement for security also aids in the security of survey data collected by users.
- iii. Reliability: Reliability is an important non-functional requirement that informs the user about the system's dependability in terms of both workload and operation. The system should be available at all times so that users can easily access it.
- iv. Maintainability: The system is both simple to maintain and simple to update.
- v. Simplicity: The system is very easy and simple, with a beautiful interface arrangement that enables users to interact with it quickly.

#### System Requirement

The requirements that are used for this software system are itemized below as:

I. The system contain three sections as listed below:

- a. Front-end: it's the user interface, that contains all the interface design, modules and Graphical user interface for easy access and interaction.
- b. Back-end: consist of server, application and databases that work in the background to provide users with information.
- c. Admin panel: it's a section controlled by admin, which is used for manipulation of software's data. Such as Adding or deleting centers, editing center. etc.

II. The system provide menu where user can click and view Testing or vaccination centers and their information

(including name, phone no, email address, contact address, image, location of the center on map, among others).

III. The system provides a menu that contains the nearest centers in proximity to a user's location. The system is able to detect user's location hence calculate the distance between the user's location and centers coordinate to provide the user with the covid-19 testing and vaccination centers that are close (nearest) to the user's location.

IV. The system provides a menu where user can view Global Covid-19 news, statistics and update

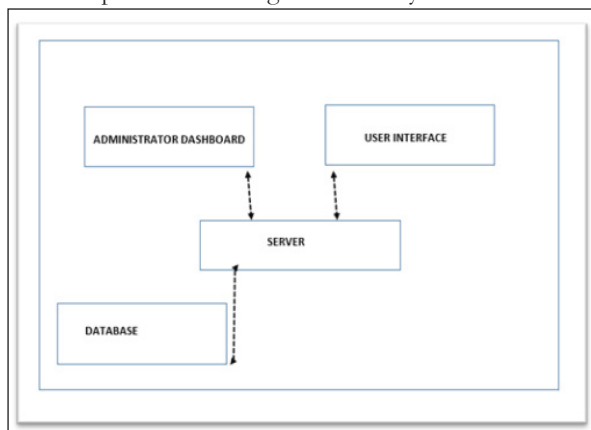
V. The system also provides users with frequently asked questions with their answers.

VI. The system also provides an interface for user survey in order to integrate the platform

VII. The system allow user to search for centers based on some specified criteria (such as by state, local government, ward etc.)

### Software Design

The software includes all of the software platforms required for system operation and interaction. The figure below depicts a block diagram of the system's software.



**Figure 2:** Software Design

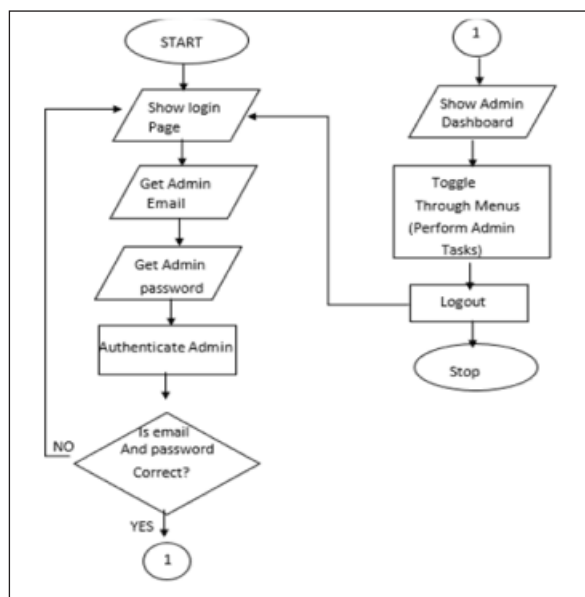
Source: Authors, 2022

### Administrator Dashboard

It is a section used for data manipulation in software. For example, adding or deleting centers, editing centers, and so on. It includes the fundamental CRUD (Create, Read, Update, and Delete) features for monitoring and managing data centers. It connects to the server in order to access the data stored in the database. The administrator dashboard has a login page, as shown below, to prevent unauthorized access. The login will require the administrator's email and password for verification and will validate it against the database values. If verification is successful, access to the dashboard will be allowed; otherwise, restricting access. The admin dashboard operation flowchart is shown below.

### Web Server

The software that provides Web pages to the rest of the world is known as a Web server. When a URL is entered into a Web browser, a message is sent to the Web server at that URL, requesting that an HTML file be sent. In



**Figure 3:** Software Design

Source: Authors, 2022

response, the Web server sends the requested file. The HTML file is read by the browser, and the Web page is displayed. The server is built on a REST API architecture. REST is stateless in the sense that the server does not store data; instead, it defines specific protocols for how data in the database can be stored, accessed, modified, or removed.

### Database Design

Any good database design should strive to eliminate or, at the very least, reduce redundant information (Dennis, Roth & Wixom, 2018). MySQL has been chosen as the database for the Nigeria Covid-19 Testing and Vaccination site finder.

### Overview of Tools and Languages Used

#### Web Server

The Web server is software that distributes Web pages to people all over the world. When a URL is entered into a Web browser, a message is sent to the Web server at that URL, requesting that an HTML file be sent. The requested file is sent by the Web server in response. The HTML file is read by the browser, and the Web page is displayed (Leierer, 2017).

#### Database Server

MYSQL server is used as a database server in this context. Although it is an open source database, it has proven to be as stable and robust as most proprietary software like oracle and SQL server (Leierer, 2017).

### XAMPP Server

It's an all in one package for windows (Windows, Apache, MySQL and PHP) to be used as server and also to run PHP/MYSQL codes (Leierer, 2017).

#### API:

- Google Maps API: is a set of application programming interfaces that allow us to communicate with its services. It will enable us to create simple to advanced location-

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	ccID	int(11)			No	None		AUTO_INCREMENT	Change
2	ccLabName	varchar(250)	utf8mb4_general_ci		Yes	NULL			Change
3	ccStateID	int(11)			Yes	NULL			Change
4	ccLGA	int(11)			Yes	NULL			Change
5	ccWard	varchar(250)	utf8mb4_general_ci		Yes	NULL			Change
6	ccTestPlatform	varchar(50)	utf8mb4_general_ci		Yes	NULL			Change
7	ccType	varchar(15)	utf8mb4_general_ci		Yes	NULL			Change
8	ccEmail	varchar(255)	utf8mb4_general_ci		Yes	NULL			Change
9	ccPhone	varchar(11)	utf8mb4_general_ci		Yes	NULL			Change
10	ccAddress	text	utf8mb4_general_ci		Yes	NULL			Change
11	ccStatus	varchar(10)	utf8mb4_general_ci		Yes	NULL			Change

Figure 4: MYSQL Interface

Source: Authors, 2022

based apps for the Web, iOS, and Android.

- Geolocation API returns a position and accuracy radius dependent on the cell tower and Wi-Fi node information detected by the mobile client. Geolocation API was used in order to detect the precise user location.
- Maps JavaScript API Maps can be customized with your own content and imagery to be displayed on web pages or mobile devices. The Maps JavaScript API includes four basic map types (hybrid, roadmap terrain and satellite) that can be specially designed with layers and styles, controls and events, and a variety of services and libraries. The Maps JavaScript API helps us in order to calculate the distance between the user's location and centers coordinates hence filter and provide the user with

the covid-19 testing and vaccination centers that are close (nearest) to the user's location.

- Directions API: This is a web service that responds to HTTP requests with JSON or XML-formatted directions between two positions. We can calculate directions between locations using the Directions API.

Software Languages used

The software was developed using combinations of languages. such as:

- Html for web page's structure and its contents.
- Php version 7.4 for creating dynamic web pages that can interact with data base.
- Css for styling the web page
- JSON for clear transmission of data from web server to the software and vice versa

```
<!DOCTYPE html>
<html lang="en">
<head>
<!-- Required meta tags -->
<meta charset="utf-8" />
<meta name="viewport" content="width=device-width, initial-scale=1, shrink-to-fit=no" />
<title>Nigeria COVID-19 Testing &amp; Vaccination Finder </title>
<!-- Favicon -->
<link rel="icon" href="assets/images/testVaxNaija_2.png" type="image/png" />
<!-- Vector CSS -->
<link href="assets/plugins/vectormap/jquery-jvectormap-2.0.2.css" rel="stylesheet" />
<!-- plugins -->
<link href="assets/plugins/simplebar/css/simplebar.css" rel="stylesheet" />
<link href="assets/plugins/perfect-scrollbar/css/perfect-scrollbar.css" rel="stylesheet" />
<link href="assets/plugins/metismenu/css/metismenu.min.css" rel="stylesheet" />
<!-- loader -->
<link href="assets/css/pace.min.css" rel="stylesheet" />
<script type="text/javascript" src="dmsAppConnect/dmsAppConnect.js"></script>
<script src="assets/js/jquery.min.js"></script>
<script src="assets/js/pace.min.js"></script>
<!-- Bootstrap CSS -->
<link rel="stylesheet" href="assets/css/bootstrap.min.css" />
<!-- Icons CSS -->
<link rel="stylesheet" href="assets/css/icons.css" />
<!-- App CSS -->
<link rel="stylesheet" href="assets/css/app.css" />
<link rel="stylesheet" href="assets/css/dark-sidebar.css" />
<link rel="stylesheet" href="assets/css/dark-theme.css" />
<script type="text/javascript" src="dmsAppConnect/dmsBrowser/dmsBrowser.js"></script>
<script type="text/javascript" src="dmsAppConnect/dmsFormatter/dmsFormatter.js"></script>
</head>
```

Figure 5: HTML codes used

Source: Authors, 2022

## RESULTS AND DISCUSSION

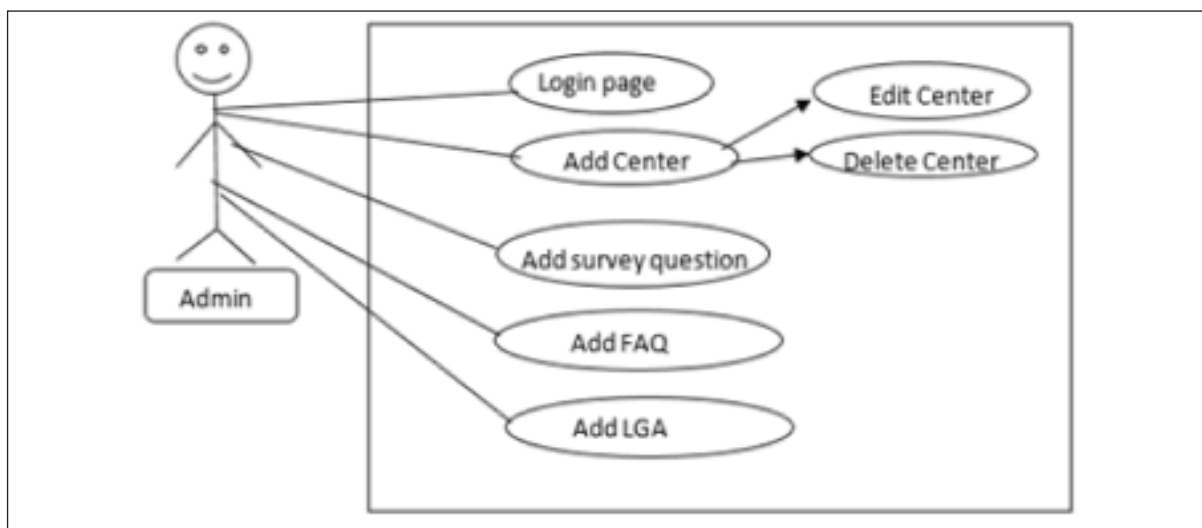
This section contains the result obtained from the study.

Admin Section

The Admin section is a section that is accessible by only admin to manipulate site's content. Normal users are not allowed to access this panel.

Login Page: this is a page that provides access to the admin dashboard. It requires user identification and authentication before access is granted. Entering the correct email(username) and password will allow access to the following menus:

- > Add center: where Admin can add new Testing or vaccination centers. And through the Add center button, admin can edit (update) or delete center.
- > Add survey question: this Is a menu that allow admin



**Figure 6: Admin Section**

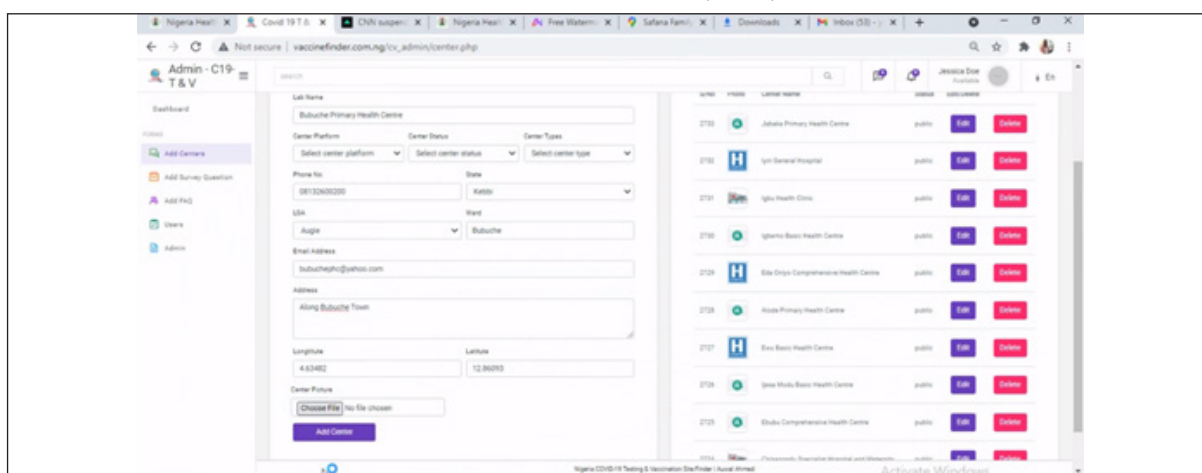
Source: Authors, 2022

to add survey question to be taken by users.

> Frequently asked question(FAQ): where admin can

add most asked question and their answers

> Add Local Government(LGA): Admin can be able to add local governments that are not contain from the source (online).

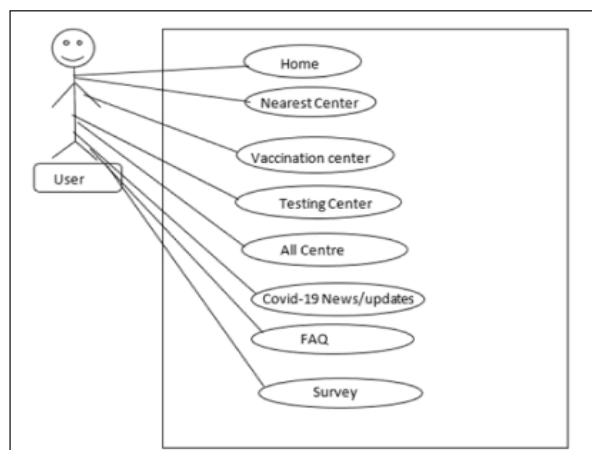


**Figure 7: Admin Section Interface**

Source: Authors, 2022

User Section

The system design to meet the above requirements (3.2.1.2) is illustrated in the system block diagram shown below:



**Figure 8: User Section**

Source: Authors, 2022

A user section (client-side or frontend) is what the user can see and interact with in the site. It encompasses everything the user directly experiences from navigation menus, images, buttons to colors, text and so on.

Users have access to the following menus:

> Home: This is the home page. It is the first page you come across when you enter the portal. The page address is <https://vaccinefinder.com.ng/index>.

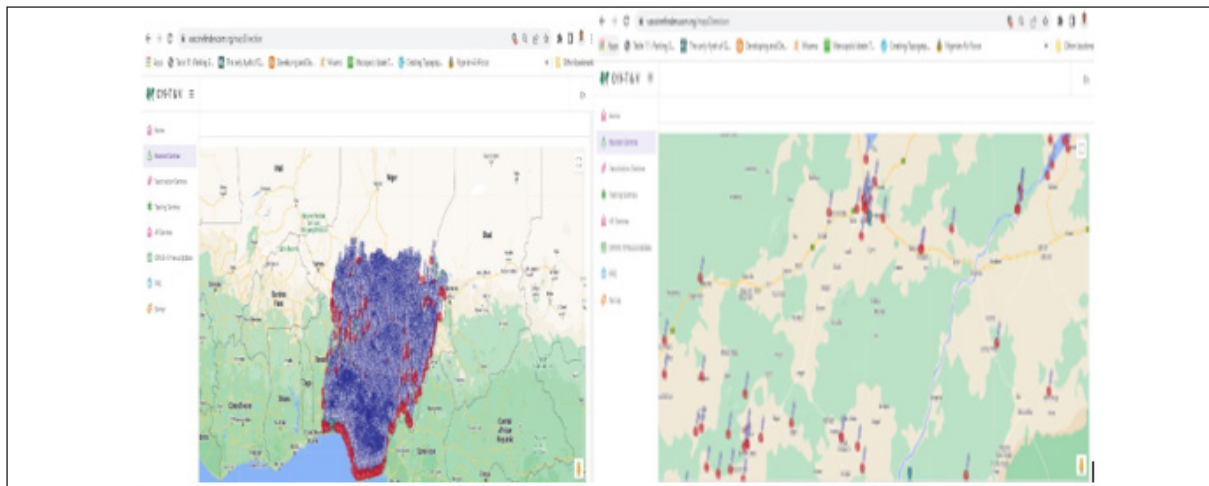
> Nearest Center: where user can be able to see the available nearest centers on map in proximity to the user location.

> Vaccination centers: contains all the vaccination centers and their information. Also a search box is provided in order to search for a vaccination center base on state, ward, LGA amongst others

> Testing Centers: contains all the Testing centers and their information. A user can search for a Testing center base on state, ward, LGA amongst others

> All centers: it's a page that contains all the Testing and Vaccination centers and allow filtration for easy access.

> Covid-19 News/Updates: provide the updated national and international covid-19 news including



**Figure 9:** All Centres

Source: Authors, 2022

covid-19 statistic

> Frequently Asked Question (FAQ): contains the FAQ added by the admin

Survey: it's a page, where user can take survey for proper evaluation and record keeping.

Below is the list all the centres as shown upon the Google earth API which shows their spatial distribution across Nigeria The above image depicts the interface which

S/No	Center Name	Center Type	State	LGA	Ward	Status
395	Tsargema Primary Health Clinic	Vaccine Center	Jigawa State	Swaram	Tsargema	public
403	Miyawa Primary Health Clinic	Vaccine Center	Jigawa State	Swaram	Miyawa	public
824	Zandam Tsargema Health post	Vaccine Center	Jigawa State	Swaram	Zandam Tsargema	public
828	Saka PHC	Vaccine Center	Jigawa State	Swaram	Saka	public
1286	Swaram Primary Health Center	Vaccine Center	Bauchi State	Alkaleri	Swaram A	public
1278	Swaram Primary Health Center	Vaccine Center	Bauchi State	Alkaleri	Swaram B	public
1882	Swaram Primary Health Care Center	Vaccine Center	Bauchi State	Mitau	Swaram Ward (Mitau)	public
8029	Gidankama Health Clinic	Vaccine Center	Zamfara State	Tulata Mufara	Swaram	public
8076	Saka Primary Health Clinic	Vaccine Center	Jigawa State	Swaram	Saka	public
8222	Kundika Primary Health Clinic	Vaccine Center	Jigawa State	Swaram	Kundika	public
8224	Kila Primary Health Care	Vaccine Center	Jigawa State	Swaram	Kila	public
8285	Farin Dutse Primary Health Clinic	Vaccine Center	Jigawa State	Swaram	Farin Dutse	public
8472	Fagari Primary Health Centre	Vaccine Center	Jigawa State	Swaram	Fagari	public

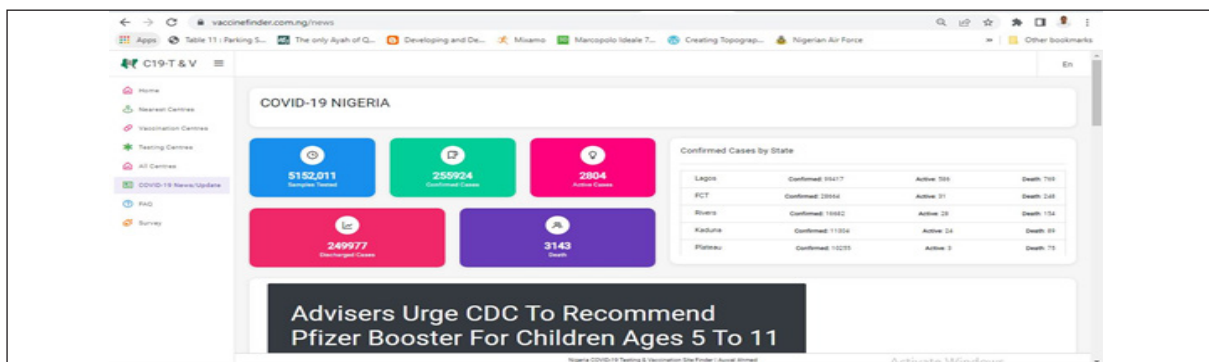
**Figure 10:** All Centres

Source: Authors, 2022

allows the user to type any name which could be centre name, local government or state which will enable the

system to display all the centres carrying the requested information.

The above page shows the Nigeria Covid-19 Figures which includes total samples tested, total confirmed



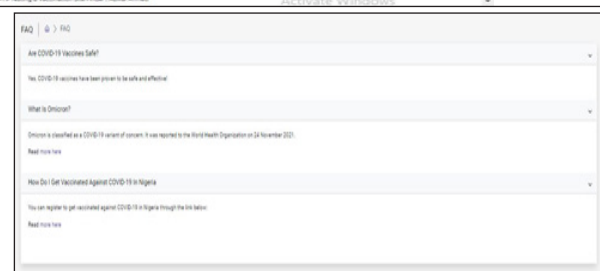
**Figure 11:** COVID-19 Updates

Source: Authors, 2022

cases, death and number of discharged patients.

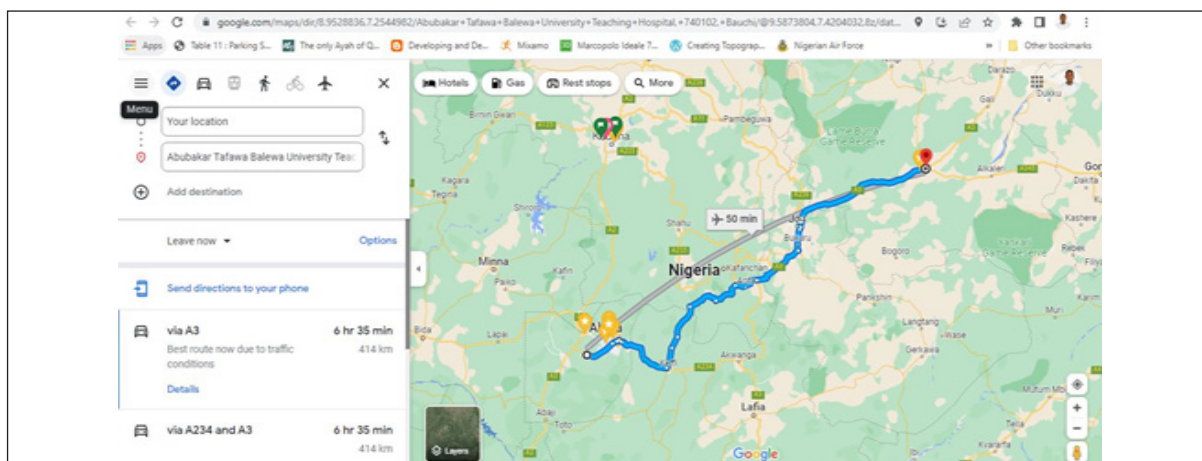
The FAQ section contains Some questions and answer about the App and Covid-19. Some of the questions include:

- Are COVID-19 Vaccines Safe?
- What Is Omicron?
- How Do I Get Vaccinated Against COVID-19 In Nigeria?



**Figure 12:** FAQs

Source: Authors, 2022



**Figure 12:** Determining distance between user and another centre

Source: Authors, 2022

When a user clicks nearest centre, the Directions API let the Portal to calculate directions and distance between the user's location and centre's coordinates to display the centre nearest to the user.

## CONCLUSIONS

The research demonstrated successful implementation of the ability to determine the closest health care facility closest to the user in order to ease and increase testing and vaccination of Nigerians. It is necessary to organize community awareness - raising activities about the importance of contact tracing. Such sensitization activities could take place in the markets, car dealerships, and underdeveloped communities. Similarly, active civic engagement of the opinions of community and religious leaders would improve people's participation in COVID-19 testing and vaccination.

Interventions to increase eagerness for COVID-19 testing and vaccination should be targeted at wealthy individuals. These could include taking COVID-19 tests to places where the wealthy congregate, such as evening clubs. Individuals with lower educational attainment should be targeted to increase their willingness to disclose contacts. Besides that, The Portal was developed successfully and met its requirements, but it requires additional testing to increase stability, particularly the user tracking feature. By editing the maps at open street maps, the application can be implemented in any specific nation or region. More research can be done to shift the map server to a server specified by the client. We hope that our findings will help increase the rate of testing and vaccination in order to prevent COVID-19 infections and other large-scale infectious diseases around the entire globe.

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