Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
1 Introduction

The infectious coronavirus has spread in the entire world. World Health Organization (WHO) has declared it as a pandemic. Its onset is in China at the end of 2019, and the number of active cases is increasing in the entire world (Cucinotta and Vanelli, 2020). In India, the first case of coronavirus pandemic was reported on 30 January, 2020 (Alansari et al., 2018). If tested positive for coronavirus, people were either advised for two weeks home quarantine or hospitalization depending on the severity. During this epidemic, in rural and urban India, ASHA (Accredited Social Health Activists) workers are frontline warriors. The ASHA program is a key component of National Health Mission (NHM) of India, launched in 2006. The main objective of NHM is to improve the availability of quality health care for people, particularly, rural India with main focus on women and children (Masuda and Viswanathan, 2019). According to NHM guidelines, any woman in the age group of 25–45 years, educated up to eighth class and residing in the village can be selected as ASHA. After selection, ASHAs undergo formal training. Their job is to create health awareness, conduct immunization drives, and facilitate reproductive and child healthcare, and promoting other healthcare initiatives in their respective state. ASHAs receive performance based incentives for community level health interventions. There are around 10.61 lakh ASHAs across the country, who act as a
link between the community and the public health system (Rahul et al., 2021).

During COVID-19 epidemic, coronavirus disease was rapidly spreading in India. To control spread of the disease, community mass screening was indispensable. There was immediate necessity of capturing the data related to public health, resources available in hospitals and quarantine camps, contact tracing, information-sharing and further decision-making, etc., for prevention, management, treatment and follow-up of COVID-19.

As a part of NHM of India, ASHAs were trained to check the health parameters and conduct health surveys. Everyday ASHAs were going door to door to check fever, SpO$_2$ and conduct survey. If any health issues were noticed, ASHAs took the patient to the nearest health centres for further treatment. Each ASHA worker notes down the data about number of infected people in home quarantine, their contact tracing information. They also captured information on elderly people staying alone, existing ailments of people surveyed. Further, they also noted down health data of pregnant women. In doing this exercise, they were also collecting information about availability of beds, doctors, nurses, number of ventilators and oxygen cylinders in the hospital, data on quarantine camps, containment zones, etc. In survey field work, ASHA workers were able to cover average 30 houses, sometimes 40 in a day. They gave this collected information to authority in public health centres. Later, this collected data was passed on to Zonal Admin to take further actions and avoid spread of the disease.

After reading the published news related to field work of ASHA workers, we realized that the process was time-consuming and not well organized (Health and Department, 2020), Kulkarni (2021). If it becomes automated, ASHAs can give service to more people in their respective wards and surveys could be conducted swiftly. To address above-mentioned issues and make process efficient, we designed an IoT enabled mobile app to capture two vital parameters and facilitate fast data collection by ASHA. This will be helpful in COVID-19 data management to treat more infected patients with available resources in the hospitals.

The structure of the chapter is as follows: Related works are described in Section 2. Various application softwares are presented in Section 3. Proposed design model is introduced in Section 4. Description about the Android package kit is given in Section 5. Visualization of the proposed app, view of the details and softwares and services used to develop the application are explained in Sections 6, 7, and 8 respectively. Finally, concluding remarks are given in Section 9.
2 Related works

Technical papers enlisted here, rightly helpful in the development of our IoT-enabled medical system and a mobile app. Design of health monitoring system based on Internet of Things (IoT) has been presented in (Kannan et al., 2019). Sensors collect patients’ body parameters such as temperature, motion, etc. This data was transferred to the microcontroller and further to cloud server. Medical history can be stored in the cloud for easy access and future analysis. Utility computing and wireless sensor networks for proof-of-concept design have been discussed (Rolim et al., 2010). Currently available mobile applications to address COVID-19 have been explained in (Noronha et al., 2020).

Low-cost, scalable, rapid, and effective device design for fever screening proposed in the studies of Kaplan et al. (2011) could be useful in many situations. The various features of COVID-19 mobile health applications were evaluated in (Ming et al., 2020). Authors have presented comparative analysis based on basic features on which various apps have been developed. The functionality of the apps was assessed according to information available on important parameters of COVID-19 useful for public and health authority. In (Singh et al., 2020), the applications IoT useful for health monitoring and hospital management system have been explored. The work proposed in (Xie et al., 2020) have focused on conditions related to difficulty in breathing and oxygenation provided as potential prognostic biomarkers. This study reported that oxygen saturation values greater than 90% are indicative of high likelihood of patient survival and such patients must receive maximum supportive care. Further, this study also mentioned, the patients with oxygen saturation values less than 90% and breathing difficulty despite oxygen supplementation, are at high mortality risk, may be more likely to benefit from investigational drugs and antibody drug therapy.

3 Application software developed by various other countries

In this section, we discuss various mobile Apps and websites developed towards coronavirus health monitoring which is useful for general public. Coronavirus health monitoring mobile Apps can be categorized as Symptoms Apps, Contact tracing Apps, Health monitoring Apps and prevalence Apps.
1. Coronavirus symptoms apps: The applications developed in this category will ask various questions to the users to check whether health symptoms are towards coronavirus disease. Accordingly, based on answers to queries, it guides users to see the doctor or not. The COVID Symptom Tracker, is an epidemiological research mobile application developed in the United Kingdom that runs on Android and iOS. It is a team work amongst Kings College London, Guys and St Thomas’ Hospitals and ZOE Global Limited (ZOE, 2021). There are applications like Symptomate—Symptom Checker Infermedica (2021), Data4Life (Data4file, 2021) that deal only with COVID-19 symptoms questionnaires to assist people regarding what the symptoms mean and suggest them what next steps they should be taking.

2. Coronavirus Contact Tracing Apps: Asymptomatic carriers spread the virus and individuals are at potential risk of fatal infections. The globe grapples with the COVID-19 pandemic by deploying contact tracing applications to trace the movement of COVID-19-infected population (Chen et al., 2020). Many nations developed smartphone applications to trace contacts of infected people and infected areas. Based on this information, it is possible to identify infected zones region wise. This information is very useful to public and NGOs, and government to take necessary steps and precautions to fight against the coronavirus. Digital contact tracing applications use mobile technologies like GPS, Bluetooth, and Quick Response (QR) codes for digital tracking and update users about their encounters with infected population. Compared to traditional contact tracking, this automated and digital technique provides government bodies a cost-effective and scalable solution (Amann et al., 2021).

COVID-19 digital contact tracking applications are being developed by most of the nations. Asian nations with past SARS experience, particularly China and Singapore, were pioneers in deploying contact tracking applications and other digital disease surveillance technologies using well-developed digital infrastructures. Europeans with the Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT) co-operative, is one of the earliest to build contact tracing apps. Austrian Red Cross was the first in Europe to develop “Stop Corona” digital contact-tracing App. Subsequently, Germany’s “Corona-Warn-App” and Switzerland’s “Swiss Covid-App” were created jointly by the two federal technical schools in Switzerland (Troncoso et al., 2020).

The “GoCoronaGo” app (Rambha and Simmhan, 2021) developed by the professors of Indian Institute of Science, India, helps to find the
people who have come in contact with COVID-19 positive public, using the GPS and Bluetooth technology. In the backend, temporal network analytics is being used for handling distant contacts. Maharashtra Government of India introduced MahaKavach App to Track Suspected COVID-19 Cases. This App helps public to contribute and help in tracing the contacts with potential risk of COVID-19, thereby helping Health officials (State innovation society, 2020). List of few contact tracing Apps developed by various countries is shown in Table 1. The source (Wikipedia, 2021) provides various COVID-19 Apps developed by other countries.

Few concerns that need to be addressed during the development phase of contact tracing applications are as follows (Akinbi et al., 2021):

- User data privacy concerns
- Lack of Trust
- Ethical issues
- Security vulnerabilities
- Technical constraints
- User behavior and participation

3. Coronavirus Health Monitoring Apps: ‘Aarogya Setu’ App developed by Government of India helps public to join essential health services, in the combined fight against COVID-19 (National Informatics Centre, 2021; Gupta et al., 2020). Indian Institute of Technology Bombay professors and students, from India, have developed ‘Corontine’ (Sukumar, 2021), a scalable platform, for the government bodies and private

| Table 1 List of contact tracing Apps developed by various countries. |
|-----------------------------------------------|
| **Country** | **Contact tracing Apps** |
| Brazil | VirusMapBR |
| Canada | COVID Alert |
| China | Health Code |
| France | TousAntiCovid |
| Germany | Corona-Warn-App |
| India | Aarogya Setu |
| Italy | SM-COVID-19 |
| Malaysia | SELangkah |
| Russia | Social Monitoring |
| United Kingdom | Protect Scotland |
| United States | PathCheck |
| New Zealand | NZ COVID |
enterprises. The Geo-fencing feature incorporated herein helps the administrator to get alerts when a person having COVID-19 symptoms breaks the quarantine.

4. Coronavirus Prevalence Apps: This category of Apps give the user the updated news and health information on Coronavirus. The World Health Organization (WHO) dashboard provides the region wise data on amount of confirmed cases and deaths in various parts of the world Dashboard (2021).

4 Design of proposed IoT enabled device

We have developed an IoT enabled portable device and a mobile App for ASHA workers. It consisted of a non-contact Infrared sensor (MLX90614) and SpO₂ sensor (MAX30100) for measuring fever and SpO₂ respectively, during mass screening. These sensors were interfaced with node MCUESP32, using I2C communication. ESP32 was programmed to get digital values of the recorded vitals. These readings were displayed and stored on cloud platforms using its Wi-Fi module. Further, this device was interfaced with mobile App “ASHA BOT”, to assist ASHA workers during the field work.

Fig. 1 shows the pictorial representation of IoT enabled device and a mobile app to aid ASHA workers during COVID-19 pandemic. During mass screening, when ASHA workers use this device, it captures revealed health parameters on ASHA Bot, in the respective fields and further data is stored on the sever. This server data is password protected by zonal officer who will be Admin for COVID-19 data management system.

5 Android package kit development

5.1 Design flow for the mobile app development

The mobile app starts with a Login page. The user has two options, either to login as Admin or as Asha worker. In either of the login options, the user has to provide the username and password. On successful login, the user is taken to the respective home page, Admin Home page or Asha Worker page. Fig. 2 shows the flow of operations during login.

Admin, on logging in, is provided with the following options: View Registered Asha worker, Patients Details, Hospital Details, Containment Zone Details, Quarantine camp data, ASHA Workers Details, Public
Fig. 1 Design of IoT enabled system and mobile app ASHA Bot for ASHA workers.

Fig. 2 Login process flow.
Details. If ASHA worker is currently not on roll Admin can also Remove ASHA Worker. Fig. 3 illustrates various selections under Admin page.

Various handles provided for Asha worker include, Register public, Conduct Survey, Collect Hospital data, Collect Containment data and Collect quarantine camp data. Fig. 4 represents various entities provided to Asha worker on successful login.

5.2 Design of admin and ASHA worker page

This section describes various options provided to Admin. Admin is a zonal officer on duty during COVID-19 pandemic and has access to perceive the information’s in various handles provided shown in Fig. 4. Admin will also register ASHA workers in his area for COVID-19 duty. ASHA worker logs in with her phone number and ID to use this application.
5.2.1 Register ASHA worker
Under this handle, the Admin needs to enter all the details of new Asha Worker to register her. Upon valid entry of data, the worker gets registered. Fig. 5 shows the process of new Asha Worker registration.

5.2.2 View patients details
The Admin can view the health-related details of the public which were collected by the Asha Worker and apply various filters on the result.
5.2.3 **View hospital details**
This option provides the options to view all the hospital details such as hospital name, number of beds available, number of test samples collected, number of positive test cases and the location of the hospital, which have been collected by the workers.

5.2.4 **Containment zone details**
All details related to containment zone such as name of the zone, its location and related images are provided under this option.

5.2.5 **Quarantine camp data**
Information related to quarantine camps such as name of the camp, number of patients quarantined, location and related images are available here.

5.2.6 **View workers details**
All the registered ASHA workers details such as name, mobile number and ID are available here.

5.2.7 **View details of people who participated in door to door survey**
The basic details about their name, date of birth, mobile number, address and ADHAR (Unique identification number given to public) number are available here.

5.2.8 **Remove ASHA workers**
The Admin has the choice to delete any ASHA worker account if she is not on the roll. Fig. 6 shows the steps in deleting an ASHA worker account.

5.3 **Description of the various fields under ASHA worker page**
This section introduces various stages which need to be performed under the ASHA worker page are as follows:

5.3.1 **Register people during survey**
This is a one-time process. The parameters include: Name, Mobile Number, Address, Age and Aadhar Number. Details are collected and stored. Fig. 7 shows the process of registering public.

5.3.2 **Conduct survey**
The health-related information of the community is collected here from time to time.
Step 1: Enter the Aadhar number (unique public ID) of subject/participant and click on load to fetch the details. If found not registered, then the subject is needed to be registered in “Register Public” option.

Step 2: Enter the health-related data of the subject/participant.

Step 3: Click on “Submit” to save the details.

Fig. 8 illustrates the steps involved in conducting survey.

Fig. 6 Delete ASHA worker account.

Fig. 7 Registering new subjects for survey.

- Step 1: Enter the Aadhar number (unique public ID) of subject/participant and click on load to fetch the details. If found not registered, then the subject is needed to be registered in “Register Public” option.
- Step 2: Enter the health-related data of the subject/participant.
- Step 3: Click on “Submit” to save the details.

Fig. 8 illustrates the steps involved in conducting survey.
5.3.3 Hospital data
ASHA worker can also approach hospitals in the community to gather the data along with on-site pictures. In details of hospital ASHA collects data like: Name of the hospital, total beds available, vacant beds available, samples collected on date, samples tested, samples confirmed and images if necessary. At present, three images can be uploaded per hospital and can be increased as well. Fig. 9 illustrates the steps involved in collecting hospital details.

5.3.4 Containment zone data
Details such as name of the zone, its location and related images are collected here. Images from each containment zone can be uploaded. Fig. 10 illustrates various steps involved in collecting containment zone details.

Quarantine Camp Data: Under this handle, details such as name of the Quarantine Camp, number of patients quarantined, its location and related images are collected here. Images from containment zone can also be
Collect Hospital Details

Enter beds and lab details

Upload Images

Data Recorded

Collect Containment Zone Details

Enter Details

Upload Images

Data Recorded

Fig. 9 Collecting hospital data.

Fig. 10 Collect containment zone details.

uploaded. Figs. 11 and 12 illustrate various steps involved in collecting quarantine camp details.

*Real time data storage:* Data which are collected stored in real-time at two places, such as Google Firestore database and Google sheets. The authorized user has access to all the data.
In this section, various entities of ASHA Bot mobile app are introduced. These sample results represent utility of the app and not the actual data collected.

### 6.1 Login page

Login the main page where the user needs to add her credentials like username and password as indicated in Fig. 13.

**Fig. 11** Collecting Quarantine Camp details.

**Fig. 12** Upload picture of the site.
6.2 Design of admin page

Explores attributes which are available in the admin page are discussed in detail.

6.2.1 Entities in admin home page

Various entities considered in the design of Admin page have been considered based on first hand from ASHA workers and information availed from the COVID-19 information portal for public Fig. 14.

6.2.2 Register ASHA worker

Fig. 15 shows registration of ASHA worker by Admin. ASHA worker unique ID, mobile number and name are all essential fields.

7 View public details

Every day in door-to-door visit, before starting survey, ASHA logs in and after registration of public she captures temperature with non-contact method and SpO₂ level. This is represented in Fig. 16. Once registered,
in the next visit based on previously entered details ASHA can continue with direct information collection.

In the statistics, longitude and latitude details are accessed which gives location of the public mobile number. Fig. 17 indicates various fields that would be useful in contact tracing operation and for analysis. During analysis details such as mobile number, AADHAR number (Identification number given by the Indian government for its citizen), Longitude and Latitude information help in contact tracing.

7.1 View hospital details

Figs. 18 and 19 indicate the data collected by ASHA from hospital and Admin can access it for the analysis. Various fields include Date, Name of Hospital, Number of beds available, Location of the Hospital and other Lab related data and link for the images captured on site.
Fig. 15 Register Asha Worker.

Fig. 16 Sample of patient details.
**Fig. 17** Accessing public data for analysis.

**Hospitals Data:**

1. Date: 25-07-2020  
   Name: BMS HOSPITAL  
   Total Beds: 500  
   Vacant Beds: 50  
   Confirmed Cases: 50

2. Date: 19-09-2020

**Fig. 18** Sample data collected from Hospital about vacant beds and confirmed cases in hospital.
7.2 Containment zone details

Fig. 20 exemplifies the data collected by ASHA workers who are working in particular Ward and Containment Zone. This data can be accessed by Admin after download depicted in Fig. 21. Various fields such as Date, Name and location of the Containment Zone and related images.

**Containment Area Data:**

1. Date : 19-09-2020
   Containment Area Name : Area Abc

2. Date : 25-07-2020
   Containment Area Name : Area new

Fig. 20 Sample data of containment zone.
7.3 Quarantine camp data

Fig. 22 shows statistics collected by ASHA at Quarantine Camp and pictorial representation of statistics available to Admin for further analysis. Fig. 23 shows various sub entities which include Date, Name of the Camp, Number of people quarantined, Location of the Quarantine Camp and supporting images.

![Quarantine Camp Data:](image)

- Date: 25-07-2020
- Name of Camp: Ashok Nagar Camp
- Quarantined Patients: 100

- Date: 25-07-2020
- Name of Camp: Camp

Fig. 22 Sample data on Quarantine camp.
7.4 Subpage to view ASHA worker details

Admin can track the number of ASHA workers currently on COVID-19 duty. Fig. 24 shows the page for Admin and statistics in Fig. 25.

7.5 View public details

Admin can get the details about the subjects in public survey and ASHA worker responsible for the task, shown in Figs. 26 and 27. Various entities

Fig. 23 Quarantine camp data for analysis.

Fig. 24 Sample Registered ASHA worker details.
include Name, ADHAR Number, and Mobile number, Date of Birth, House Number, Area, City, State and Pin Code of survey participants.

7.6 Remove ASHA workers
Admin can remove ASHA workers who are not on roll as indicated in Fig. 28.
This is an important page for ASHA worker for their activity. The detailed explanation of the about these pages are as follows:

### 7.7.1 Home page

Fig. 29 represents various fields for which ASHA worker has to collect the data.

### 7.7 ASHA worker page

This is an important page for ASHA worker for their activity. The detailed explanation of the about these pages are as follows:

**Fig. 27** Public details for analysis.

**Fig. 28** Remove ASHA worker.
7.7.2 Register subject
ASHA registers new subject for the survey. She need to enter the information in respective field. She will use the IoT enabled hand held device to capture body temperature and Spo2 level with click on load tab. This is exemplified in the Figs. 30 and 31.

7.7.3 Conducting survey
ASHA worker ask a few more polar questions of Yes/No type to a person so that she can enter the status. These questions are related to health alignment of organs like heart or kidney or COVID-19 cases in the family or their travel history. This is as indicated in Fig. 32.
ASHA worker needs to ask questions about indicators which are available on the page as indicated in Fig. 32.

7.7.4 Assemble hospital data
ASHA visits to hospitals lab to collect the spot pictures and data about number of beds available in the hospital, vacant beds, number of COVID swab samples collected, tested and how many samples are tested positive. ASHA enters figures in respective fields to get data on Hospital and Quarantine camps as represented in Figs. 33 and 34, respectively.
Fig. 30  Register Subjects.

Fig. 31  ASHA worker registers a subject and captures body temperature and SpO₂.
Fig. 32 Questionnaire with yes/no on health symptoms.

Fig. 33 Hospital data—number of bed availability, statistics on samples.
7.7.5 Contentment zone data
ASHA worker visits to Containment Zones in their ward to get the latest statistics. She will do listing of contacts if person is found COVID-19 positive, along with their tracking, identification, quarantine follow up contacts. She will take live photos about supply of Essentials and medicines to the people in Containment Zone etc. This will give an idea to authority about how well the facility is reaching to the people as demonstrated in Fig. 34.

7.7.6 Quarantine camp data
During Covid 19 pandemic, in various wards Quarantine camps were formed for the people who are not COVID-19 positive but who are believed to have been exposed to the infection. Such people were kept separated and their movement was restricted for the purpose of preventing transmission of disease.

Persons were quarantined in their homes, and in community-based facilities. ASHA will visit quarantine camps, to collect the live pictures about the
physical infrastructure and functional Service requirement at quarantine facilities. Quarantine camp information is shown in Fig. 35.

### 8 Software and services used

Software used in the development of this mobile application are as follows:

- **Android Studio**: Android Studio has been used to develop the whole interface. The language chosen in Android Studio for this app development is Java.
- **Google Firestore Database**: Google Firestore database has been used to store data in real time.
- **Google Sheets**: Google sheets has been used to collect and store data in real time.
- **Google Auth**: Google Auth has been used for authentication purpose.
- **Google Storage**: Google Storage has been used to store media files.
**App usage:** Currently this device and app is in testing stage. Android application package (Apk) has been provided to authorities to download it and further give access to ASHA workers to test it on field.

9 Conclusions

In this chapter, we have explained and exemplified utility of our designed IoT enabled mobile app ASHA Bot, developed particularly for ASHA workers to collect on filed data and zonal officers can utilize this to realize day to day statistics of COVID-19. The proposed app is further scalable for other statistical needs. ASHA workers can use this application later with addition of necessary handles, as they primarily work as health workers for ladies and children.

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Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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