

# A Framework for Dengue Surveillance and Data Collection in Pakistan

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**Abstract**— Health monitoring through smartphones applications has emerged as a popular and effective practice. Many countries including Pakistan are suffering from a viral disease called Dengue. Dengue is a mosquito-borne single positive-standard RNA virus of the family Flaviviridae. It can be identified from its symptoms, such as skin rashes, fever, headache, and nausea etc. Due to the limited connectivity and availability of information technology services in rural and far-off areas in Pakistan, timely reporting the Dengue incidents to the authorities has been a serious issue. Moreover, currently there does not exist any data about Dengue infected areas and affected patients that hinders the government authorities to timely predict the disease outbreaks. To that end, we propose a framework to collect the information of suspected patients of Dengue through smart phones. The collected information is subsequently transmitted to the doctors and authorities for further necessary measures. A key benefit of the proposed architecture is that it will result in establishing a data repository of Dengue patients that can be further used for Dengue outbreak prediction.

**Keywords**— Dengue, Disease Outbreak, Mobile Application

## I. INTRODUCTION

Dengue is a mosquito-borne virus that has recently affected most parts of the world. Dengue virus is transmitted by female mosquitoes, especially *Aedes aegypti*, and to a lesser extent via *Ae. albopictus*. The mosquito also transmits other diseases that include Chikungunya, yellow fever, and Zika infection. Dengue fever is common in tropical areas, with risk differences that are affected locally by rain, temperature, and unplanned rapid urbanization [1]. The first outbreak of dengue fever in Pakistan occurred in 1994, but a sudden increase in cases and an annual epidemic of trends took place in November 2005 for the first time in Karachi. In Lahore, there was an outbreak of dengue fever that reported 16,580 cases and 257 deaths and about 5,000 cases and another 60 in the rest of the country. Three provinces of Pakistan that are affected by dengue outbreak are Khyber Pakhtunkhwa, Punjab and Sindh [2].

Traditionally, a medical professional performs a clinical determination to diagnose a Dengue infection. However, symptoms of Dengue in the start are not as severe as later in the course. During the early infection period, the Dengue patients may not be given appropriate treatment. It is important to recognize the symptoms of Dengue as early as possible, but this requires access to the Dengue detection kit

which is available in hospitals only because of high cost. Therefore, a more suitable method is needed for diagnosis of Dengue in patients.

In this article, a mobile-based framework is proposed to collect information about Dengue patients and the regions affected by the disease. In the presented framework, the health workers in any area interact with the suspected patients, collect the information about their symptoms, and transmit that information to the doctors who might be remotely located. The doctors access the patients' information through a Web application and after analyzing the symptoms can send the advice to the health workers through the same Web application. The health workers receive the information on the smartphone and subsequently communicate with the patients to inform them about the doctors' advice. Based on the observed symptoms, the doctors might prescribe medications or laboratory tests for further diagnosis. In case the patient is diagnosed with Dengue fever, he/she is recommended to visit the hospital. All the information of patients is stored in the repository that can be used by health officials for further analysis of Dengue outbreak and its prevention by applying machine learning techniques. A benefit of the framework is that it even if the Dengue suspects or patients reside in far-off and rural areas, their information is immediately transmitted to the District Headquarters hospitals. Only the patients need to visit local rural medical centers and must register themselves. On receiving the advice from the doctors, the patients could be referred to the hospitals in other cities if the local rural medical centers do not have sufficient arrangements to deal with Dengue patients. To summarize, the proposed architecture is meant to quickly report the confirmed or suspect Dengue cases identified in rural or urban areas to the government officials for immediate actions because in past failure to timely reporting the Dengue cases resulted in casualties.

In rural areas of Pakistan, most of the people are not technologically literate and do not have access to smartphones or even if they possess smartphones, communicating their health conditions through specialized apps could be difficult for them. Considering the fact, the framework introduces the health workers as the entities responsible for communication between the patients and the doctors. For the smartphone to transmit data to the cloud, Internet connectivity is required. However, in situations when there is no Internet access, the data is temporarily stored in SQLite database and is sent automatically to cloud as the Internet becomes available. In

case of any malfunctioning in the mobile application, health workers can use data collection sheet to record patient data manually and can later update the data on mobile application. All Dengue related patients' information is stored in cloud that can be used by health officials and researchers for further analysis of early Dengue outbreak and its prevention.

The rest of the paper is organized as follows. Section II discusses the related work whereas Section III presents the proposed architecture. The discussion on the proposed framework is presented in Section IV whereas Section V concludes the paper.

## II. RELATED WORK

A mobile based patients' data collection system called PDCT was presented to collect data from rural and urban areas for epidemic surveillance, especially in remote areas of Pakistan [3]. However, our proposed framework provides both the Android as well as Web application for data collection and exchange of information between the health workers and the doctors. In Fiji, a mobile application that uses the Global Positioning System (GPS) technology for Dengue monitoring was proposed. The presented application provided an information network to allow health authorities to quickly identify Dengue infected areas in Fiji and also shows the spread of Dengue. The objective of the application was to obtain the feedback from people about the remedy of papaya leaf, to enable the user to self-report Dengue cases, and to store the location of the user via GPS [4]. In [5], a telephone triage service is deployed as a basis for Dengue forecasting in Pakistan. The proposed system identifies an outbreak in a certain region and both the number of patients and their positions are predicted exactly two to three weeks in advance. Although the application is beneficial in collection of information, implementing such service at a national scale is not deemed suitable. In [6], the authors analyzed the blood samples obtained during a joint monitoring of fever in two slum areas in Karachi, Pakistan between June 1999 and December 2001. The epidemiology of the Aedes vector capacity is evaluated in [7] to the extent that the burden of public health and loss in different geographical environments and threats to the epidemic are interrelated.

Different strategies were proposed for future control of Dengue outbreak including timely and adequate clinical management, laboratory diagnosis, availability of trained staff, endogenous rehydration, and early reaction to a serious disease. Several reasons for the spread of Dengue outbreak in Lahore have been investigated in [8].

In 2011, patterns and hotspots related to Dengue epidemics in Punjab were investigated. Data were collected from all regional hospitals in Punjab to develop a monitoring system for Dengue. A positive correlation revealed that people after 30 years of age were associated with a reduced risk of being infected by the Dengue virus. It is important that public health units and authorities monitor the geographic patterns and hotspots of the detachment virus, so that precautionary measures can be taken, and valuable resources can be preserved in future outbreaks [9]. In [10], from 2011 to 2013, random blood samples were collected from five different union boards in ten towns of the city and used for data analysis. Most cases were observed in the rainy and early autumn seasons. The Dengue was most common in people between 15-45 years old, especially men, workers, and low-income workers. Several Dengue fever cases were reported in

the Malakand region in 2015 by real-time PCR. A total of 27 blood samples were taken from hospitalized patients of Dengue between 15<sup>th</sup> August and 5<sup>th</sup> November 2015 and were provided to the National Institute of Health Islamabad Pakistan Virology Department for laboratory analysis. A total of 398 cases were reported in 2015, of which 27 patients were present with acute Dengue infection symptoms [11].

In contrast to the existing studies and methods, we have presented a framework that involves both the health workers and the doctors to exchange the patient related information, such as their demographics, symptoms, and prescriptions for further necessary actions. The proposed framework also establishes a repository of infected Dengue patients and areas for disease outbreak prediction.

## III. PROPOSED FRAMEWORK

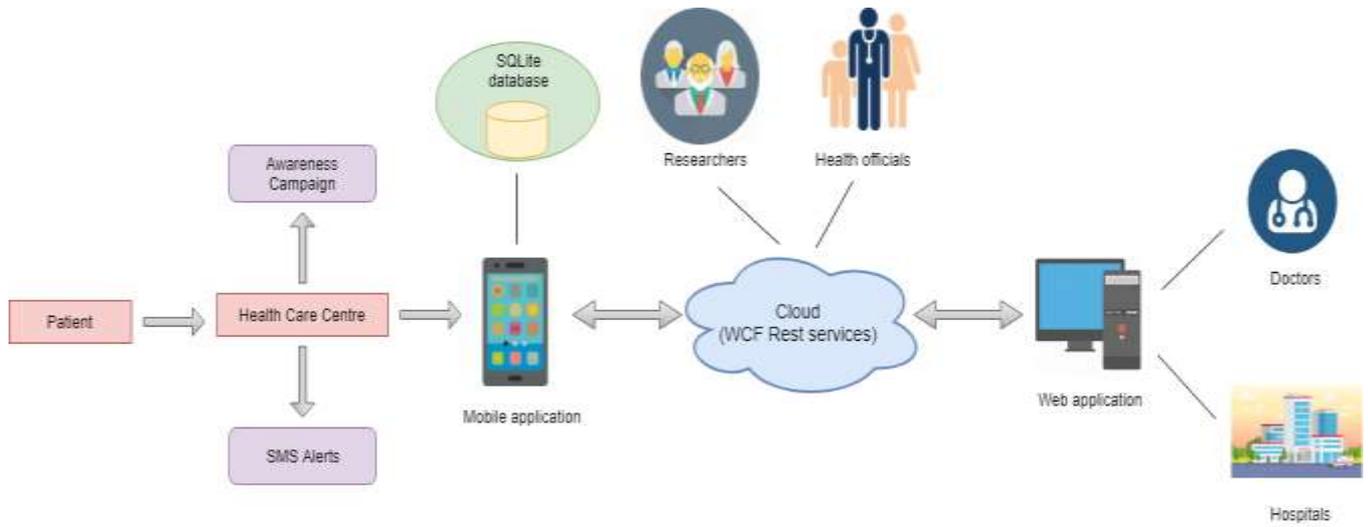
The architecture of the proposed Dengue surveillance framework is shown in Figure 1. The two key components of the proposed architecture are the: (i) Web application and (ii) mobile application whereas the major stakeholders in the framework are the healthcare workers and doctors. The doctors in the proposed framework use the Web application whereas the health workers use a mobile application to electronically transmit all the patients' information containing the demographics and symptoms to the doctors who might be at remote locations, for example at District Headquarters hospitals. The exchange of information from the health workers' mobile applications to the doctors' Web based application and back to the health workers and for storage at cloud is performed through Windows Communication Foundation (WCF) REST services. With the help of health ministry, the health works are assigned to each rural healthcare center that works in remote areas. The health workers carry Android phones and a mobile application for collection of Dengue related information from the suspected patients and subsequent transmission to the doctors.

Another aspect of the proposed framework is that it also introduces two supplemental components namely: (i) a Dengue awareness campaign and (ii) an SMS alert service. The awareness campaigns are meant to educate the community about the: (i) disasters of Dengue outbreaks, (ii) the precautions to stop the disease spread, and (iii) measures to be taken after the Dengue incidents have been confirmed. Such campaigns are beneficial to create awareness in masses both in the rural as well as urban areas. The SMS alert feature can be integrated with the awareness campaign and can be continued throughout the process of Dengue data collection. The activities performed in the proposed framework are depicted through an activity diagram in Figure 2.

Following sub sections contain the detailed explanation of the following components of the framework:

- Mobile application
- Web application
- Awareness campaign
- SMS alert

*Figure 1: Framework for Dengue surveillance and*



### A. Mobile application

As stated earlier, the mobile application is used by the health workers to obtain the details of suspected patients of dengue and to transmit that information to the doctors for subsequent actions. Figure 3 shows the login interface for the health workers whereas Figure 4 depicts the registration screen for collecting patients' details including the demographics.

Once the patients' details have been obtained, the symptoms that a patient is suffering from are selected from a list for subsequent transmission to the doctors and storage at the cloud server. Figure 5 shows the screen for selection of symptoms. The framework also allows the health workers to upload the pictures of the observed symptoms.

In (Figure 6), for example skin rashes in case of any confusion because it might be difficult for health workers to distinguish between the rashes caused by the Dengue and any other skin allergies.

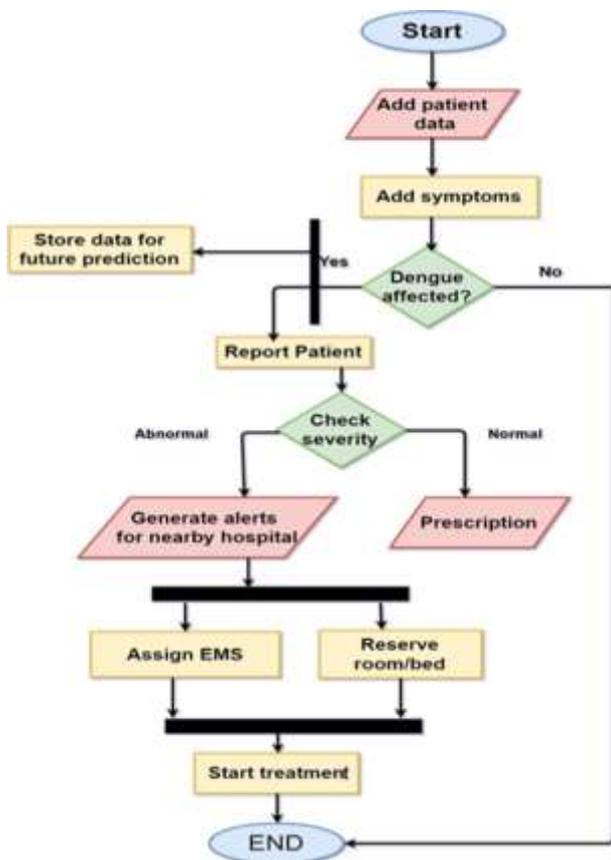


Figure 1: Activity diagram for mobile Application



Figure 3: Login for health worker



Figure 4: Add patient information

Therefore, sending the pictures along with visualizations helps in accurate diagnosis of Dengue. The collected information is initially stored in SQLite database that is subsequently transmitted to the doctors and other officials who receive the data through a Web application. Upon receiving the information, the doctors may issue a prescription (medication along with the advice to hospitalize the patients in the nearby hospitals in case Dengue is diagnosed) or advice some laboratory tests to clarify the diagnosis.

The prescription or the doctor's notes are received by the health workers on their smartphones. The communication between the mobile app and the Web app is performed through the WCF which is a Web service.



Figure 5: Symptoms selected by Health Worker



Figure 6: Additional feature for uploading picture



Figure 7: Prescription sent by doctors to the health workers meant for suspected patients

The proposed framework also permits the doctors to see the patients on video calls, if needed. On the basis of symptoms that they received through mobile app and the video call, doctors can refer patient to visit hospitals and seek proper medication. In case of failure of the system, it is necessary to have some alternative for data collection of patients. For this purpose, the records can manually be maintained and entered into the system later once the system is restored.

### B. WCF Service

The Windows Communication Foundation (WCF), previously known as "Indigo", is a runtime and an Application Programming Interface (API) set in .NET Framework for creating linked, service-oriented applications [12]. All the communication with the WCF is made from the endpoints. The endpoints allow customers to access the functionality offered by a WCF service. The WCF can be used to create RESTful services in .NET, which is responsible for the communication between the Web applications and the mobile applications. The REST is an architectural style for networked hyper-media applications mainly based on client-server communication, which is used to create Web services. Mostly it is used with the HTTP protocol [13]. The REST service focuses on accessing resources and resource can be considered as the objects. Once the resources are identified, it is necessary to represent these resources in a system that can be JavaScript Object Notation (JSON) or XML. JSON is a common format that is used for sending and requesting data through a REST API. A JSON object resembles a JavaScript object in which each property and value must be enclosed in double quotation marks [14]. As already stated that the WCF services connect

the Web application and the mobile application and make a bridge to pass information between them. Therefore, we have used WCF RESTful services for communication in our proposed framework. The data from the Web app and mobile app is exchanged and stored in cloud through these services.

### C. SMS service

SMS feature is introduced because of the vast usage of mobile phones. It can be used for sending precautionary measures regarding Dengue outbreak and prevention. This SMS can be sent from the health officials. People can receive these messages on their mobile phones in both Urdu and English language for their convenience. These messages can provide guidelines and the measures which people can take to prevent themselves from being infected with Dengue fever.

### D. Awareness campaign

With the help of government agencies, awareness seminars can also be conducted in schools, colleges, clinics, and Union Councils to create awareness about the Dengue spread and prevention. Such campaigns are essential for community involvement for Dengue prevention and the sustainability of a health living environment in developing countries like Pakistan.

## IV. DISCUSSION

Considering the heavy death toll because of Dengue outbreaks in previous few years in various parts of Pakistan, it is high time to make use of Information and Communication Technologies (ICT) for timely identification of Dengue cases and prediction of disease outbreaks. Therefore, in this paper, we proposed a mobile based framework for data collection of infected patients of Dengue. Besides its significance in timely reporting the Dengue cases to the authorities, the presented framework also helps in establishing a cloud-based data repository. The repository can be used by the researchers and government institutions for prediction of Dengue outbreaks. Moreover, timely identification of Dengue affected areas will help government mobilize their resources to minimize the damages. In rural areas of Pakistan, most of the people are not technologically literate and do not have access to smart phones. Therefore, it might not be feasible in all of the cases to rely on the patients to provide information about their symptoms to the doctors through smart phones. Therefore, this framework suggests delegating the health workers on the tasks of data collection through the Android application. In contrast to the previous approaches that rely on only GPS to obtain a patient's current location, such as in [3], our proposed framework also attempts to minimize the referrals of only suspected Dengue patients in the hospitals or Emergency Medical Services (EMS) by pre-admit screening of patients where the doctors remotely evaluate the patients' symptoms and decide whether the patient is infected or not. In situations where the severity level of virus is normal or on initial stage, the doctors prescribe the medications and such patients need not be hospitalized. However, for the patients that are diagnosed with critical conditions by the doctors are advised to get hospitalized in their nearby hospital and a bed is allocated for such patients before their arrival to the hospitals. Moreover, the staff of that specific hospital is also informed

in advance about such patients so that they start receiving the treatment immediately after reaching at the hospital. The doctors can also communicate instantly with the patient through video call in case it is needed for quickly deciding the case as a Dengue victim or otherwise.

To overcome the data exchange issue between the mobile application and the Web based application, REST services are used. The patients' data from the mobile app is transmitted in JSON format through REST services and updated on the database. The same procedure is followed for transferring the data from the Web application used by the doctors either containing the prescription or the advice to hospitalize.

Another aspect of the proposed system is that it also stores the patients' data and the information about the affected areas in a repository. Such information can later be used by the researchers and government led agencies to predict the disease outbreaks and identify the disease hotspots. We are hopeful that through the mutual commitment of the government and community and by using the IT services, the public health domain in developing countries like Pakistan can surely be benefitted from.

## V. CONCLUSIONS

With the advances in technology, healthcare domain like various other domains has also progressed from diagnosis to monitoring. Dengue virus in last few years severely struck various cities of Pakistan and due to insufficient preparations to handle the disaster resulted in several casualties. Therefore, in this article we presented a framework that uses smartphones along with state-of-the-art computing mechanism to collect the data about the Dengue patients. Particularly, the framework is of significance for the rural populations to attract the attention of government authorities in the event of Dengue outbreaks. Moreover, the framework also enables the government officials and public health researchers to employ machine learning techniques on the collected data for prediction and identification of areas that are likely to be affected by the disease so that measures and actions could be taken in advance to manage the situation and minimize the damages.

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