Computer Engineering and Intelligent Systems
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol.13, No.2, 2022

Internet of Healthcare Things (IoHTs) Technology to Strengthen Nigeria Health Systems: A predictive technique for Syndromic Surveillance of Suspected cases of Filovirus Diseases in Africa.

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Abstract
Infectious disease should be early recognised, treated timely and adequately, otherwise it spreads and leads to many other complications that is capable of causing health hazards, which can relatively become a cause of multiple cases of death. The emergence and re-emerging of Filovirus diseases especially in African continent are alarmingly threatening the healthcare workers and poses greater fatality rate. Ebola Virus Disease (EVD) and Marburg Virus Disease (MVD) are in the family of Filovirus infectious disease, that is predicted to continue emerging especially in regions where the reservoir host species are known. The upsurge of Internet of Things (IoTs) in Healthcare has provision very many technological advancement and positive solutions to healthcare challenges across the globe especially in many developed countries of the world. Internet of Healthcare Things (IoHTS) is a pool of innovative technological medical related devices that are connected together to provide seemingly control management, monitoring and surveillance, predictive detection and information sharing, etc that is capable of improving quality of healthcare delivery. Thus, early recognition, and timely detection and response to highly contagious and deadly virus is critically important in this modern era. This research study employs the Case-Study methodology to present an investigative framework of the use of Internet of Healthcare Things (IoHTs) technique to detect, predict and real-time report of -re-emerging Filovirus diseases in order to provide early recognition, quick response and intervention management with improved contact tracing tool of Geographical Information System (GIS) for active surveillance for informed decision-making on emergency healthcare delivery while minimizing the spread of the viruses. The study proposes to apply the emerging IoTs innovations to symptomatically detect and predict particular Filovirus (MVD or EVD) based on the defined physiological condition systematically presented. The objectives of the study are not limited to properly review the existing frameworks suitable for the research study, and design the propose architectural framework for the performance improvement of the system. The outcome is to provide a scientific way of detecting and predicting re-emerging Filovirus Diseases, and reporting such data in real-time for improve rapid response to emergency health intervention. The system structure is logically abreast with the technique to provide Suspected individuals with opportunity to early, easily and speedily detect and predict (know) their health condition during any Filovirus (EVD and MVD) outbreaks, and significantly minimize the spread of the diseases.
Keywords: Ebola Virus Disease, Marburg Virus Disease, Internet of Healthcare Things, Smart Health Care, Filovirus, Predictive Detection, Syndromic Surveillance and Real-Time Reporting.
DOI: 10.7176/CEIS/13-2-05
Publication date: April 30th 2022

1. Background of the study

In this contemporary world, rapid proliferation of smart systems which are readily available and in use today especially in the area of Internet of Things (IoTs) technology in Healthcare is trending and rendering fascinating real time access to data and useful information sharing. (Anjali, et al., 2016). The Internet of Things (IoTs) technologies such as the wireless sensor network and the various body sensor network wearable devices are related IoT devices which are very important in delivering crucial timely Health emergencies especially in the area of management of infectious and deadly viruses like the Ebola Virus Disease (EVD) and Marburg Virus Disease (MVD). And such devices are becoming very smart as they are used to provide real time data generated from the individual's physiological environment (Lopez, 2013). Smart Devices are increasingly being utilized in many areas of Health to track, monitor and report real-time data to help patient and doctor response in the management intervention and emergency response to health issues. (Koffi, et al, 2015). A Statistical Research have shown that 90% or more of the infected patients with Filovirus diseases like EVD and MVD results in death cases especially in cases where the viral load is greater than 6-log genome copies per millilitre in an untreated patient, which is as a result of lack of preparedness techniques for early identification and rapid intervention management of the viral disease with the use advanced technological infrastructure. (Robert et al., 2018). There have been many cases of deaths associated with the emergence of Filovirus infectious diseases and some of which as a result of delay in response to emergency healthcare services, inadequacies in infectious disease management and intervention,

inappropriate medical equipment and infrastructure in-place, and lack of preparatory measures to tackle the outbreak in Nigeria and Africa at large. According to a recent Forbes report of 2021 on Marburg virus disease (MVD), the case fatality rate of known cases of Marburg virus is about 80% while there are still unknown mild cases of exposure to the pathogen. (Drake, 2021). Nigeria as one of the underdeveloped countries in the world is faced with very many problems, with the increasing population, to the crumbling economy, and alarming unemployment rate, not to mention the dilapidating and little or no funding healthcare structure, to the lack of provision of medical infrastructures, and the interoperability concerns in the various health sectors with standardization of healthcare service delivery. Nigeria healthcare workers has for many decades, and eventually till present times faced with tedious workloads of moving patient health records files, traditional methods of paper records, test and results, clinical reports, and folders from one office to another or transferred from one hospital to another in many unorganized manners over the time. Therefore, the lack of timely and satisfactory healthcare service delivery and its proper information sharing with other related problems of health management is growing and re-occurring challenges across the world especially in most of the developing countries like Nigeria. (Amadi et al, 2020). Hence, this study is to use these very important technological devices in detecting and reporting of patients' health condition data with the focus on EVD and MVD.

2. Introduction

The Internet of Things (IoTs) is the unique identification of objects and their virtual representations in an internet-like structure, which is also referred to as real-life objects, 'Things' to the Internet, that provide remote surveillance of identifiable objects and their state at any time and location, hence with the use of smart devices like sensors, actuator and embedded systems to sense, monitor certain environment and generate data, collect and share such data in real time for an improve and informed decision making. (Babu et al., 2018). Also, the term IoT can be viewed as a giant network of interconnected objects with smart devices that sense, gather and share data over one larger system, the 'Cloud' virtual or digital world (Gulraiz & Joyia, 2017). Internet of Healthcare Things (IoHTs) is a branch of IoTs the focuses on the use of innovative medical devices like smart wearable and implantable devices to provide an improve healthcare and medical services. This emerging technologies are proven to be very useful in control management of infectious disease outbreak. Thus, Diseases and Medical attention should be sort for and well-treated on time so as to not lead to many other predominant health issues, which sometimes may result to death. The lack of preparedness measures, early recognition, timely response and satisfactory healthcare service delivery alongside its related assistive information on health complications are alarmingly on the increase across the world especially in most developing countries like Nigeria (Amadi et al., 2020). Global emergency on infectious disease should be well prepared for and with innovative technology provision, adequate management intervention strategies in-place for readiness of any unforeseen and rather unavoidable outbreak in Nigeria and Africa at large. Suffice it to say that in Nigeria, the healthcare sector which has long be suffering from the very many manual system of healthcare delivery, and as such, is possibly going to achieve a more proactive, predictive and innovative healthcare services that is capable of delivering sustainable, affordable and accessible healthcare provision especially in public health epidemiology of infectious disease management using Internet of Healthcare Things (IoHTs) technologies to strengthen healthcare system. According to the report by WHO (2017) on Strategic framework for emergency preparedness, the limited surveillance systems and testing capacity in some countries in the region impact on early outbreak detection to facilitate timely intervention, limit transmission and save lives. Hence, implementing robust surveillance, effective testing strategies and robust resurgence planning will help to identify hotspots earlier and respond effectively. The study is on the use of Internet of Healthcare Things (IoHTs) in Infectious Disease Management with a focus on Ebola Virus Disease (EVD) and Marburg Virus Disease (MVD) Management intervention. The study is limited to probable (Infected or Suspected) patients with Contacted case, identifying a suspected case and reporting of derived real time health data for rapid response to medical practitioners and stakeholders within the healthcare sector. It is to explore and design the various means whereby the efficient reporting of data between patient, medical personnel and health facilities using IoHT innovative technology for real-time data sharing and health emergency rapid response. (Suwon Kim & Seongcheol Kim 2017). This is required in order to provide quick response to the outbreak, surveillance and self-tracking of contact (tracing) cases and reporting of such data in real time such that it can be used to analyse the health status of patients and to better ascertain the development process of the cases and/or contacts under surveillance. (Gope & Hwang, 2016). In Public Health, infectious diseases in Epidemiology especially cases of EVD and MVD are undoubtedly a life-threatening Infection that requires certain level of greater attention, proactive vigilance and rapid response whenever there is an alert or rumor of such a case. (Shweta, et al., 2010). Hence the need for the introduction and use of IoHT Smart Technology with ArGIS tool in providing self-tracking for contact tracing, and reporting of real time data for the Ebola Virus Disease.

3. Literature Reviews: The Emergence and Re-Emergence Of Filoviruses

The Filoviridae family which involves the outbreak of Ebola virus and Marburg virus diseases are diseases that are capable of causing deadly haemorrhagic fever in humans and non-human primates (NHPs), and as a threat to global health, economic growth and security. Although the EVD and MVD have similar reported, they are differently known viruses that have the ability to cause high fatality rate during outbreak. Recent study showed that 75% of the emerging infectious diseases that are pathogenic related organisms which are zoonotic in nature includes Ebola virus disease and Marburg virus disease majorly overwhelming economic development across the world. (Ermias et al., 2017). Marburg virus disease was first discovered in 1967 at Frankfurt laboratory in Germany. There have been relatively 12 major outbreak of Marburg virus since its inception in 1967 and its mostly in the southern and eastern region in Africa continent. The fatality rate of Marburg virus is about 88% as reported according to the World Health Organisation (WHO, 2021). Ebola Virus is an infectious virus that in any slightest direct contact is capable of inserting its genetics into the DNA of any host contacted cell, replicates and generates rapidly such that it takes control of all biological processes in the host body, which as a result is also known as viral disease. The chances of survival do not totally depend only on the host-contact immune system but also on timely response to the health emergency and adequate management and treatment of the Contact Case. The Contact Case is the patient that has made contact with the Suspected Case of EVD, while the Suspected Case is the patient that has been in close contact with the Confirmed Case, and the Confirmed Case is the patient which the sample has been taken to the laboratory and has been scientifically confirmed a case of EVD. (Amadi, et al., 2020).

4. Ebola Virus Disease (EVD)

The 2014 Ebola Outbreak in Nigeria: According to WHO (2015) publication on the Ebola Virus Disease outbreak, the said infectious disease was first identified in 1976 at two geographical locations simultaneously in West Africa in South Sudan and Democratic Republic of Congo which are mostly central African continent. In December, 2013 it is reported that a baby boy of about 18 months old who hailed from a small community in Guinea is said to have been infected by his close connection with bats; and which as a result of this discovery a formal notice was raised to the Public Health of Guinea Ministry of Health for alert and to create public awareness. Soon after that incident, in the first quarter of the following year, precisely in March, 2014 the Ebola Virus Disease was said to have spread across the capital city of Conakry in Guinea, this lead to the scientific confirmation of the Ebola Virus Disease (EVD) and it was also referred to as Zaire ebolavirus, as confirmed and deaths cases were formally recorded by the World Health Organization (WHO), 2014 during the outbreak. Thereafter in the same year, precisely in August, 2014 the spread of the said virus went across borders of about seven (7) or more countries of which Nigeria happened to be one. the spread which was followed by Liberia, Sierra Leone and Nigeria, where many prominent and dedicated medical practitioners and heroes lost their lives in course of their dedication to work ethics and passion in saving lives, (Elhadj, et al., 2015). They not only lose their lives but that of their beloved ones were relatively at stake and other proportion of health workers lives were at stake and/or risk in the quest to provide medical and healthcare related services, especially in most cases where there are no protective preventive measures in place to provide personal protection against the infectious disease and/or no adequate training provided for the nurses and health officers for infection, prevention control, (Amadi, et al., 2020).

The symptoms associated with Ebola Virus are persistent high temperature and fever, sore-throat, headache, anorexia, myalgia, fatigue, weakness, abdominal pain, stomach cramping, nausea, vomiting and diarrhea, hemorrhagic body rash, swelling and bleeding, confusion, persistent bleeding from eyes, nose and mouth, dehydration and lethargy, hypertension and multiple organ failure, and sudden shock that often lead to death case (Rachah & Torres 2016). However, there are periods of incubation, which the primary stage ranges from 3 to 8 days and the secondary stage is sometimes between 8 to 21 days respectively, (Ohuabunwo, et al., 2016).

5. Marburg Virus Disease (MVD)

Marburg Virus Disease (MVD), also referred to as Marburg Hemorrhagic fever, is known as a severe and often deadly in humans and is usually transmitted from fruit bats to human and further spread from human to humans and non-human primates by causing a severe viral hemorrhagic fever. Genetically Marburg virus is a zoonotic disease from the Filovirus family. The Marburg Virus Disease (MVD) was first discovered in 1967 at Frankfurt laboratory in Germany. Zoonotic diseases are predicted to be emerging periodically especially in regions where the reservoir host species are known. According to the 2014-2015 World Health Organization (WHO) reports on Ebola Virus Disease outbreak, relatively a total of 11,325 death cases recorded. A statistical study shows that MVD have infected about 475 persons globally and according to the recent report on the outbreak of Marburg Virus Disease, in Guinea, West Africa on 9th August, 2021 has it that a Guinean man contracted the disease and later died, and few days later it was reported by WHO that another person had been infected by the MVD, which the known cases fatality rates is around 80% and perhaps has been present in West Africa for a long time now. (Forbes & WHO, 2021).

Syndromic Surveillance: Syndromic Surveillance encompasses the systematic collection and geographically-based analysis of clinically-observed symptoms presented at hospitals and other healthcare settings. Syndromic Surveillance is a means to detecting public health or institution-specific outbreaks of infectious disease more quickly than the current method of waiting for confirmed laboratory results. Internet connected user-friendly reporting tools in emergency rooms, nursing stations and doctors' offices will allow relevant data to be collected quickly. The information and analysis will be readily available, paving the way for collaboration between machines and people and resulting in faster response times and intervention strategies. (Furness, 2016).

The availability of and access to Big Data, real-time results and personalized information capture will connect institutional research with front-line applications. (Diamond, 2016). Others include fertility sensors, fever monitor.

INTERNET OF HEALTHCARE THINGS (IOHTS)

IoHT appliances have proven really beneficial in the health and wellness domains. Many wearable devices are being developed, which monitor a person's health condition. Health applications make independent living possible for the elderly and patients with serious health conditions. Currently, IoT sensors are being used to continuously monitor and record their health conditions and transmit warnings in case any abnormal indicators are found. If there is a minor problem, the IoT application itself may suggest a prescription to the patient. IoT applications can be used in creating an Electronic Health Record (EHR), which is a record of all the medical details of a person. It is maintained by the health system. An EHR can be used to record allergies, surges in blood sugar and blood pressure. Many benefits provided by the IoT technologies to the healthcare domain that are not limited to tracking of objects, staff and patients, identification and authentication of people, automatic data collection and sensing (Vilamovska, et al., 2009). The following summarizes the benefits:

Saves time and resources: Using IoT for data collection and workflow automation is an excellent way to cut down on waste (such as unnecessary tests and expensive imaging), reduce system costs and minimize errors (especially the ones related to human factor).

Efficient management of diseases: Remote monitoring technique is an approach to diagnosis and facilitates management and monitoring of patients' conditions effectively. The RPM is used with the chronically ill and elderly with high medical care which allows the physicians to closely monitor the patient's medical conditions and intervene if need be facilitating immediate treatment without losing time. "According to the National Broadband Plan drafted by the Federal Communications Commission (FCC), the use of RPM technology in conjunction with electronic health records (EHR) could save the healthcare industry $700 billion over 15 to 20 years. (Rao, 2018)

Real time patient data sharing: Being connected to the health care system through the Internet of things, patients get more engaged in their treatment.

Cost effective: Using IoT solutions and connected medical devices allows healthcare providers to monitor patients in real time. This means less unnecessary visits to doctor, and less hospital stays and readmissions thanks to efficient data collection and management.

Early prevention and intervention: IoT in healthcare helps to detect early signs and symptoms of diseases and infections so that there would be planned intervention and proper control measures can be taken. (Rachah & Torres 2016).

Medication is more proficient: IoT solutions allow hospital staff to spend less time searching for drugs, track supplies and medicine, and track hygiene practices in hospitals and effectively prevent hospital infections. Healthcare IoT solutions help patients adhere their treatment plans and doctors to track compliance to prescriptions.

Redresses doctors' workload: doctors improve diagnosis accuracy since they have all the necessary patient data at hand. (Alamelu & Mythili, 2017).

Better communication of patients and doctor by using real time location services and mobile apps.

General improvement of healthcare delivery: Healthcare solutions that are connected through cloud computing and use big data can provide caregivers with the ability to access real time data which can be used to make informed decisions and to provide evidence-based treatments.

Energy efficiency: IoT medical devices have the capacity to yield desired results with little disbursement of energy or work. (Anjali, & Kalbande, 2016).

6. Related Works and Emerging Technology

Ennafiri & Mazri (2020) designed a three-layer architecture based on the use of Internet of Things system to provide Smart Healthcare in controlling of COVID-19 Pendemic, the study obtained an IoT-based smart bracelet wearable device to monitoring Covid-19 pandemic in real-time which provided a high quality care to patients. And also help to reduce and control spread of the virus. The system is very useful to both the patient and health workers to have real-time access to health information anywhere and anytime. However, it did not integrate GIS in contact tracing during outbreak and it also identified the reliability and availability threat of not receiving updated data in-cases of technical issues.

Kangbai, et al., (2018) introduced the use of Internet of Things and Blockchain technologies to obtain a real-time data during the 2014 outbreak of Ebola Virus in West African. The study conducted an automated process analysis and contact tracing to early detect and track Ebola virus and further obtained surveillance data in real time. The design required mutual collaboration of Cellphone and telecommunication stakeholders to achieve a common objective of digital disease surveillance for early detection of virus and drastic reduction of disease transmission. Greater data security was achieved with the use of Blockchain cryptography. The study achieved its aim and objective by strengthening disease communication amongst public health workers and improve outbreak surveillance of contact cases in real-time. The study is therefore limited as it did not provide active tracking of patient location and movement with GIS in its contact tracing during outbreak (Amadi, et al., 2020).

Ermias, et al., (2017) identified the problem of multi-sectoral collaborations and interdisciplinary partnership to jointly tackle the concerns of zoonotic diseases present in many countries, and introduced a semi-quantitative mechanism to developed the One Health Zoonotic Disease Prioritization system. The design presented the integration of a multidisciplinary team of professionals from human, animal and environmental health agencies and other relevant sectors to achieve the aim and objective of quantifying the burden of zoonotic diseases, detecting and responding to endemic and emerging zoonotic pathogens, in form of prioritizing the diseases. It obtained the launching of public health appropriate prevention, detection and response strategies as a One Health approach to zoonotic diseases. The study did not however implement the robust control and preventive measures in form of the state-of-the-art tool for early identification and proactive action during zoonotic diseases outbreak.

Ogunro, et al., (2018) presented an investigation of 2013 to 2015 EVD outbreaks in West Africa, with its implication on public health practitioners within the sub-regions of Africa continent and focusing on southern region of Nigeria especially in rainforests locations of south-western and south-eastern parts. The study provided serological evidence of probable exposure of National Health Population to natural infection of EVD around rainforest regions in Nigeria and concluded the need to discourage the uncontrolled hunting of monkeys in the country to safeguard the public health in general.

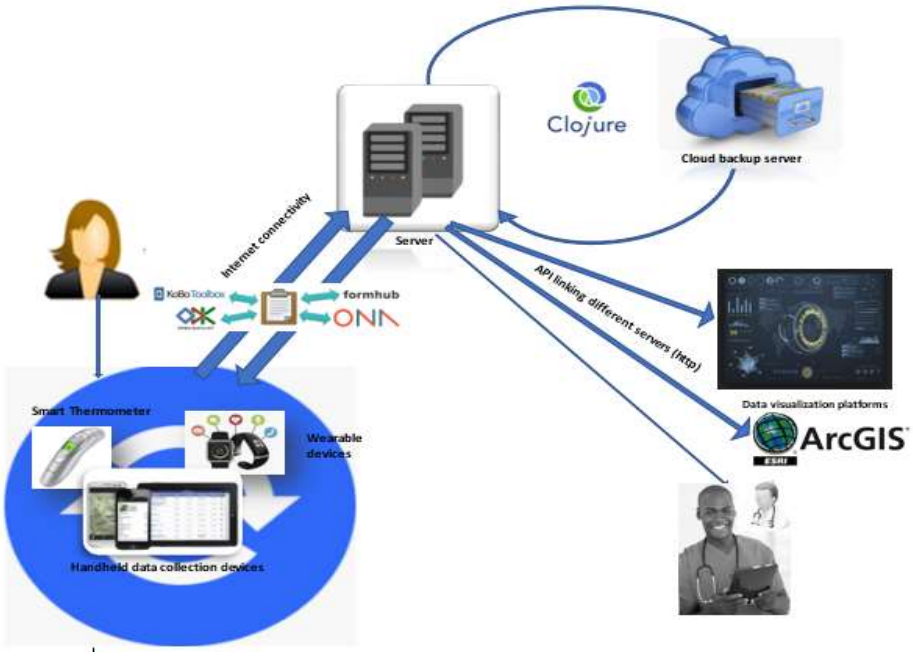
6.1 Apple's Research-Kit and Parkinson's Disease

In 2018, Apple open-source Research Kit API allows Apple Watches to monitor Parkinson's disease symptoms. The API aims to make an automatic and continuous process where an app on a connected iPhone can present the data in a graph, give daily and hourly breakdowns, as well as minute-by-minute symptom fluctuation. Apple's Research-Kit also includes an arthritis study carried out in partnership with GSK, and an epilepsy study that used sensors in the Apple Watch to detect the onset and duration of seizures. Apple is keen to tout the potential for its apps to aid with medical research and care, and to that end, in 2017 it launched Care-Kit, an open-source framework designed to help developers to create apps for managing medical conditions. Care-Kit can be used to design apps with a specific medical condition.

Symptomatic Classification of Filoviruses Referencing MVD and EVD

S/N	SYMPTOMS	EVD		MVD	
		YES	NO	YES	NO
1	Body Temperature				
2	Prolonged high fever				
3	Frequent Headache				
4	Abdominal or stomach pain				
5	Vomiting				
6	Nausea				
7	Diarrhea				
8	Sore throat				
9	Lethargy				
10	Chest pain				
11	Weakness				
12	Dehydration				
13	Red eyes				
14	Lack of Appetite				
15	Difficulty in breathing				
16	Internal or external bleeding				
17	Skin texture				
18	High fever				
19	Severe headache				
20	Severe malaise				
21	Muscle aches and pains				
22	Severe watery diarrhea				
23	Abdominal pain and cramping				
24	Deep-set eyes				
25	Expressionless faces				
26	Extreme lethargy				
27	Non-itchy rash				
28	Multiple bleeding (nose, gums, vagina)				
29	Confusion				
30	Irritability and aggression				
31	Orchitis (inflammation of testicles				
32	Severe blood loss and shock				

7. The Propose Architectural Framework Design



IoHTs Architectural design framework for Filovirus Diseases management.

8. Discussion and Analysis Of The Propose Model

The propose model is user-friendly system that is designed based on a mobile application, a software which has a backend database that can be adapted for many mobile devices with the purpose of detecting, predicting and reporting suspected individuals during any Filovirus disease outbreaks especially in cases where more than one virus disease re-emerges, regardless of the location and time. The model is design for flexibility, maintainability and scalability. The role of every user on the system has important prerogative and actions directed to the database. The application system is structured to house the User Interface, Database, Extract-Transform –Load (ETL), and the Intelligent components. The User interface(UI) component: allows for the user to interact easily with the system using the ionic framework module in the operation phase, which enables users to easily interact with the system by means of inputting necessary details and obtain the result from the system. The Database components: allows for data storage as well as enabling users' access and retrievals of stored data. Intelligence component: is a logical design model that compares the individual input symptoms and signs (that is the physiological derived data) with the system knowledge-base and makes an inference which detects and predicts the Filovirus disease differentials based on the critical proportion return level set for the program module. Conditionally, the disease is predictable in an individual's body only if it returns a given high-level percentage based on the input data, which in view triggers alert message report for positive detection of the virus to the Stakeholders of Emergency Healthcare, in order to locate easily and speedily respond to the suspected Patient. Otherwise, the system returns nothing but Infection Prevention Control (IPC) measures for the individual to be well-informed on the outbreak. The propose architectural design integrates the ArchGIS Geographical Information System module to the overall Framework for the improvement of Contact Tracing surveillance.

9. Conclusion

This study presents the patient user as the primary actor of the system, the system allows for the registration of patient, upon which access to clinical activities and knowledge based is achieved. The extracted data is transformed, analysed and loaded into the database, the intelligent component of the system compares the patient's health condition using the presented signs and symptoms with reference to the defined ratio and/or critical level parameter set for the logical intelligent system to relatively predict the patient symptomatically and/or differentially. Consequently, the functionality and usefulness of the model was validated with the use of prototype system that was developed and implemented as a mobile application: Filovirus Smart Care Framework is purposively design to apply in the secondary level healthcare institution. The Filovirus Smart Care system is expandable to technological advancement in various related disease predictions and therefore recommended for

implementation. Thus, this research work will be useful and relevant in enhancing the early Detection, Prediction and Reporting of Filoviruses.

9.1 Authors' Contributions.

The main Author conceived the idea for the research area and wrote the initial draft of the manuscript. The proposed system design, problem formulation, suggestive guide and influence on the shape of the research. All authors suggested related works, discussed the structure of the paper and results. All authors read and approved the final manuscript.

Acknowledgement Not applicable.
Competing interests: The authors declare that they have no competing interests
Funding No funding for this work.

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