Epidemiology and Remote Health Service Delivery Using Satellite Communication: A Strong Tool for the Realization of the AU Agenda 2063

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Abstract—**The future of Africa is too important to be left alone in the hands of the Government and African Union. As Africa arises and begins to journey towards the Africa we want, we look forward to actualizing Agenda 2063. We do not see it only as a vision, but also as an action plan set in place, geared towards achieving the Africa of our dreams. The purpose of this term paper is to present ways, from the perspective of an African student, of actualizing the AU 2063 Agenda with the aid of Satellite Communication using remote health service delivery as a tool. Remote Heath Service Delivery will serve as an effective tool in the actualization of the AU Agenda. If the right measures are implemented, African countries will be amongst the best performers in global quality of life measures. This can be achieved through wise investments in Science and Technology. To achieve the AU 2063 Agenda, this paper emphasizes the need for the incorporation of Satellite Communication. It discusses the relationship between satellite communication and African development and maintains that to achieve the 7-Point Agenda, Satellite Communication cannot be over-emphasized. In a bid to meet the needs presented by the AU Agenda, different conventional methods have been proffered as solutions or likely solutions. Hospitals and other health care service providers have been built and implemented, but this approach has been unable to meet the unending demands of proper health care services that will ensure that African citizens are healthy and have long life span. These solutions have gone a long way in reducing mortality rate in Africa, but its effect is limited. Due to the inadequacies of the conventional methods of delivering health services to remote areas, ICT has been included so as to proffer more effective solutions to health challenges. Taking various diseases into consideration, we will discuss how Satellite Communication as an intervention means can be used for disease prediction and timely prevention. This chapter concludes that integrating Satellite Communication as an approach to achieving the laid out 7-point Agenda is the best way forward to actualizing the AU's Agenda in record time.**

Index Terms—**Epidemiology, GIS, Malaria, Remote Sensing, Satellite, Telemedicine.**

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I. Introduction

It cannot be over-emphasized that a healthy nation is a wealthy nation. No wonder the first aspiration on the au agenda 2063 is to be a prosperous Africa based on inclusive growth and sustainable development. this goes to say that by the year 2063, Africa will be a prosperous continent where African people have a high standard of living, good quality of life and enjoy sound health and well – being. remote heath service delivery will serve as an effective tool in the actualization of the au agenda. If the right measures are implemented, African countries will be amongst the best performers in global quality of life measures. This can be achieved through wise investments in science and technology, and provision of basic services including health, nutrition, water and sanitation [94]. The delivery of health care services over a distance has gained much traction over the years. As a noble initiative, the African union supports the effective monitoring of illness-causing diseases through the au agenda 2063. The aspiration 1 particularly calls to home, as it states thus, "a prosperous Africa based on inclusive growth and sustainable development" [95]. Remote health service delivery can achieve the au agenda by developing Africa's human and social capital through increasing availability to superior health care services, particularly in the remote areas of Africa.

Engraved in the au agenda 2063, are 7 aspirations expressed by the united voices of the people of Africa. They have painted a very clear and vivid picture of the Africa of the dreams; the Africa they want for themselves and their unborn generations to come. A host of reports have argued that satellite can make a substantial contribution to improving health service delivery in Africa. Remote health service delivery is the provision of good health services without the presence of physical contact. This takes us to the study of epidemiology which is the study of how sicknesses and diseases are distributed and controlled in a population. This is in relation to the au agenda aspirations. Health service delivery to very rural areas can be very difficult; the detection and containment of disease outbreak appears to be impossible. Remote health service can serve as a tool for bridging the gap between standardized health care and rural areas [95]. As at 2013, the 35 million more Nigerians were living in extreme poverty than in 1990. Just in Lagos (which has been predicted to become the largest mega city on the African continent in 2030), two out of three people live in slums. Because of these statistics, the health service delivery system in the remote areas has not been anything more than terrible. “An integrated, prosperous and peaceful Africa driven by its own citizens” is one of the visions of the au, which is based on steady growth and sustainable development. The remote health service delivery can drive the au agenda by incorporating the use of satellite for surveillance purposes so as to bolster health care delivery services, especially in rural areas which have minimal access.

II. LITERATURE REVIEW

A. *Weaknesses of Conventional Health Service Delivery Methods*

In a bid to meet the needs presented by the AU Agenda, different conventional methods have been proffered as solutions or likely solutions. Hospitals and other health care service providers have been built and implemented, but this approach has been unable to meet the unending demands of proper health care services that will ensure that African citizens are healthy and have long life span. These solutions have gone a long way in reducing mortality rate in Africa, but its effect is limited [95]. Achieving the AU agenda requires that the African population be healthy and capable of capacity building. However, Africa is far from this reality. 75 percent of the population that is 854 million people live in the rural areas, and as a result, access to quality health care is made impossible by the high poverty rates in these areas, sheer distance and paucity of medical facilities. According to the international finance corporation, sub-Saharan Africa has just 11 percent of the world population but carries 24 percent of the world disease burden. This alarming piece of statistics demonstrates that there is a need to discover and implement a sustainable, affordable but effective way to deliver health care if at all the AU agenda 2063 would be achieved. Wellbeing framework fortifying is a noteworthy worry with most medicinal services frameworks being genuinely under-financed. In spite of the fact that 53 nations have marked the Abuja Declaration submitting them to assign 15 percent of their financial plans to the wellbeing area, most have not met this objective and a portion of the individuals who have met it, have done as such utilizing contributor subsidizes, an unsustainable circumstance. There are conventional methods used to provide health services such as medicine sellers and traditional healer who give health advices. Health care facilities (health centers, pharmacy, rural clinics) which should not be far, it should be an easy walking distance of the community especially for pregnant women and children. Having them at a good number in the community to adequately provide good health services for everyone. Health service delivery in past times has evolved at an excruciatingly slow pace. This coupled with the traditional beliefs of Africans living in the rural areas has allowed for this development to be sluggish. Health service in rural areas is either very expensive or just unavailable hence the call for a Remote service. Even when expatriate help is got, the time for such personnel to arrive at rural areas to tend to the situation might take too long for dire cases. Disease outbreaks can turn into incidents of catastrophe from ignorance and Remote Health Service Delivery provides a way out [94]. The AU agenda 2063 seeks to accelerate the implementation of past and existing continental initiatives for growth and development. Due to the importance of health, the AU requires that most of the population should be healthy (a good example; the procedures taken to the curing of the Ebola project in Africa). But viewing the statistics online brings a lot of burden knowing that “46 percent of Africans don't have a say in decisions about their health care”. Africans cannot access good health care services and so there is an urgent need to implement good and sustainable health systems for the AU agenda to head towards its goals.

B. *ICT as A Tool for Health Care Service Delivery*

Due to the inadequacies of the conventional methods of delivering health services to remote areas, ICT has been merged to proffer more effective solutions to health challenges. ICT has been able to provide new and more efficient ways of accessing, communicating, and storing information in the health sector. Because of ICT, one can easily diagnose oneself without the need of visiting a medical practitioner, hence averting the costs that would have been incurred. A patient can easily access the internet where a list of possible diagnosis is made available. This has its own shortcomings as well. A patient can be mis-diagnosed and hence lead to more severe complications. Also, another challenge is absence, to a large extent, of internet broadband access and where it is present, is usually not very affordable [95]. The advent of technology has brought about unlimited opportunities. A huge element of these opportunities is the ability to garner relevant and useful knowledge in form of information. The health sector has major loopholes regarding information gathering and the emergence of ICT seems to provide an answer in form of remote health service delivery. This progress entails the use of GPS – based systems to track outbreak of various contagious diseases and control it before it spreads out. ICT can serve as a catalyst of change for Africa to face her health issues such as cancer, obesity, cardiovascular diseases and more. Using the services of both eHealth and health care to achieve this supported by electronic processes such as electronic health records, telemedicine’s and others. As highlighted from the ineffectiveness of the conventional approach to Health care delivery in African countries especially in the event of a disease outbreak, Remote Health service delivery is the tool to turn to in realizing the first aspiration on the AU Agenda. Technological advancements have allowed for one to have a personal doctor who can diagnose one’s ailment. Remote Health care involving surgical operations and other medical practices can be done easily from a remote center or location with the use of the internet. Although this technology can be expensive, it has a far better chance of sustaining the lives of Africans than the conventional methods [87]. It is not a surprise today that technology has exceeded our humanity and has brought series of innovative opportunities today. The health sector in Africa due to inadequate resources has been known to be faulty in retaining information in files, store rooms etc. Using ICT will promote the health system in the rural areas.

C. Satellite Communication as a Tool for Delivering Health Care Services

The infant mortality rate in Africa will drastically reduce if the right diagnosis could be given by medical experts in the shortest possible time, so that right treatment can be administered to save lives. Developed countries like India employs E-Health to transmit digital images over long distances. This is achievable through Satellite Communication. Magnetic Resonance Images (MRI's) and X-Rays are sent easily across the world, then they are interpreted and sent back. E-Medicine increases the efficiency of medical expertise, by making sure quality care is given to maximum number of patients. Using Satellite Communication, an expert doctor can simply provide professional opinion to several other doctors in various locations even in real-time. Surgeries and operations can be carried out with less complexities with the assistance of experts in the particular field of interest. This way, loss of lives is reduced to its barest minimum hence fast-tracking Africa's development. Generally, E-Health has been proven to break geographical barriers and even time barriers, and it has guaranteed the achievement of precise diagnosis with comparatively low cost and in the shortest time possible. [94]. Satellite communications can serve as a major player in health monitoring activities, otherwise known as telemedicine. Health care services can be delivered via wired and wireless networks to remote locations in the African community [25]. Telemedicine is the integration of satellite communications and medical services. To this end, a Smart Health Monitoring Center, a smart healthcare delivery system, was inaugurated by the Africa Union Commission in 2017. The project is intended to provide accurate epidemiological studies in African remote cities along with the superior motive of fulfilling the vision of AU Agenda 2063. Satellite communications provide remote medical care, which helps to curb the outbreak of diseases in a population. Using satellite communications, it is possible to cover a wider area for surveillance to track outbreak of contagious diseases, proffer good quality health care services which is in line with the achievement of the AU agenda, thereby reaching both the rural and remote areas. Satellite communications which involves the use of satellites to send and receive signals plays a very important role in the early detection and containment of disease outbreak. Geographic Information Systems (GIS) can be used to facilitate access to epidemiological data through observation satellites [2]. Mathematical models and analysis can then be made by spatial statistics. Also, polar-orbiting meteorological satellites can be used to remotely sense environmental data by using AVHRR sensors [41]. In addition to all this, a smart health care delivery project was initiated to the actualization of this goal and this could help give the best and precise diagnosis in the shortest time frame and even without the presence of a medical personnel. Satellite communications cannot be downplayed in health systems. Satellite techniques have been used in disease epidemiology for decades in the western world. Its application in developing countries especially Nigeria is under exploited but highly desirable. Health care services can actually be administered through wireless networks to the various rural areas (remote locations). The process of using satellite is called "Telemedicine which is the use of telecommunications to provide clinical health care from a distance [22]. Employing this method will provide accurate epidemiological research options and possible cures even from a far distance.

A pool of information has been gathered over the past years on the link between the environment and diseases and the Health Care Service Delivery has been presented with numerous challenges. Hence taking examples of various diseases, we will discuss how Satellite Communication as an intervention means can be used for disease prediction and timely prevention [69].

III. SATELLITE COMMUNICATION IN EPIDEMIOLOGY AND REMOTE HEALTH SERVICE DELIVERY

A. DISEASES: HEALTH CHALLENGES AND DISORDERS

This cluster presents in detail different studies and readings that have geared the impact of satellite communication in solving mainly one of the leading public health problems that is malaria [16]. It also includes discusses that broadly situates all kinds of diseases and related topics affecting human, animals and plants alike citing most relevant literatures. It identifies the ways satellite communication has help and is presently tackling the detection, prevention and control of all types of Health Challenges and Disorders.

[2] aimed at analyzing how environmental, biological and socio-economic factors contribute to the resurface of malaria. They also analyzed the current surveillance and control systems/activities in Rwanda. To that effect, they attempted to determine the impact of a Citizen Science approach and the role of technological tools in the support of malaria vector surveillance and control. Short Message Service text message was employed for malaria surveillance and control. The system showed the possibility of using SMS text messages in reporting the counts of malaria surveillance indicators. The involvement of the local communities in the science of mosquito ecology will lead to more sustainable solutions for malaria control.

[4] focused on developing software applications and an environment to provide timely epidemiological data, it also aimed at striking the importance of input from all stakeholders during the design, implementation, and operation of the system. There was also a need for the system to be adaptable to the changes made to its input. Observation of the planet Earth space sensors provided relevant data on rainfall, temperature, and other environmental factors with geographic information about water bodies and land use characteristics that affect mosquito habitats and their exposure to humans. The Epidemic Prognosis Incorporating Disease and Environmental Monitoring for Integrated Assessment (EPIDEMIA) project was implemented and it served as the web interface between public health users and the

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EPIDEMIA system. In addition to malaria case surveillance, environmental data can also be used to predict malaria epidemics in environments where vector populations are sensitive to meteorological conditions and habitat availability. The environmental data used was from remotely sensed earth observation satellites.

Wangdi et al. [5] The aim of this study is to develop and implement a spatial decision support system (SDSS) that would ride on open source Geographic Information system (GIS) to help distribute long-lasting insecticidal net (LLINs) as part of the malaria mitigation efforts of Bhutan. SDSS contains modules for the planning and monitoring of the delivery and of solutions like spraying indoors and distributing long lasting insecticidal nets in target households, and for mapping malaria surveillance data. Application of the SDSS was implemented in all the study sub-districts. The SDSS was accepted well and its use is expected to be extended to other malaria affected areas and even some other vector-borne diseases. The system however viable could not be used by other countries that would want to also implement a similar operation because the SDSS did not include web-based components that could help keep track of all the activities was carried out at all levels.

Yukich et al. [10] aimed their research at the need for an effective surveillance system that would targets areas of infection and increases the capacity to identify transmission hotspots, and monitor almost real-time malaria data to rapidly identify changes in malaria transmission, morbidity and mortality. To gather data on key malaria indicators, 10 malaria sentinel sites were developed. Also, data on patients and the confirmation of the malaria outbreak was collected for about 43 months. In order to achieve total malaria elimination, timely provision of accurate malaria surveillance data is key. It was observed that the highest malaria transmission season occurred between September-Decembers, while the lowest transmission occurred in April-May. A well-designed model would provide more environmental information from areas not available for study, generating models with broader areas are suitable for other diseases detection.

Wimberly et al. [14] assessed the reliability of various temporal variability indicators in malaria risk and also tested for the presence of spatial and seasonal trends of malaria cases, they also determined if there is a spatial synchrony in the pattern of malaria cases. For the assessment of patterns of clinically diagnosed outpatient malaria cases with other indicators of malaria risk, a subset of eight districts that had a complete monthly record of outpatient malaria cases for at least 8 years along with records of total outpatient visits and confirmed cases for the majority of these years was accurately analyzed. The analyses showed strong correlations between proportions of outpatient malaria cases in the eight districts examined, indicating that the counts of outpatient malaria cases captured the temporal trend of the outpatient malaria burden on the health system in a given district. The system enhanced preparedness and accelerate the public health response to the infectious diseases, thereby minimizing human and economic costs, particularly in regions of low income.

Midekisa et al. [15] developed a malaria early-warning systems that enhanced public health decision making for control and prevention of malaria epidemics. The fundamental step to develop the system is to quantify the relationship between malaria cases and environmental determinants.

Malaria transmission is seasonal in Ethiopia and varies across the country depending on climatic and ecological factors of advantage to the parasite development, including elevation, rainfall, and temperature the system provides predictions of the temporal and spatial pattern of epidemics that could help to control and prevent malaria epidemics. The approach used in developing the malaria early-warning system was to use statistical forecasting models based on historical malaria cases and environmental risk indicators. Regardless of these warnings, results showed that Land Surface Temperature (LST) is a potential indicator of malaria risk in the highlands of Ethiopia. There was evidence of reduction of malaria cases Rwanda and Ethiopia due to the prevention and treatment of malaria.

Olabode et al. [22] Created awareness on satellite application especially Geographic Information system (GIS) in Foot and Mouth disease surveillance and control. This helped to lessen the negative impact of the disease. The image processing system allowed conversion of remotely sensed imagery into maps. They hoped for an enhancement in the satellite data available to be integrated with GIS. Their study revealed that satellite techniques have been used in disease epidemiology for decades in the western world, yet its application in developing countries like Nigeria is under exploited but highly desirable.

Peckham et al. [3] investigated how satellite communication is re-structuring global health. A lot of satellite image-providers and organizations are involved in creating geospatial content driven by clear commercial Imperatives. It would be gainful if these organizations would provide an evaluation of tele-epidemiology which would in turn pave a way for future research. Recently, satellite data-gathering and digital image-processing are becoming fundamental to the concept of ‘‘planetary health” surveillance. This is based on the understanding that human health and human civilization depends on the thriving of nature and its components.

Penny et al. [40] tackled the issue on the lack of the impact on vaccine coverage, and the high HPV vaccine coverage documented in routine records. They designed a mixed-method, cross-sectional study to estimate the possibility of incorporating HPV vaccine into the routine vaccine delivery mechanisms in Piur. They chose school-based vaccination of fifth-grade girls, aged 9 years or older, in primary residing in diverse districts. Results showed that school-based vaccination is feasible in a well-organized health system with a high level of commitment to immunization from national to local level. It would also be encouraged by high rate of young girls attending schools.

Jutla et al. [51] explored the use of satellite enabled means of predicting cholera in endemic regions. Using satellite-derived chlorophy11 and air temperature data to predict endemic cholera. There showed to be a relationship between chlorophy11 and cholera incidence. Two seasonal modelling strategies were used to predict cholera incidences with a series of environmental variables and macro-environmental processes which showed conditions favorable for cholera outbreaks. Satellite data over a range of space was used in developing cholera prediction model for the Bengal Delta with several months lead time.

Jutla et al. [52] also tried to predict cholera outbreak in the Bengal Delta region using remote sensing, space distribution of chlorophy11, using the data got from sea WIFS, in the Bay of Bengal region using 10 years of satellite data. This study is going to facilitate the design of in –situ sampling strategies of coastal chlorophy11 in the region. The result from this study suggested that daily chlorophy11 concentration may not be useful in developing a cholera predictive model.

Thomson et al. [53] hoped to reduce mortality and the negative social and effects of malaria and also prevent epidemic and protect malaria-free areas. Weather-monitoring satellites and geographical-information systems (GIS) were used in this study. The lower spatial resolution satellites observed large areas of the Earth's surface several times a day, including remote regions difficult to access on the ground. Data from sensors on the satellites were gotten for free through local reception systems throughout the world. It was seen that villages sited near muddy soils were those in which the use of nets was most common, which indicated that they suffered from a relatively high degree of mosquito biting. The study and its results emphasized the need for including satellite data in the study of disease vectors.

Maxwell et al. [58] identified how land surface remotely sensed data can be used to study the relationship between cancer and environmental contaminants, focusing mainly on agricultural chemical exposures. Remotely sensed data from satellites and air borne data were used in the research. A huge amount of remotely sensed imagery exists to support cancer epidemiological studies. Aerial photography and the Landsat satellite data are the most common and most accurate image products. Satellite data providers know the importance of remotely sensed imagery for human health and have identified the link between environmental factors and human health and wellbeing. These collections of satellite imagery data are an untapped resource for research in the aspect of exposure assessment and long-term cancer studies.

Vesecky et al. [59] assisted in the control of carrier borne disease using Biospheric Monitoring and Disease Prediction. The concept makes use of a remote sensing, medical satellite (MEDSAT). The MEDSAT ground segment is the mobile ground station located within the malaria risk region. This is in a van which would house a satellite communication downlink as well as several computer workstations and essential peripherals within the van. Satellite sensor data, visible and infrared images would be processed and combined with available surface data in geographical information system GIS, and send them on to the local public health system for use. A light-satellite design for a MEDSAT satellite with a Pegasus launch is feasible.

Helene et al. [80] recognized risk maps for each leishmanial species in Ghardaia, while considering the specific region of the vectors, using land cover and topographical characteristics got from satellite remote sensing imagery. Using expert and bibliographic knowledge, habitats of vectors and reservoirs were mapped. The vector habitat and risk maps were validated using available entomological data and epidemiological data. Satellite remote sensing analysis was used to map and differentiate risk areas for the two species causing cutaneous leishmaniosis and identify palm groves and areas bordering the river crossing the city as areas at risk the disease. High spatial resolution satellite imagery has provided the useful information in order to take necessary preventive and control measures which would prevent the future outbreak of the disease.

Linthicum et al. [71] determined the spatial distribution of Rift Valley Fever (RVF) viral activity through identification of an ideal mosquito habitat and by analyzing the records obtained from the Pacific and Indian Ocean. The analysis showed that Rift Valley Fever outbreaks can be predicted up to 5 months in advance. It was also observed that all known RVF outbreaks from 1950 to early 1998 in East Africa followed periods of abnormally high rainfall.

Odhiambo et al. [97] investigated the potential for weather driven early warning systems to prevent disease occurrence. The lagged effect of each environmental variable on weekly malaria mortality was modeled using a Distributed Lag Non-Linear Modeling approach. Malaria mortality was associated with precipitation. The NDVI threshold for increased mortality risk was between 0.3 and 0.4. The study described association of lag patterns of weekly remotely sensed environmental and meteorological conditions on malaria mortality in three malaria endemic regions in Western Kenya. This paper reinforces the applicability of the use of remote-sensing data which is available at appropriate spatial and temporal resolution for risk mapping of malaria in areas where weather data is not reliable and readily available.

Walker et al. [73] Strengthened predictions of the time of emergence of the outbreaks in specific places, and also improved the precision and reliability of warnings given to farmers. They used computer-based warning systems to merge the local knowledge and the satellite information, simulating a widely distributed and evenly spaced network of weather stations, using reliable and consistent information to automatically inform the user on the state of Oestrus ovis probable outbreak. The current satellite-based approach offers the advantage of providing the degree-day information very efficiently requiring minimal staff input, and therefore, can support Veterinary Services in improving warnings to farmers throughout the country. This approach is not all encompassing. It only considers the temperature of some particular areas and leaves out temperatures of some other areas.

The value of scenario planning lies as much in the opportunities it creates for dialogue and information sharing as it does in the creation of the futures themselves. None of the authors of this paper have a financial or personal relationship with other people or organizations which could improperly influence or bias the content of the paper.

Kelly et al. [16] hoped to fully realize the role mapping and geographical reconnaissance (GR) have played an important role in supporting malaria control and eradication. The uniform strategy to classify both malaria risk and incidence, as well as the overall preparedness of malaria programs for elimination implementations. A spatial decision support system SDSS provides a mechanism to relate regularly collected data with associated geographic locations, conduct spatial queries and analysis, and produce automated reports and illustrative maps for relevant areas of interest. The effective management of any malaria elimination information system thus requires both spatial perception and the inclusion of a geographical component to any malaria.

B. Identified Diseases Causes through Remote Sensing

Matawa et al. [6] wrote about modelling the spatial temporal distribution of tsetse as a function of topography and vegetation greenness in the Zambezi valley of Zimbabwe. It was basically to predict the spatial distribution of tsetse in the study areas as a function of elevation and topographic position index. It established a fact based on study on the factors affecting distribution of tsetse, but didn't factor in temporal variation in the tsetse habitat.

Houngbedji et al. [7] wrote on spatial mapping and prediction of plasmodium falciparum infection risk among school-aged children in Cote d'Ivoire. It was purposed to implement control strategies and planning the deep knowledge of spatial characteristics of factors that influence malaria. The national malaria control program (NMCP) produced long lasting insecticidal nets in order to reduce the influx of mosquitoes.

Escobar et al. [9] showed the ecological approaches in veterinary epidemiology: mapping the risk of bat-borne rabies using vegetation indices. This was to consider the critical role of the degree of the area of the analysis in ecological niche modelling (ENM). Here the resulting model identified approximately 25-thousand-kilometer square suitable for bat-borne rabies occurrence, in coastal areas of central Chile.

Chuang et al. [17] proposed a method of detecting climate anomalies in the northern great plains of the United States of America and in this case, West Nile River Virus. It was aimed at analyzing and evaluating the contributions of different seasonal environmental variables for predicting the occurrence of the virus. The effective management of malaria requires a spatial perspective and the inclusion of a geographical component to any malaria elimination.

Zhou et al. [18] wrote a report on spatial epidemiology in zoonotic parasitic diseases. The aim of the report was to evaluate the developments that have been made in controlling diseases caused by zoonotic parasites. In the report also, a comprehensive design and implementation of "Mekong Disease Control Web GIS" was discussed.

Kalluri et al. [19] discussed the use of remote sensing techniques for the surveillance of areas that are infested with arthropod vector-borne diseases. The aim of the paper was to review the developments that have been made in studying infectious diseases that affect humans, caused by arthropods, using remote sensing techniques. The data of the epidemic disease outbreak obtained from this review can be entered into the web system and then disease information can be gotten in real time.

Rogers et al. [20] used temporal Fourier process to obtain meteorological satellite data obtained from satellite data so as to predict the distribution of tsetse flies in the West African region. This enabled the application of remotely sensed satellite data in the prediction of the distribution and abundance of tsetse flies in West Africa.

Evans et al. [57] wrote on estimates of global mortality attributable to particular air pollution using satellite imagery. It was basically to undertake a global assessment of mortality associate with long term exposure to fine particulate air pollution using remote sensing. The exposure levels were derived from the MODIS and MISR satellite instruments.

Linthicum et al. [64] wrote a report on the incorporation of both polar orbiting and meteorological satellite data as a tool for the detection of Rift Valley Fever Virus. This was aimed at detecting accurately parameters like ground moisture which could be used in determining flooding.

[18] wrote this article on epidemiology at the extremes. Was basically an examination of factors that affect the health outcomes in very remote areas of Australia aimed at examining the factors contributing to excess health burden in remote areas.

Painter et al. [35] wrote an article on the advantages of integrating telemedicine into caring for patients with posttraumatic stress disorder (PTSD). One of such numerous advantages being cost-effectiveness. This article emphasized on the importance of developing a telemedicine-based model that will increase the engagements of rural veterans in treatments. The author used a pragmatic randomized effectiveness trial method to observe the effects PTSD has on care teams.

Craig et al. [36] developed a spatial statistical model and a map showing the history of the pervasiveness of malaria in Botswana. The aim was to develop a malaria risk map using a systematic variable selection process for spatial analysis.

Kazembe et al. [65] investigated satellite hemodialysis fallbacks in the province of Ontario. This was aimed at determining the incidence of nature, and the outcome of such fallbacks to aid resource planning. The use of satellite units by regional centers to provide community-based dialysis has become a model for Ontario.

Machault et al. [78] wrote this article on remote sensing and malaria risk for military personnel in Africa. Aimed at developing a model that provides remote-sensed environmental information to serve as an indicator of malaria risk among nonimmune travelers. Remotely sensed environmental data can provide important planning of information on the level of malaria.

Asare et al. [80] researched on mosquito breeding site, water temperature observations and simulations towards improved vector-borne disease models foe Africa. This was aimed at developing an energy budget model in order to predict the water temperature of typical mosquito larval. It was revealed that disease models should not apply air temperatures as water temperatures.

Oviasu [82] wrote an article on determining the location of suitable satellite center's for chronic kidney disease (CKD) treatment within Edo state, Nigeria. It was basically to determine the efficiency of health service available to chronic kidney disease. The results from this study have been able to highlight the problems associated with having just one major CKD health care service within the state.

C. Disease Control Using Satellite – Related Approach

VoPham et al. [1] wrote about emerging trends in geo-spatial artificial intelligence (geoAI) and it was about analysing and visualizing the real-world phenomena according to their locations, enabling environmental epidemiologists to use Geographic Information System (GIS) technologies to create and link exposure models to health outcome data using geographic variables to investigate the effects of factors such as air pollution on the risk of developing diseases such as cardiovascular disease.

Zhang et al. [12] wrote about remote sensing and disease control difference in water index in the field of schistosomiasis research and modified the above method by using the normalized difference Water Index (NDWI) from Remote Sensed (RS) images to accurately get the water areas for snail habitats.

Semenza, et al. [13] expatiated on the issue of linking environmental drivers to infectious diseases. The disease incidence is used to estimate disease risk but there is a difference between risk and disease occurrence.

Zuzek et al. [24] discussed about the Communications Satellites in the National and Global Health Care Information Infrastructure: Their Role, Impact, issues and outlining the critical role satellites will play in the National and Global Information Infrastructure for health care applications and will outline the differences in their requirements for NII vs. GII.

Roodenbeke et al. [25] proposed that policy makers adopt innovative methods to attract and retain health professionals through an outreach service as a strategy to increase on the down-trodden access to health care services in remote areas.

Ahmed Ibrahim et al. [38] wrote about integrating remote sensing and GIS to manage primary health care centres which was described furthermore on Pre-processing of satellite images carried out to overcome the distortions due to the earth curvature, relief displacement and the acquisition geometry of the satellites. Well-defined GCPs has been collected from GPS measurements to register the Quick Bird image using second order polynomial function. Accuracy assessment of the produced geo-images.

Liu et al. [27] wrote about how to use software to facilitate remote sensing data access for disease early warning systems by using satellites to measure the rainfall, vegetation greenness, soil moisture and surface area. Stevens et al. [39] wrote about the sources of spatial animal and human health care data by providing comprehensive review of the range of innovative sources of spatial animal and human health data, including data warehouses m-Health, Google Earth, volunteered geographic information and mining of internet-based big data sources.

Martinez et al. [41] expatiated on satellite can help the value of WhatsApp communication in paediatric centre in West Africa on the review of mobile telephone consultations using WhatsApp and which the results from the seamless ability to facilitate real time communication. Geissbuhler et al. [42] evaluated the telemedicine, feasibility and potential risks of a telemedicine network in western Africa. The author also initiated a telemedicine network in Mali in the year 2001 by employing internet-based technologies for telecommunications and long-distance learning.

Mars [43] discussed about advancing telemedicine in both urban and rural health care delivery in Africa which brought about the use of satellites for the exchange of information from one site to another via electronic communications for the purpose of health communications.

Jimoh et al. [44] described a model for health workers in Africa to adopt ICT as a tool for investigating the impact of ICT and satellite monitoring among maternal and child health care workers in the remote areas of Nigeria.

Adewale [45] discussed about an internet based tele-medicine system in Nigeria, the paper discussed some of the challenges and implementation issues of tele-medicine in Nigeria and how we can use satellite for the provision of health care services, clinical information and education over a distance.

Sene et al. [46] on this paper tele-medicine framework using case-based reasoning with evidence described a tele-medicine framework with knowledge engineering using taxonomy reasoning of ontology modelling and semantic similarity using these regular steps; (i) establish diagnosis; (ii) apply evidence; (iii) adaptation; (iv) retain; (v) retrieve treatment.

Rogers et al. [47] described the health and climate opportunities on the advances and selected critical uncertainties in weather and climate prediction relevant to the health sector and creating a conceptual approach using satellites.

Ford et al. [54] suggested that using satellites remote sensing to predict infectious disease outbreaks, this involves a predictive model that can lead to future prevention of the outbreak of an epidemic and pandemic diseases. If this means can be employed epidemic diseases would be curbed. This can be achieved with the method of measuring the physical, chemical and biologic parameters of the earth's surface.

Kant and Krishna [66] employed the use ICT to collect to be able to detect any form of disease outbreak, so as to respond adequately and effectively to the disease outbreaks. The modern ICT were employed to collect, store and mage the data which were related to the disease surveillance.

Myers et al. [69] suggested the use of expert knowledge and statistical modelling of disease outbreak to predict the periods during which the epidemic diseases breakout and the particular areas that are likely to be affected. This is to increase preparedness of any disease or epidemic that may breakout so as to enable good public health delivery.

Hay and Lennon [72] proposed that to control vector borne diseases can be done using meteorological satellites by getting meteorological variables across Africa to enable us predict accurately the areas and risk of the vector borne diseases.

Beck et al. [74] employed the use of remote sensing and earth observing satellites to provide good health services and to map out environmental variables that are vector borne disease related so as to predict the vector borne diseases accurately using the related variables. If this is employed, health investigators will be able to assess many environmental variables particularly of vector borne diseases.

Bourke et al. [75] suggested the use of remote and proximity sensing technologies which relies on the images from radiometric sensors, these sensors are installed on an aerial platforms or satellites. Due to the issues that recently emerged in rural health across Australia and around the globe these sensors help to regulate the health issues and to find the areas affected or having health challenges

Zuzek and Bhasin [24] employed the use of medical examinations, radiology and pathology to offer communication channels and bandwidth on demand. The communication satellites have shown clearly that medical information can be exchanged at a distance.

Stevens and Pfeiffer [39] employed the use of spatial analysis to be able to give a comprehensive review of animal and human health data to inform risk-based animal disease surveillance and control. This helps to deal with the increase of diseases in a more effective way including the use of data warehouses, m-health, Google earth and mining of internet –based sources.

Wang et al. [49] reviewed the developmental arc of theoretical epidemiology which emphasized mainly on vaccination. This reviews the main concepts and results of the basic deterministic field models of theoretical epidemiology. With the statistics gotten, vaccination will help curb the spread of any breakout of diseases and help provide effective control over the spread of any epidemic diseases. The opportunities and challenges of the study of the behavior of vaccination and disease dynamics were summarized in this paper.

Davey and Davey [87] suggested Mobile health Technology in improving public health systems in developing countries. This is done to understand ways and improvements which may be supported by such system, m-health has the potential to improve greatly the health outcomes in developing countries like the country India. The potential to reduce isolation especially in rural areas, and provide support to health care workers as well as patients can be gotten from Mobile Communication technologies.

Rafiei et al. [91] employed an analytic approach to examine the process of image analysis, remote sensing and variable rate prescription, on the occupational health services integrated in primary health care in Iran. This is to describe about health care system in Iran and occupational health services. It seemed that there were still some remote areas that might suffer from inadequate services but with a transparent policy to merge with the private sectors and provide a sustainable mechanism which would improve the quality of health services.

Birks et al. [92] employed a multiple case study research design that included focus groups and interviews. This study reports on the models of health service delivery in isolated areas of Queensland and in remote areas, this indicated that the health workers are residents and as such provide health services and support to the residents of this environment while the specialist who are non-residents provide medical and allied health care services.

Chandras and Ghosh [93] employed a dynamic monitoring for variable rate fertilization which was established with the help of remote, ground and proximal sensing to reduce the contamination of groundwater from the gas called nitrogen and to rather increase its use efficiency in crops. There is a great feasibility of using satellites to map the rice nutritional status.

Davidson et al. [37] employed a GIS-based methodology which would be used for improving needle exchange service delivery, a simpler method which would be used to identify people who are in need to access needles and a better way to meet the needs of those people.

Colston et al. [38] suggested the evaluation of meteorological data from satellites, stations and global models for an epidemiological study so as to predict the outcome of a known climate outcome which is named rotavirus infection episodes.

Linard et al. [85] employed the use of satellite imagery and existing point datasets, for disease risk mapping in Somalia. This was employed so as to produce easily gridded population dataset at 100 × 100 meters spatial resolution. The land cover information was gotten from satellite imagery. With this, results had shown it is possible to have these datasets of Somalia for good health service planning and delivery.

Lindsay et al. [77] investigated satellite hemodialysis fallbacks in Ontario province, this is done to help plan the health care service delivery in a more efficient way to get to all the patients. The incidents registered were 170 patients having multiple fallbacks. Ontario, in order to provide good community dialysis makes use of the satellites by regional centers.

Dermody and Bennett [96] employed the use of satellite hemodialysis to provide good health services. This study is to decrease the stress of nurses in health care units and satellite hemodialysis unit with the use of questionnaires. With the results established, would educate the managers for them to understand the nature of the stressors and limit the nursing stress thereby improving patient health care.

Latkin et al. [76] employed the use of GIS, to assess the spatial use of drugs, this study showed the daily use of cocaine and cracks to be associated with the neighborhood in the western portion. It suggests the type of drugs used, areas independent of whatever the characteristics of the neighborhood is.

IV. Conclusion

Satellite communications has paved a way for individuals to receive prompt health services through telehealth and telemedicine. With the aid of Geographic Information System (GIS) technologies, the application of satellite communication systems to epidemiology has enabled real-time forecast, surveillance and monitoring of health and disease conditions in defined populations.

This paper has reviewed articles on health challenges, disorders & diseases; causative agents of diseases and satellite-related methods & solutions to control diseases including the way forward. It has provided a thorough, comprehensive literature on the development of software applications for the provision of epidemiological data, provided knowledge into factors influencing the distribution of vector-borne diseases, applying remote sensing to monitor environmental health risks among other highlights.

In Africa, telemedicine has served as a beacon of light to medical patients, particularly in remote, rural and inaccessible regions. As the demand for professional medical services in rural areas keeps increasing, the stipulation and supply of medical aid from a distance using satellite communications remains an effective way in providing remote health service delivery to affected and isolated areas. Through this, costs can be reduced and sustainable health provision can be maintained by improving access, equity, quality and accountability.

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