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Abstract

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The foundation of public health interoperability requires integration and interoperability at both structural and semantic levels. Many countries are now implementing EHRs that subscribe to HL7 standards and FHIR resources. This area still has potential for enhancing interoperability and strengthening surveillance for emerging and re-emerging epidemics like Zika, Ebola in low resource settings. Global warming and climate change across the globe is not only affecting animals and plants, but is affecting the distribution of diseases and prevalence of diseases across the globe. As a result, technologies that can work best in rugged terrains are required for management and control of emerging and re-emerging epidemics. Wide area network optimization technologies and FHIR APIs for data pull models are required to enhance data collection and reporting for better management of disease outbreaks.

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DIGITAL INTEROPERABILITY, DISEASE SURVEILLANCE, AND CLIMATE CHANGE

1. INTRODUCTION

Digital interoperability means the ability of health information systems to work together within and across organizational boundaries in order to advance the health status of, and the effective delivery of healthcare for, individuals and community.

Interoperability is an area with great potential in strengthening surveillance for emerging and re-emerging epidemics like Zika and Ebola in low resource settings.

The foundation of complete public health interoperability will require integration and interoperability both at structural and semantic levels. This will ensure secure reliable and consistent exchange of data between devices, application platforms not only for routine patient care but also enhance surveillance of emerging and re-emerging epidemics.

1.0 BENEFITS OF INTEROPERABILITY

The full potential of digital health will require opening up of health system architectures for semantic interoperability. This will require common interfaces for plug and play devices to integrate information into healthcare systems and a standard interoperable interface to exchange data between back-end solutions.

Semantic interoperability will ensure

1. Easier and faster access to patient’s information
2. Opportunities for better diagnosis, quality of treatment and patient safety
3. Improved cost effectiveness
4. Increased consumer choice and enhanced competition

1.1 INTEROPERABILITY WITH FHIR API

Fast Healthcare interoperability Resource is a proposed interoperability standard developed by the healthcare IT standards body HL7.Health level seven international (HL7) is a non-profit, ANSI- accredited standards developing organization dedicated to providing a comprehensive framework and related standards for exchange, integration, sharing, and retrieval of electronic health information.

Interoperability with FHIR business case proposes the implementation of this standard in an NGO with a public health mission in HIV/AIDS care and treatment and research to bring together communities within HIV programs. This will involve interoperability using FHIR specifications to explore capabilities of open source EHRs in developing to embrace FHIR specifications for solving interoperability and integration problems between EHR, HIE, LIS, and Portal applications to improve patient care, research/clinical trials, and public health surveillance by providing a much wider platform availability and dissemination of health-related information between developing and developed countries

1.2 DELIVERABLE

The proposed system will focus on open MRS FHIR API and research and studies database as well as the mobile applications for contact tracing and laboratory Information system. Open MRS system can update few resources like a person, patient, practitioner, location, encounter, observation, allergy intolerance, and laboratory and radiology diagnosis into FHIR repository with the Help of HTTP PUT and POST operations while doing CRUD operations on these objects in their database. These resources can then be bundled together in the context of patient portal that can query FHIR server for these resources to update and copy each time. This can also be done for the mobile application for read-only view of patient information and basic clinical data.

RESTFUL API will be used to meet Application Access certification criteria where serialized JSON response of FHIR resources will be used to generate exchange data for research database application

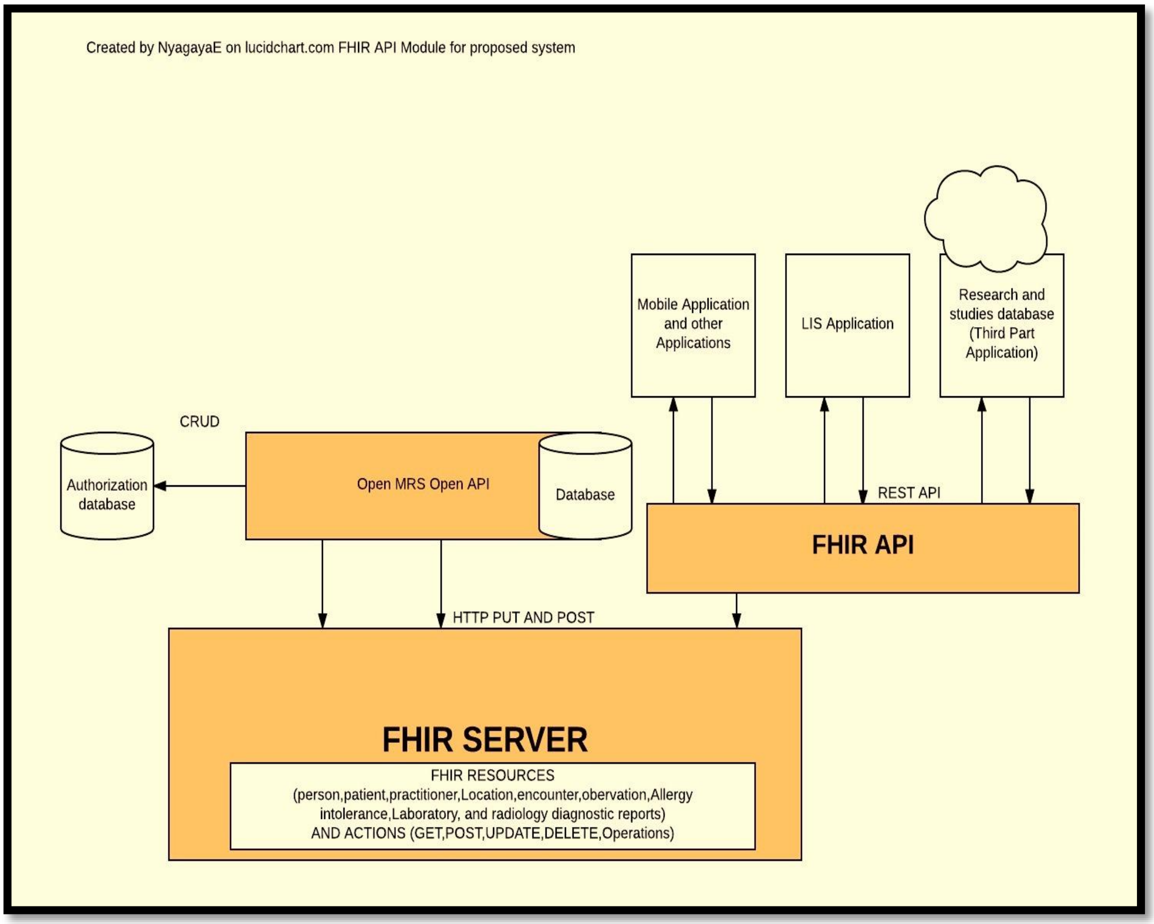


Figure 1: Proposed system model: FHIR API for OpenMRS and Research study database

2.0 EXPLORING FHIR FOR PUBLIC HEALTH IN DEVELOPING COUNTRIES

FHIR for public health is still a gray area that needs to be explored. As at 2017 public health workgroup is working to support the HL7 mission to create and promote standards by helping to assure that HL7 V2 and V3 models, messages, documents, and services address the requirements of public health agencies, government and none government specific interest areas. These areas are not limited to outbreak investigations, disease and event detection, response and control, human an animal population health monitoring, vital records among others.

Open Medical Records System (OpenMRS) is an efficient electronic medical record (EMR) storage and retrieval systems for treating the millions of HIV/AIDS and tuberculosis (TB) patients in the developing world. OpenMRS subscribes to HL7 and has begun to implement FHIR resources. This presents a step towards utilization of EMR that subscribe to FHIR resources in developing countries to improve public health surveillance.

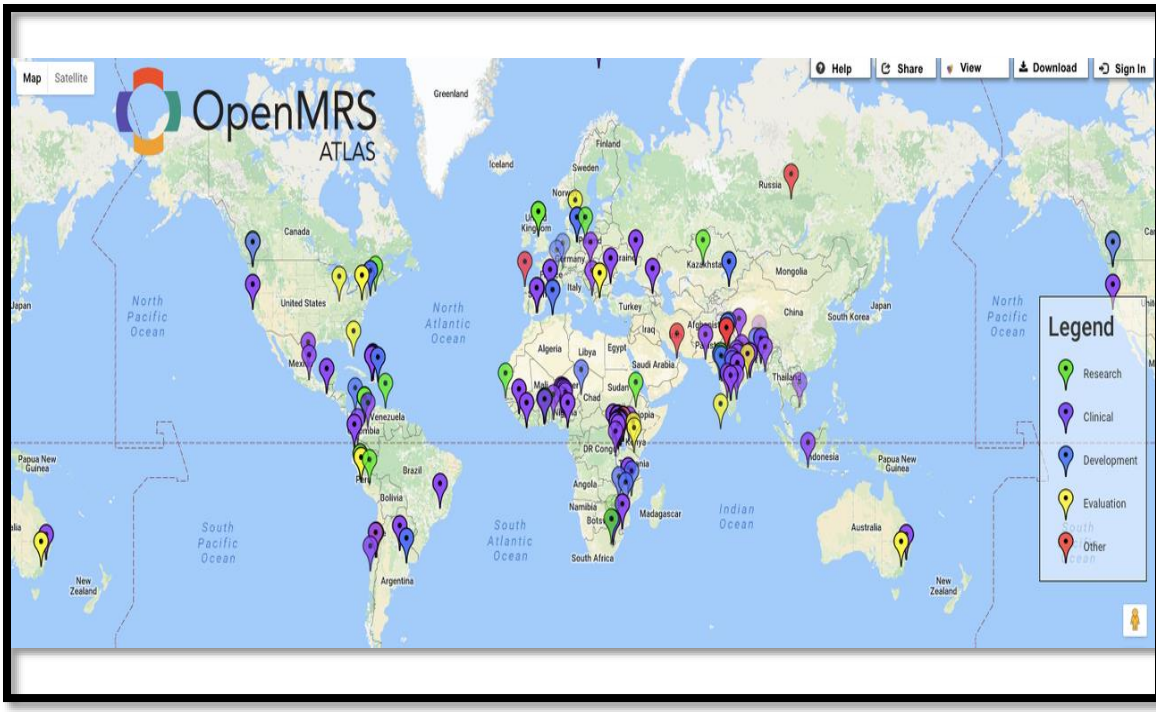


Figure 2: OpenMRS Atlas

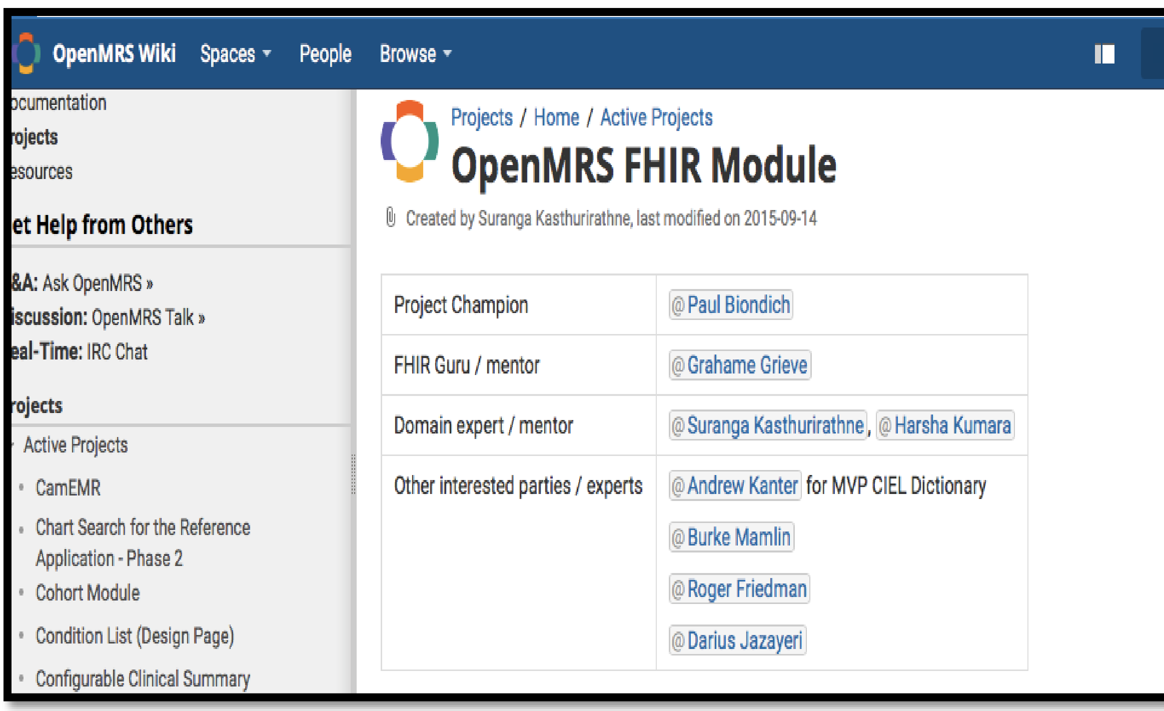


Figure 3: OpenMRS FHIR Module

Current status of FHIR support

To date, the FHIR module supports the following resources and actions.

Resource	Person	Patient	Practitioner	Location	Encounter	Observation	AllergyIntolerance	DiagnosticReport (Laboratory)	Diagnostic (Radiolog
GET	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
POST	Yes	Yes	Yes	Yes	Yes	Yes			
UPDATE	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes
DELETE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Operations	N/A	$everything	N/A	N/A	$everything	N/A	N/A	N/A	N/A

Figure 4: OpenMRS current FHIR support status

3.0 SURVEILLANCE IN LOW RESOURCE SETTINGS

This project looks at integration and utilization of already existing application to manage disease outbreak like flu in low resource settings. EMRs like Open Medical Records System (OpenMRS) and Clinical Patient Administration Kit (CliniPAK) have been used in low resource setting for case management during a disease outbreak. Open MRS has been customized and used during Ebola surveillance in Sierra Leone. CliniPAK has been used in a very remote setting with inadequate power supply and Internet connection for case management and patient follow up.

Source: https://www.vecnacares.org/solutions/clinipak/

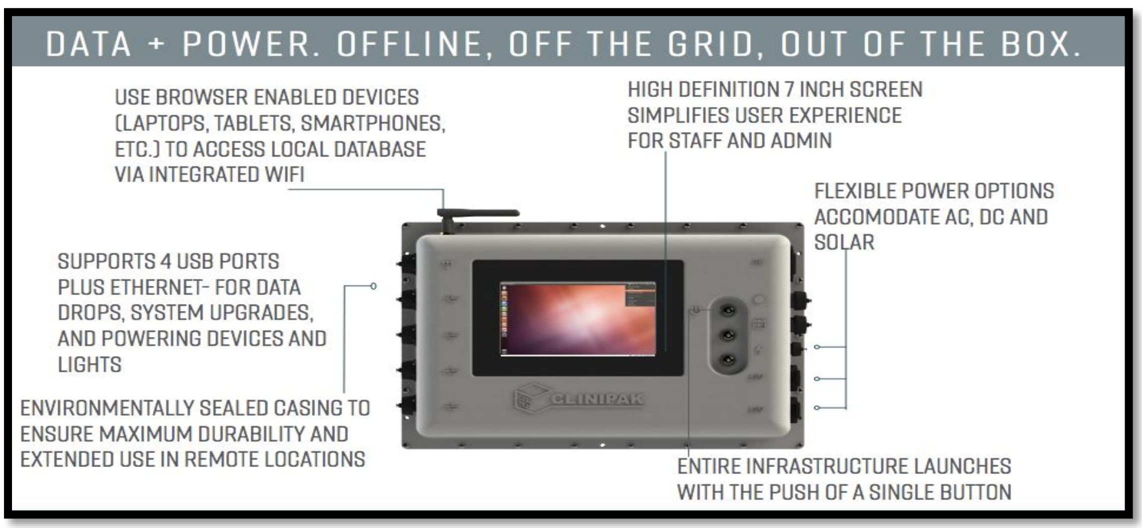


Figure 5: Clinical Patient Administration Kit Components

Source:https://www.vecnacares.org/solutions/clinipak/

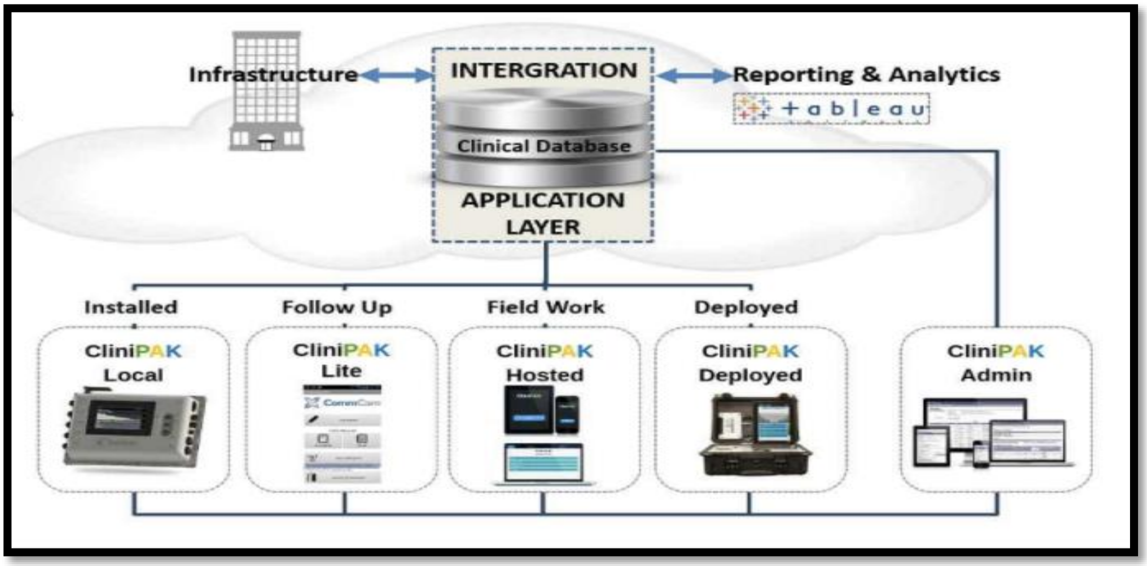


Figure 6: Clinical Patient Administration Kit network architecture

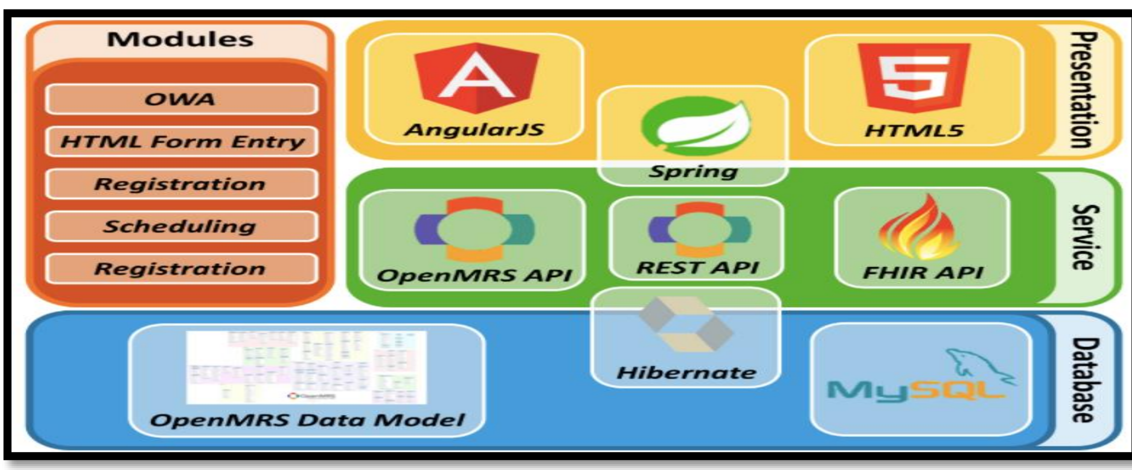
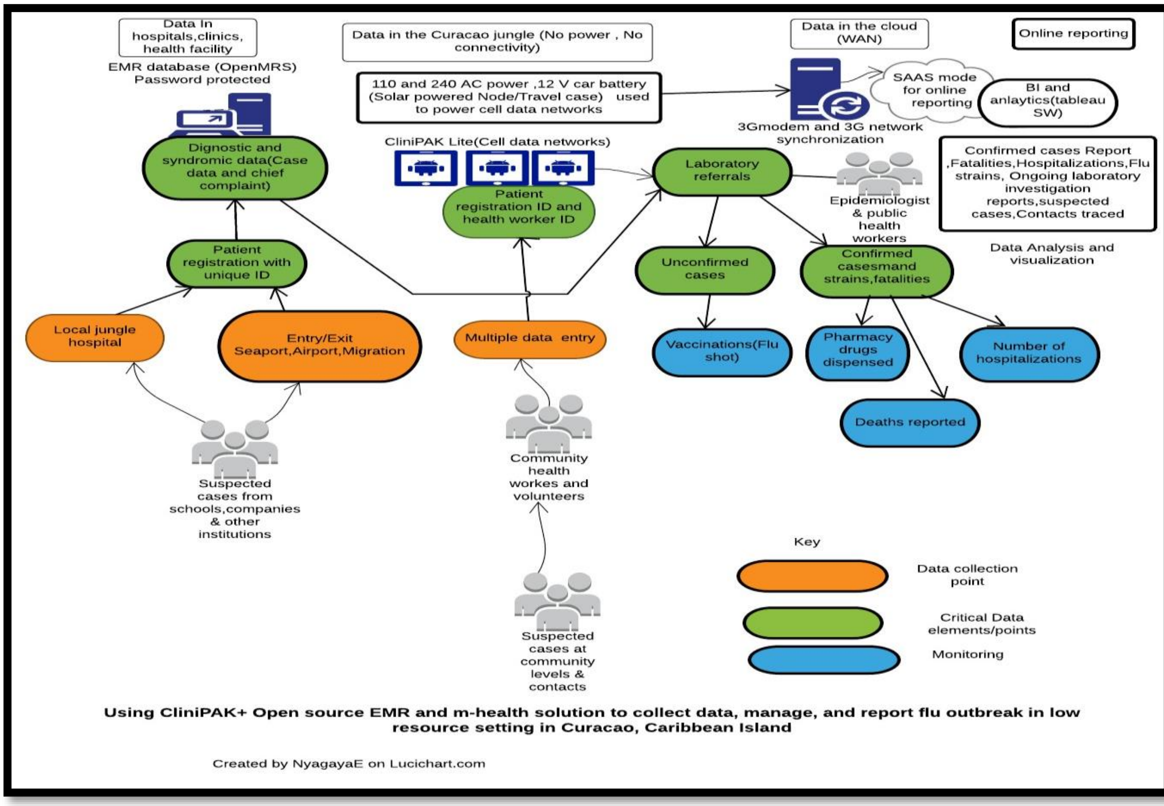


Figure 7: OpenMRS Components

This project was aimed at integrating CliniPAK and Open MRS to support flue surveillance in the Caribbean while utilizing Riverbed technology for Wide Area network optimization.

Riverbed technology can be deployed on-site, in the cloud, and any other place where CliniPAK and Open MRS may be located. Riverbed is critical in connecting remote users to the hospital office server and cloud storage data center.



Using CliniPAK+ Open source EMR and m-health solution to collect data, manage, and report flu outbreak in low resource setting in Curacao, Caribbean Island

Figure 8: Flu Surveillance using OpenMRS, CliniPAK, & WAN optimization using riverbed

4.0 CLIMATE CHANGE AND PUBLIC HEALTH

Climate Change across the globe is not only affecting animals and plants but is affecting the distribution of diseases and prevalence of diseases across the world. New health threats are emerging in various parts of the world. While not everyone has an equal risk of contracting these diseases, it is important to consider the impact of these emerging and re-emerging epidemics and prepare adequately to manage and control the spread of these epidemics using systems that can talk to each other.

The two scenarios considered for my portfolio project were climate change and Zika virus and climate change and brain eating amoebae. Some of the highlights on public health implications and control measures are as follows;

4.1 CLIMATE CHANGE AND ZIKA VIRUS

In 2016, The World Health Organization declared ZIKV infection to be an international public health emergency. However, there has not been significant evidence suggesting that Zika is the cause of microcephaly, which can lead to severe neurological sequelae in babies. "ZIKV is transmitted to humans primarily through the bite of infected mosquitoes, Aedes aegypti, and Aedes albopictus. These mosquitoes are the principal vectors of dengue and ZIKV disease." The signs and symptoms of ZIKV are usually mild and develop in only one in five persons. Severity requiring hospitalization is uncommon and case fatality is relatively low. Currently, there is no vaccine and antiviral treatment available for ZIKV infection. The only way to prevent ZIKV infection is to prevent maternal infection. ZIKV has been activated as a category V Notifiable Infectious Disease similar to Ebola virus and MERS. To control ZIKV, CDC has issued Travel health notice targeting pregnant women, for the following countries, Cape Verde, Mexico, Africa (Angola, and Guinea-Bissau), Asia (Maldives, and Singapore), The Caribbean, Central America, The Pacific Islands, and South America along with other risk areas. Affected countries have developed ZIKV surveillance systems among pregnant women. America and Puerto Rico have implemented ZIKV registries.

4.1.1 CONTROL AND PREVENTION

Since there is no vaccine to control ZIKV, The best way to prevent ZIKV spread by mosquitoes is through personal preventive measures that are preventing mosquito bites using repellents, use of insecticides treated mosquito nets, and wearing the right clothing. These control measures target pregnant women and their babies as the most vulnerable populations. The alternative control measure is source reduction, targeting mosquito-breeding habitats. As of January 2017, U.S. Centers for Disease Control and Prevention (CDC) presented a draft Programmatic Environmental Assessment (PEA) proposal to support mosquito control activities to combat Zika virus in the United States. This Act was guided by the relevant legislation and agency including U.S Public health service Act, The National Environmental Policy Act of 1969, Endangered species Act, Federal Insecticide, Fungicide, and Rodenticide Act, HHS General Administration Manual (GAM) part 30 Environmental protection, and Emergency and the National Environmental Policy Act, May 10,2010. Two alternatives were reviewed for the assessment. The alternative that was meant to enhance support for Integrated Mosquito Management that includes CDC supporting either directly or through technical and/or financial assistance mosquito control activities of territorial, tribal, state and local government was considered.

4.1.2 RECOMMENDATION AND CONCLUSION

With an Unknown real scope of complications, additional research on ZIKV pathogenesis is paramount. Measures of control already being implemented include ongoing surveillance, development, and distribution of better diagnostic test, provision of guidance, and advice on strengthening mosquito control, and source reduction efforts. CDC experts are working to protect pregnant women better understand the link between ZIKV infection and adverse health outcomes. WHO/PAHO have continued to recommend member states to enhance surveillance systems for the detection of this virus. Future prevention of ZIKV will largely depend on vaccine research development.

4.2 CLIMATE CHANGE AND FRESHWATER BRAIN EATING AMOEBA

Climate Change across the globe is not only affecting animals and plants but is affecting the distribution of diseases and prevalence of diseases across the world. Potential warming of freshwater bodies due to climate change has expanded the occurrence of water-borne diseases into new regions. Thermophilic organisms like Naegleria fowleri that can survive in temperatures up to 115°F (46°C) have the opportunity to thrive as freshwater bodies' heat up.

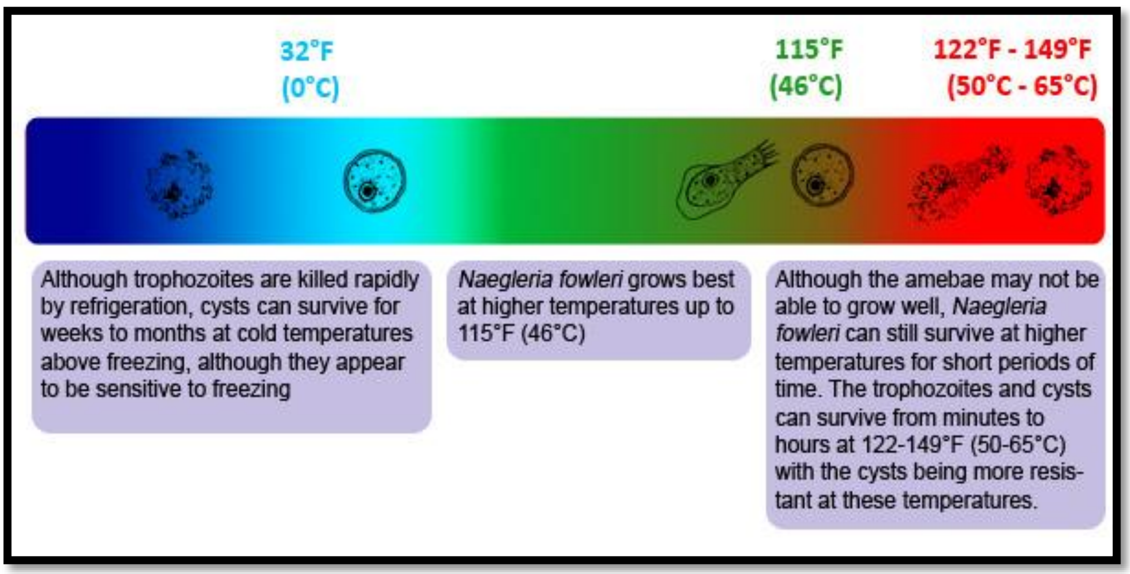


Figure 9: Naegleria Fowleri survival temperatures

In this regard, Naegleria fowleri is found in warm freshwater and soil around the world, and in the United States southern tiers. Due to climate change, recent cases of Naegleria fowleri infections have been reported in a Northern tier state of Minnesota. This case had no history of travel. From 1962 to 2016 only 4 people out of 143 known infected individuals in the United States have survived. CDC rates infection fatality at 97%.

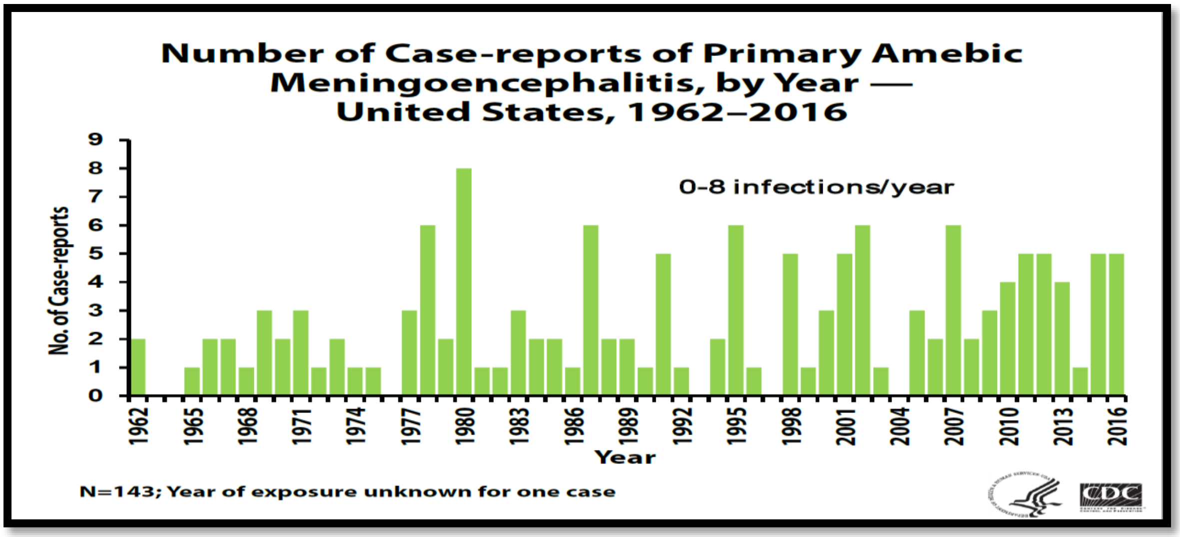


Figure 10: United States PAM Statistics as at 2017

4.2.1PUBLIC HEALTH IMPLICATIONS

Since this disease effects, recreational swimmers in swimming pools that are not properly treated, ponds, lakes, and rivers worldwide and it is unknown as to why some who are exposed are infected while others are not, the potentially affected is millions who swim in these waters worldwide during warmer months. Both in the U.S. and globally, PAM caused by Naegleria fowleri has historically affected mostly younger males

4.3 RECOMMENDATIONS

Control and prevention of PAM have been made difficult due to rarity and ubiquity of cases observed. Infection risk is very low. In a period of 10 years, 40 cases have been reported in the U.S. Many cases in developing countries are unreported.

“Attempts has been made to determine what concentration of Naegleria fowleri in the environment poses an unacceptable risk” No method exists that can accurately measure the numbers of amoebae in the water. This has made it difficult to set standards to protect human health and how public health officials would measure and enforce any standard.

That said, Naegleria fowleri is associated with Climate change. Climate change laws and legislation, and climate change indicators in developing and developed countries can help further prevent the spread of thermophilic organisms in freshwater bodies and soil. Countries that do not have legislative instruments to directly address climate change should be encouraged to implement these laws through acts of parliament agreements. The Paris agreement is one such law. Climate change law can also be incorporated into general environmental regulation and policies.

5.0 CONSIDERATIONS

As FHIR specifications continue to grow and evolve. Many large IT companies are also embracing and provide support for FHIR. The EHR supported by IT companies are being implemented across the globe both in developed and developing countries. It is known that interoperability of Health IT systems has continued to be a challenge. FHIR resources for public health still remain a gray area even among FHIR implementers. In my view, this area still has the potential for enhancing interoperability and strengthening surveillance for emerging and re-emerging epidemics like Ebola and Zika in low resource settings. The foundation of complete public health interoperability will require integration and interoperability both at structural and semantic levels. This will ensure secure reliable and consistent exchange of data between devices, application platforms not only for routine patient care but also enhance surveillance of emerging and re-emerging epidemics.

Use of emerging and existing technologies for public health surveillance will ensure that we have adequate systems at all level to manage and control emerging and re-emerging epidemics that may result from climate change.

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