Capstone Proposal

2019

Principle Investigator (PI): Grace Grifferty

Title: Strengthening Visceral Leishmaniasis Data Systems in Kenya: ensuring high-quality data for program decision-making at the country, regional and global levels

Institution: Northeastern University

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Amount requested: $177,500

I. Specific Aims and Objectives

Visceral Leishmaniasis (VL) has a global incidence between 50,000 – 90,000 each year, with over 90% of these cases occurring in Brazil, Ethiopia, India, Kenya, Somalia, South Sudan, and Sudan. It is fatal in 95% of untreated cases, making it the second leading cause of parasitic death behind malaria. In Kenya, 2,500 VL cases occur annually leaving 5 million people at risk of infection. The World Health Organization (WHO) and the London Declaration on Neglected Tropical Disease in 2012 vowed to eliminate VL by 2020. The elimination target for VL requires 100% detection and treatment of all cases.

Previous survey studies found no dependable strategies for prevention, treatment, and control, in addition to a lack of infrastructure of any health facilities dedicated to VL and no public health programs. Epidemiological mapping, household surveys, facility surveys, and systems analyses revealed a widespread lack of knowledge about VL symptoms, treatment, and prevention amongst locals and healthcare professionals. To achieve the WHO goal in the Eastern African region data must be collected, in the clinic and the field, to understand VL case patterns.

The Kenyan government has developed several health information technology projects, but none have been implemented on a national scale. To this point, the electronic systems are not designed to collect entomological, demographic, environmental and ecological data related to VL case patterns. Currently, VL data collection comprises of paper-based methods that are not synced electronically between the clinician, Ministry of Health and non-governmental organizations like the WHO. These paper-based forms also do not collect entomological, environmental and ecological data related to VL case patterns. These paper-based methods do not collect relevant demographic information besides the location of VL cases. Baringo County bears a disproportionate burden of VL endemicity and has only one VL treatment center: Kimalel Health

Center. Kimalel Health Center is an ideal location for this study since all positive VL cases in the region are brought here for treatment. This centralization of cases renders this location ideal for a pilot study utilizing an electronic Medical Record System and Geographic Information System to collect data related to VL case patterns. Using iPads to collect VL data in both the clinic and in the field, using both an electronic Medical Record System and Geographic Information System, at the Kimalel Health Center will increase understanding and accessibility of entomological, demographic, environmental and ecological data related to VL case patterns. ***We hypothesize*** that Baringo County will be endemic for VL, i.e., more than one positive case identified. ***We also hypothesize*** that collected entomological, demographic, environmental and ecological data will correlate to VL positive cases. In the long-term, we hope that this data collection enables an unprecedented overview of VL prevalence in Baringo County, leading to targeted intervention strategies and facilitated information sharing between Ministry of Health and non-governmental organizations like the WHO.

Specific Aim 1. To conduct a pilot study of electronic Medical Record System and Geographic Information System on iPads in Kimalel Health Center.

A pilot study will be conducted at Kimalel Health Center; it is the only VL treatment site in Baringo County. Using iPads clinicians will be able to input relevant clinical data into an electronic Medical Record System that is synced to the cloud and accessible from any location with an internet connection. The residence of individuals positive for VL will be identified. A community healthcare worker will travel to the residence to collect entomological, demographic, environmental and ecological data on an iPad using a Geographic Information System.

<u>Specific Aim 2.</u> Analysis of Collected Data to Generate Predictive Hot Spot Maps

Entomological, demographic, environmental and ecological data collected on iPads from positive VL cases will be compiled. Specifically, this project seeks to obtain the entomological data (density and distribution of infected sand flies and termite mounds), human demographic data (settlements, livestock migration routes, location of asymptomatic and symptomatic VL cases) in Baringo County. The inputted data will be accompanied by multimedia obtained at sites (images, videos) for an unprecedented overview of VL in Baringo County. Correlations between collected data and environmental and ecological variables from online databases - including rainfall, vegetation, soil type, temperature, and humidity - will be analyzed to map disease hot spots and predict future outbreaks.

II. Background and Significance

What is Leishmaniasis?

Leishmaniasis is one of many Neglected Tropical Diseases (NTDs): debilitating and chronic parasitic, viral and bacterial infections (Liese, Houghton, & Teplitskaya, 2014; United To Combat Neglected Tropical Diseases, 2017) that burden over 1.5 billion of the world's most vulnerable, impoverished, marginalized and hard to reach communities in low and middle income countries (United To Combat Neglected Tropical Diseases, 2017). There are four forms of Leishmaniasis: visceral, cutaneous, mucocutaneous and post-kala-azar dermal leishmaniasis (Eduard E. Zijlstra, 2012; WHO). This proposal focuses on Visceral Leishmaniasis (VL) since it is the most dangerous form. VL has a global incidence between 50,000 – 90,000 each year, with over 90% of these cases occurring in Brazil, Ethiopia, India, Kenya, Somalia, South Sudan and

Sudan (WHO, 2018). VL is transferred from the bite of female sandflies infected with protozoan parasites (*Leishmania donovani*) to over 70 animal species, including humans (WHO, 2015). VL is identified by fever, weight loss, spleen, and liver enlargement as well as anemia (WHO). It is fatal in 95% of untreated cases, making it the second leading cause of parasitic death behind malaria (WHO, 2015).

In 2012, the World Health Organization (WHO) included Visceral Leishmaniasis (VL) as a disease targeted for elimination in its roadmap for NTDs by 2020 (Diseases, 2019; WHO, 2012). Inspired by this, pharmaceutical companies, donors, non-government organizations (NGOs) and the leaders of NTD endemic countries signed the London Declaration on Neglected Tropical Disease in 2012 (London Declaration on Neglected Tropical Diseases, 2019), vowing to control or eliminate 10 NTDs, including VL, by 2020 (London Declaration on Neglected Tropical Diseases, 2019; WHO, 2012). The elimination target for VL requires 100% detection and treatment of all cases (Le Rutte et al., 2016).

Epidemiology of Visceral Leishmaniasis in Kenya

Since the 1940s, Turkana, Baringo, Kitui, Machakos, Meru, West Pokot, and Elgeyo Marakwet districts were endemic for VL in Kenya (Fendall, 1961). Between 1950 and 1960, over 1000 positive VL cases were identified in these districts alone (Fendall, 1961). In 1952, an outbreak occurred in Kitui district with over 300 cases reported, peaking by 1953 with over 2000 reported cases (Fendall, 1961). In 1966, another outbreak occurred in Meru district with 15000 cases (Wijers & Minter, 1966). Additional outbreaks happened in the 1970s in Machakos district and the Kitui district again in the 1980s (Ho, Siongok, Lyerly, & Smith, 1982; Ngoka & Mutinga, 1978). Baringo, and neighboring districts like West Pokot, first came into focus as VL hot spots in

1955 (Mutinga, 1975). More recently outbreaks have occurred in non-endemic districts Wajir and Mandera between May 2000 and August 2001 (Tonui, 2006). Since then, outbreaks have been sporadic throughout the country; for example, a 2015 outbreak in six counties and a 2017 outbreak in Masarabit county (WHO, 2017b). Due to difficulties in collecting consistent data in pastoral and rural populations, data collection has been inconsistent. Thus, the true extent of VL prevalence in Kenya is unknown. Currently, 2,500 VL cases occur annually in Kenya leaving 5 million people at risk of infection (WHO, 2017a). VL is endemic in semi-arid and arid areas of the Rift Valley, as well as Eastern and North-Eastern regions of Kenya. Specifically, six counties are endemic: Baringo, Isiolo, Turkana, Marsabit, Pokot and Wajir (WHO, 2017a).

Previous studies identify critical gaps in health systems

Kenya was the first African country to implement a national policy on the control of NTDs (Ministry of Public Health and Sanitation, 2010). The Kenyan government identified the critical need for creating comprehensive information on the distribution, critical co-endemicities, and scale of the economic and societal burden of Leishmaniasis and other NTDs (R. G. Wamai et al., 2015). In support of these efforts, a consortium of researchers from Northeastern University, the University of Nairobi School of Public Health (UONSPH), Kenya Medical Research Institute (KEMRI) and policy-makers in the Ministry of Health (MOH) agreed to complete a population survey of Leishmaniasis in East Pokot, Kenya to gain precursory data on Leishmaniasis. Their population survey in 2012 exposed that there are **no dependable strategies for prevention, treatment, and control, in addition to a lack of infrastructure of any health facilities dedicated to VL and no public health programs** (R. G. Wamai et al., 2015). These groups also conducted four unique studies between 2011 and 2013, performing epidemiological mapping, household surveys, facility surveys and systems analyses (R. G. Wamai et al., 2015). These studies revealed **a widespread lack of knowledge about VL symptoms, treatment, and prevention amongst locals and healthcare professionals** (R. G. Wamai et al., 2015). The WHO Bi-Regional Consultation on the Status of Leishmaniasis Control and Surveillance in East Africa identified critical areas of weakness of VL programs in Kenya: a weak surveillance and reporting system, and a lack of active case detection (WHO, 2017a). NTD programs in Kenya are young, and much work still needs to be done to develop them.

Current Clinical Data Collection Systems

An electronic health record is a digital repository of patient data, where information securely exchanged and accessed by authorized users (Odekunle, Odekunle, & Shankar, 2017). A literature review revealed that electronic health record systems had not been widely implemented in sub-Saharan Africa (Odekunle et al., 2017). They identified that high cost of procurement, high cost of maintenance, lack of financial resources, inadequate electricity supply, poor internet connectivity, and limited primary user's computer skills were factors that hindered widespread adoption of electronic health systems (Odekunle et al., 2017).

The Kenyan government has developed several health information technology projects: District Health Information Software Version 2 (DHIS2) for collecting national health care indicators, KenyaEMR and International Quality Care Health Management Information Systems for managing 600 HIV clinics throughout the nation, and most recently, the Afya Electronic Health Management System (AfyaEHMS) to function as a county electronic health record (Muinga et al., 2018). Currently, AfhyaEHMS was piloted in Machakos County and later rolled out in Baringo County in four health centers and one dispensary (Muinga et al., 2018). There was a plan to continue rollout into Kilifi, Bungoma, Garissa, and Turkana to over 70 health centers (Muinga et al., 2018). However, this has been scaled back to include only primary care facilities rather than a mix of health centers and county hospitals (Muinga et al., 2018). This allowed developers to focus their efforts on smaller modules (Muinga et al., 2018). Despite the development of data collection software and their implementation at several health care facilities, these softwares have not been implemented on a national scale, preventing it from being used for VL data collection. **<u>Also, these clinical data collection systems do not collect entomological, demographic, environmental and ecological determinants that contribute to VL case patterns.</u>**

Currently, VL data collection comprises of paper-based methods: Ministry of Health-designed Leishmaniasis Case Investigation Form and Leishmaniasis Reporting Form for clinicians and Ministry of Health Form 515 for community health extension workers. The WHO DHIS2 tool for capturing VL data but is only being piloted in Kenya. In summary, VL data is manually collected and is not synced electronically between the clinician, Ministry of Health and non-governmental organizations like the WHO. In order to facilitate data collection and sharing, an electronic system must be designed that can be quickly filled out by users and received by the Ministries of Health and the WHO. **<u>These paper-based forms do not collect entomological, environmental and ecological data related to VL case patterns</u>**. These paper-based methods do not collect relevant demographic information besides the location of VL cases.

Current Geographic Information Data Collection Systems

Epidemiological studies to understand the environmental factors associated with the distribution of VL in Kenya is lacking. This, coupled with the benefits of mobile technology in public health, calls for an innovative method to collect this data. The WHO defines mHealth as a subarea of electronic health that provides health services and information through mobile technologies, like phones. The potential of using mobile technologies within the public health realm is just being realized. With over five billion mobile phone users in the world (Kallander et al., 2013), and the continent of Africa experiencing a revolution in communications with the roll-out of affordable wireless services to rural populations, the potential of mHealth are far reaching into never before accessible communities. Mobile phones attempt to address the gaps in field data collection. Several mHealth pilots have been conducted in low-income settings. None, however, have achieved large scale use in rural Africa. For this to happen, the systems would need to require minimal or no additions to infrastructure, inexpensive, locally maintained and comfortable for front-line healthcare workers to use when switching from paper-based solutions. Ideally, these mHealth systems would fit directly into existing workflows and be easily modified to suit local conditions (Asiimwe et al., 2011). For example, community healthcare workers in Malawi used mobile phones to communicate with health facilities (Lemay, Sullivan, Jumbe, & Perry, 2012). The study determined that those community health workers that had mobile phones called to report essential health data to facility-based supervisors within 9 minutes, while their counterparts without phones averaged 24 hours due to public transportation issues in trying to visit the facility (Lemay et al., 2012).

Previous studies used geographic information to predict the distribution of disease caused by VL vectors, which proved useful for prevention and forecasting outbreaks (Abdullah, Dewan, Shogib, Rahman, & Hossain, 2017; Alvar et al., 2012; Chamaille et al., 2010; Colacicco-Mayhugh, Masuoka, & Grieco, 2010; Cross, Newcomb, & Tucker, 1996; Ebi & Nealon, 2016; Gebre-Michael et al., 2004; Gonzalez et al., 2010; Mullins et al., 2011; Peterson, Pereira, & Neves, 2004). Gebre-Michael *et al*. used a geographic information system to predict the distribution of vectors associated with VL based on survey data indicating the absence or presence of two VL parasites across Ethiopia, Kenya, and Somalia. They predicted that each parasite favored certain seasons, midday land temperatures and vegetation (Gebre-Michael et al., 2004). Cross *et al.* developed a computer model using the occurrence of a parasite (dependent variable) and weather data (independent variables). Their results showed that sand-fly activity was at its highest occurred in the Spring and Summer months. Abdullah *et al*. demonstrated that precipitation in warm weather, land surface temperature, and the normalized difference water index were the most critical environmental factors impacting the occurrence of VL in Bangladesh (Abdullah et al., 2017). Combining a Geographic Information System with mHealth technology will enable an unprecedented investigation into entomological, demographic, environmental and ecological determinants contributing to disease case patterns.

Why focus on Baringo County?

Baring County is one of the most rural counties in Kenya and is endemic for VL (World Food Programme, 2015). It is home to over 550,000 people, according to the latest census (World Food Programme, 2015). This population comprises of dominant ethnic groups including Pokots, Tugens, Endorois, and Ilchamus (World Food Programme, 2015). Over 52% of the population lives in absolute poverty (World Food Programme, 2015), compared to the national average of 45%. Baringo has four livelihood zones: mixed farming (43% of the population), pastoral (31%), agropastoral (22%) and irrigated cropping (4%) (World Food Programme, 2015). Close to 90% of the population depends on pastoral livestock production for their livelihood (World Food Programme, 2015). Baringo County has only one VL treatment center: Kimalel Health Center (R. Wamai, 2018). This is an ideal location for this study since all positive VL cases identified in the region are brought here for treatment. **This centralization of cases renders this location ideal for a pilot study utilizing an electronic Medical Record System to collect clinical and demographic data.**

Baringo County is diverse in its geography, making it a unique location to collect entomological, demographic, environmental and ecological data related to VL case patterns. The county varies in altitude from 700-3,000 meters above sea level (World Food Programme, 2015). The climate varies from humid in highlands to arid in lowlands (World Food Programme, 2015). Overall, Baringo is classified as an arid region, receiving 350-600 mm of annual rainfall in the lowlands and 1,000-1,500 mm in the highlands (World Food Programme, 2015). Long rains occur between March and May, while shorter rains occur between August and November; although more unreliable in the arid areas (World Food Programme, 2015). Baringo County is susceptible to both natural and man-made hazards including drought, floods, forest fires, bush fires, disease, landslides and human conflict between ethnic groups (World Food Programme, 2015). Extreme weather, including episodes of torrential rain, prolonged dry spells, and heat waves, are becoming unpredictable, severe and frequent (World Food Programme, 2015). **The different geographical factors within Baringo County makes it a unique area to study the entomology of sand flies and demographic, environmental and ecological factors influencing VL case patterns.**

Summary of Project Significance

Despite efforts by the Kenyan Government to develop clinical data collection software and their implementation at several health care facilities, these softwares have not been phased in on a national scale, which prevents its potential use for VL data collection. Also, these clinical data collection systems do not collect entomological, demographic, environmental and ecological determinants that contribute to VL case patterns. Instead, they collect clinical data related to cases. VL data is currently manually collected and is not synced electronically between the clinician, Ministry of Health and non-governmental organizations like the WHO. These paper-based forms also do not collect entomological, environmental and ecological data related to VL case patterns besides the location of VL cases. Epidemiological studies to understand the environmental factors associated with the distribution of VL in Kenya is lacking. This study is unique in that it is the first of its kind in Baringo County, combining an electronic Medical Record System and Geographic Information System on iPads to collect entomological, demographic, environmental and ecological data related to VL case patterns at the only VL treatment facility: Kimalel Health Center. In the long-term, we hope that this data collection enables an unprecedented overview of VL prevalence in Baringo County, leading to targeted intervention strategies and facilitated information sharing between Ministry of Health and non-governmental organizations like the WHO.

III. Research Design

Specific Aim 1. To conduct a pilot study of an electronic Medical Record System and Geographic Information System on iPads at Kimalel Health Center

Objective 1a: Baseline Assessment of Facility

Methods and Rationale

Using checklists, we will first conduct a baseline assessment of the Kimalel Health Center to determine internet access, electricity availability and personnel availability to develop an understanding of current gaps in capacity for the installment of an iPad program. It is anticipated that the initial baseline screening will reveal a lack of infrastructure required for the implementation of an iPad system (constant electricity supply, outlets for charging iPads).

Anticipated Results

If the checklists reveal a lack of constant electricity or outlets for charging iPads, we will work alongside a company like Strauss Energy to install solar panels. Services from this organization include visiting the site, assessing energy requirements, delivering and installing the appropriate solar panels. If the checklist reveals that solar panels are not needed, no further steps will be taken.

Objective 1b: Use of electronic Medical Record System to track VL cases

Methods and Rationale

It is possible to download an innovative mobile application that improves the monitoring and evaluation of health services in health centers on tablets, like iPads. MicroClinic Technologies created ZiDi as an innovative cloud-based enterprise health management system designed for large scale use in the public and private sectors (Mendoza, Okoko, Konopka, & Jonas, 2013). After a successful 12-month pilot in Kisumu County in 2012, ZiDi is the only E-health Solution approved by the Kenyan Ministry of Health, endorsed by the Kenyan Medical Supply Authority as well as Microsoft and the World Bank (Mendoza et al., 2013). The platform allows health workers to record and access patient data at any time with web-enabled devices, preferably on tablets like iPads (Mendoza et al., 2013). Regardless of connectivity, however, a health worker is able t enter a patient's demographic information, health parameters, symptoms, tests, diagnoses, and prescribed drugs even when the iPad is offline (Mendoza et al., 2013). After the iPad is reconnected to the internet, ZiDi automatically uploads data to the cloud (Mendoza et al., 2013). Data stored in ZiDi is easily retrieved and exported as an Excel file for offline analytics (Mendoza et al., 2013). Also, ZiDi is interoperable with existing information systems including the DHIS2 (Mendoza et al., 2013). Consumption data of essential medicines and supplies are exportable into the Kenyan Medical Supplies Authority's logistics management information systems (Mendoza et al., 2013).

ZiDi software will be downloaded on iPads. Each patient that tests positive for VL at the Kimalel Health Center will have their information collected on the ZiDi software. A trained health worker will be responsible for inputting VL data onto the software. Potential problems include a few VL cases reported to the Kimalel Health Center. This would result in a low number of excursions to residences to collect geographic information, limiting the scope of this study. To prevent this from occurring, we will reach out to organizations conducting VL research in Baringo County to encourage transportation of VL positive cases to this health center. It is likely that there will be technical issues related to the ZiDi software. If this is the case, the ZiDi company will be contacted to troubleshoot any technical difficulties we have.

Anticipated Results

The information yielded from this section of the study will indicate the prevalence of VL cases in Baringo County. While it was hypothesized that Baringo County is currently endemic for VL (defined by one or more positive cases of VL), it is possible that clinical data collected at Kimalel Health Center will indicate otherwise. If VL is not endemic in Baringo County, this hypothesis will be rejected. Regardless of the prevalence outcome, the newly generated information will add to the current understanding of VL distribution in Baringo County.

Objective 1c: Tracking of positive VL cases using Geographic Information Systems

Methods and Rationale

After positive VL cases have been identified at the Kimalel Health Center and their clinical data has been input into the ZiDi software, the healthcare worker will travel to their residence via motorcycle to collect data on a Geographic Information System. Specifically, a GIS program titled WOLF-GIS Apex is recommended for public health research since a consistent WiFi connection is not required ("WOLF-GIS APEX,"). Compatible with iPads, this software allows users to create, collaborate and share maps ("WOLF-GIS APEX,"). Additionally, users can capture time-stamped data, notes and images of specific geo-locations ("WOLF-GIS APEX,"). Information uploaded by other users is also able to be synced to personal maps ("WOLF-GIS APEX,"). Users are also able to measure distances, draw and customize, points, lines, and polygons, and forecast weather ("WOLF-GIS APEX,"). Using this software, the healthcare worker is able to record entomological evidence (density and distribution of infected sand flies and termite mounds), human socio-demographic data (settlements, household income, occupation, education, family size, livestock migration routes, location of asymptomatic and symptomatic VL cases) and the upload of multimedia for an unprecedented overview of VL in Baringo County.

It is likely that there will be technical issues related to GIS software. If this is the case, the GIS company will be contacted to troubleshoot any technical difficulties we have. It is also possible that the healthcare worker will be unable to travel to the identified residence of the VL positive case. If this occurs topographic, geographic, satellite and terrain maps available as base layers on the online GIS system will be used to identify possible entomological, demographic, environmental and factors that may be contributing to VL case prevalence. While these images do not allow identification of entomological factors (density and distribution of infected sand flies and termite mounds), human demographic data (settlements, livestock migration routes, location of asymptomatic and symptomatic VL cases), other environmental factors may be identified like elevation, vegetation, and water features.

Anticipated Results

Prevalence of VL cases will be linked to entomological, demographic, ecological and environmental data. For example, Abdullah *et al*. demonstrated that precipitation in warm weather, land surface temperature, and the normalized difference water index were the most critical environmental factors impacting the occurrence of VL in Bangladesh (Abdullah et al., 2017). No matter which factors turn out to be positively correlated to VL cases, this generated data will add to the understanding of VL prevalence in Baringo County. It is possible that these results show that none of these factors relate to VL case patterns. In this case, the hypothesis will be rejected.

Specific Aim 2. Analysis of Collected Data to Generate Predictive Hot Spot Maps

Methods and Rationale

Using GIS on iPads, this project seeks to obtain the entomological evidence (density and distribution of infected sand flies and termite mounds), human socio-demographic data (settlements, household income, occupation, education, family size, livestock migration routes, location of asymptomatic and symptomatic VL cases) and the upload of multimedia for an unprecedented overview of VL in Baringo County. This data will be correlated with environmental variables including rainfall, vegetation, soil type, temperature, and humidity to map disease hot spots.

VL transmission involves complex relationships between entomological, demographic, environmental and ecological factors (Pigott et al., 2014). These complex relationships require a modeling approach that can account for highly non-linear effects of covariates on the probability of disease presence, which may be done using the Boosted Regression Tree modeling framework (BRT) (Pigott et al., 2014). This method was previously used to generate global distribution maps of leishmaniases (Pigott et al., 2014). Our study will use the same BRT method to generate predicted maps of VL cases in Baringo County.

Anticipated Results

Although BRT models are complex, results may be summarized in ways that give powerful ecological insight (Elith, Leathwick, & Hastie, 2008). Their predictive capability is superior to most traditional modeling methods (Elith et al., 2008). BRT differs from traditional statistical methods by combining the strengths of two algorithms: regression trees (models that relate a response to their predictors by recursive binary splits) and boosting (an adaptive method for combining many simple models to give improved predictive performance) (Elith et al., 2008). The final map generated will indicate where VL is likely endemic in Baringo County. This map may be used to develop future intervention strategies. If this map indicates that there are no hot spots for VL in Baringo County, it is possible that there are no demographic, environmental, ecological or entomological factors related to VL prevalence. If this is the case, the hypothesis that there are correlated factors will be rejected.

IV. Budget and Budget Justification

PROPOSED BUDGET

Budget Item	**Phase I** *(0-1 month)*	**Phase II** *(1-2 months)*	**Phase III** *(2-26 months)*	**Total**
PI/co-PI Salary	$3,000	$3,000	$24,000	**$30,500**
Graduate Research Assistant	$0	$0	$46,500	**$46,500**
Undergraduate Student	$0	$0	$0	**$0**
Healthcare worker	$0	$0	$28,000	**$28,000**
Total Salaries	**$3,000**	**$3,000**	**$98,500**	**$105,000**
Fringe Benefits	$1,000	$1,000	$10,000	**$12,000**
Supplies & Services	$3,000	$5,000	$5,000	**$13,000**
Travel	$0	$3,000	$8,000	**$11,000**
Other costs	$0	$0	$0	**$0**
Total Direct Costs	**$7,000**	**$12,000**	**$121,500**	**$36,000**
Indirect Costs (Overhead)	$2,000	$3,000	$32,000	$37,000
Indirect Cost Rate (%)	26%	26%	26%	
Total	**$9,000**	**$15,000**	**$153,500**	**$177,500**

BUDGET JUSTIFICATION

Timeline of Project

Phase I (i.e., the initial set-up of this project) includes procuring iPads, downloading relevant software and training a healthcare worker on how to use all software. Phase II includes the baseline assessment of the Kimalel Health Center, which may include the installment of solar panels. Phase III includes a two-year long process of implementing Objectives 1b (use of electronic Medical Record System to track VL cases) and Objective 1c (tracking of positive VL cases using Geographic Information Systems) completed by the Healthcare worker. This phase also includes ongoing data analysis of collected data by the graduate student.

Senior Personnel & Fringe Benefits

Based on a 9-month salary estimate of $102,000, and noting that Phase I and II each comprise of one month periods, and the PI will spend 25% of his time on this project during this time, the PI is requesting a salary of $3,000 for both phases with the addition of a 27.5% fringe benefit rate totaling $4,000. The PI will spend 10% of his time on Phase III; therefore she is requesting a salary of $24,000 with the addition of a 27.5% fringe benefit rate totaling $30,500.

Other & Fringe Benefits

Support for one Graduate Research Assistant is requested to carry out data analysis under Objectives 1b and 1c in Specific Aim 1, and all of Specific Aim 2. The annual stipend is $31,000 per academic year (9 months), plus a half for summer, both with a 7.65% fringe benefit rate. The student will be spending 50% of their time on this project. Therefore, the PI is requesting an annual salary of $25,000 which totals to $50,000 for two years. The healthcare worker will be active during Phase III, where he or she will be spending 100% of their time on this project achieving Objectives 1b and 1c in Specific Aim 1. Based on the estimate of $14,000 annual salary for a Research Assistant at the University of Nairobi, the PI requests a total of $28,000 plus a fringe benefit of 7.65%, totaling $30,000 for two years.

Supplies and Services

The PI requests $1,000 for the purchase of two iPads (9.7″ Retina display, A10 Fusion chip, Touch ID, Up to 128GB storage, Support for Apple Pencil). One iPad will remain at Kimalel Health Center while the healthcare worker will use the other during travel. The PI requests $1,000 for the purchasing of ZiDi software and upkeep, as well as $1,000 for a two-year subscription of WOLF-GIS Apex. Therefore, the PI requests a total of $3,000 for Phase I. $5,000 is requested for the installment of solar panels at Kimalel Health Center, which occurs during Phase II. Lastly, $5,000 is requested for the purchase of a motorcycle and accompanied gas cost for the healthcare worker to travel to VL patient residence sites for data collection.

Travel

The PI requests $3,000 for airfare to and from Kenya during Phase II and III, for the survey of Kimalel Health Center, installment of solar panels and initial oversight of the Phase III data collection. An additional $5,000 is requested for transportation and accommodation during this time. In total, the PI will remain in Kenya for months 2-3 to oversee Phases II and III. The PI also requests $3,000 for travel and accommodation fees associated with attending the American Society of Tropical Medicine and Hygiene 2020 conference at the Metro Toronto Convention Centre in Toronto, Ontario Canada.

Indirect Costs

The modified indirect cost rate at Northeastern University for research studies conducted off-site is 26%. The specific cost associated with each Phase differs based on the totaled direct costs. This accounts for rent and other services provided by the university.

V. References

Abdullah, A. Y. M., Dewan, A., Shogib, M. R. I., Rahman, M. M., & Hossain, M. F. (2017). Environmental factors associated with the distribution of visceral leishmaniasis in endemic areas of Bangladesh: modeling the ecological niche. In *Trop Med Health* (Vol. 45).

Alvar, J., Velez, I. D., Bern, C., Herrero, M., Desjeux, P., Cano, J., . . . den Boer, M. (2012). Leishmaniasis worldwide and global estimates of its incidence. *PLoS One, 7*(5), e35671. doi:10.1371/journal.pone.0035671

Asiimwe, C., Gelvin, D., Lee, E., Ben Amor, Y., Quinto, E., Katureebe, C., . . . Berg, M. (2011). Use of an innovative, affordable, and open-source short message service-based tool to monitor malaria in remote areas of Uganda. *Am J Trop Med Hyg, 85*(1), 26-33. doi:10.4269/ajtmh.2011.10-0528

Chamaille, L., Tran, A., Meunier, A., Bourdoiseau, G., Ready, P., & Dedet, J. P. (2010). Environmental risk mapping of canine leishmaniasis in France. *Parasit Vectors, 3*, 31. doi:10.1186/1756-3305-3-31

Colacicco-Mayhugh, M. G., Masuoka, P. M., & Grieco, J. P. (2010). Ecological niche model of Phlebotomus alexandri and P. papatasi (Diptera: Psychodidae) in the Middle East. *Int J Health Geogr, 9*, 2. doi:10.1186/1476-072x-9-2

Cross, E. R., Newcomb, W. W., & Tucker, C. J. (1996). Use of weather data and remote sensing to predict the geographic and seasonal distribution of Phlebotomus papatasi in southwest Asia. *Am J Trop Med Hyg, 54*(5), 530-536.

Ebi, K. L., & Nealon, J. (2016). Dengue in a changing climate. *Environ Res, 151*, 115-123. doi:10.1016/j.envres.2016.07.026

Eduard E. Zijlstra, J. A. (2012). *The Post Kala-azar Dermal Leishmaniasis (PKDL) Atlas A Manual for Health Workers*. Retrieved from Spain:

Elith, J., Leathwick, J. R., & Hastie, T. (2008). A working guide to boosted regression trees. *J Anim Ecol, 77*(4), 802-813. doi:10.1111/j.1365-2656.2008.01390.x

Fendall, N. R. (1961). The spread of kala-azar in Kenya. *East Afr Med J, 38*, 417-419.

Gebre-Michael, T., Malone, J. B., Balkew, M., Ali, A., Berhe, N., Hailu, A., & Herzi, A. A. (2004). Mapping the potential distribution of Phlebotomus martini and P. orientalis (Diptera: Psychodidae), vectors of kala-azar in East Africa by use of geographic information systems. *Acta Trop, 90*(1), 73-86.

Gonzalez, C., Wang, O., Strutz, S. E., Gonzalez-Salazar, C., Sanchez-Cordero, V., & Sarkar, S. (2010). Climate change and risk of leishmaniasis in north america: predictions from ecological niche models of vector and reservoir species. *PLoS Negl Trop Dis, 4*(1), e585. doi:10.1371/journal.pntd.0000585

Ho, M., Siongok, T. K., Lyerly, W. H., & Smith, D. H. (1982). Prevalence and disease spectrum in a new focus of visceral leishmaniasis in Kenya. *Trans R Soc Trop Med Hyg, 76*(6), 741-746.

Kallander, K., Tibenderana, J. K., Akpogheneta, O. J., Strachan, D. L., Hill, Z., ten Asbroek, A. H., . . . Meek, S. R. (2013). Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low- and middle-income countries: a review. *J Med Internet Res, 15*(1), e17. doi:10.2196/jmir.2130

Le Rutte, E. A., Coffeng, L. E., Bontje, D. M., Hasker, E. C., Postigo, J. A., Argaw, D., . . . De Vlas, S. J. (2016). Feasibility of eliminating visceral leishmaniasis from the Indian subcontinent: explorations with a set of deterministic age-structured transmission models. *Parasit Vectors, 9*, 24. doi:10.1186/s13071-016-1292-0

Lemay, N. V., Sullivan, T., Jumbe, B., & Perry, C. P. (2012). Reaching remote health workers in Malawi: baseline assessment of a pilot mHealth intervention. *J Health Commun, 17 Suppl 1*, 105-117. doi:10.1080/10810730.2011.649106

Liese, B. H., Houghton, N., & Teplitskaya, L. (2014). Development assistance for neglected tropical diseases: progress since 2009. *International Health, 4*(3), 162-171.

London Declaration on Neglected Tropical Diseases. (2019). *London Declaration on Neglected Tropical Diseases | Uniting to Combat NTDs*. Retrieved from

Mendoza, G., Okoko, L., Konopka, S., & Jonas, E. (2013). *mHealth Compendium*. Retrieved from Arlington, VA:

Ministry of Public Health and Sanitation. (2010). *National Strategy for the Prevention and Control of Leishmaniasis (Kala azar) Infection in Kenya*. Ministry of Public Health and Sanitation

Muinga, N., Magare, S., Monda, J., Kamau, O., Houston, S., Fraser, H., . . . Paton, C. (2018). Implementing an Open Source Electronic Health Record System in Kenyan Health Care Facilities: Case Study. *JMIR Med Inform, 6*(2), e22. doi:10.2196/medinform.8403

Mullins, J., Lukhnova, L., Aikimbayev, A., Pazilov, Y., Van Ert, M., & Blackburn, J. K. (2011). Ecological niche modelling of the Bacillus anthracis A1.a sub-lineage in Kazakhstan. *BMC Ecol, 11*, 32. doi:10.1186/1472-6785-11-32

Mutinga, M. J. (1975). Phlebotomus fauna in the cutaneous leishmaniasis focus of Mt. Elgon, Kenya. *East Afr Med J, 52*(6), 340-347.

Ngoka, J. M., & Mutinga, M. J. (1978). Visceral leishmaniasis in Kenya: the onset of an epidemic outbreak in the Machakos District of Kenya. *East Afr Med J, 55*(7), 328-331.

Odekunle, F. F., Odekunle, R. O., & Shankar, S. (2017). Why sub-Saharan Africa lags in electronic health record adoption and possible strategies to increase its adoption in this region. *Int J Health Sci (Qassim), 11*(4), 59-64.

Peterson, A. T., Pereira, R. S., & Neves, V. F. (2004). Using epidemiological survey data to infer geographic distributions of leishmaniasis vector species. *Rev Soc Bras Med Trop, 37*(1), 10-14.

Pigott, D. M., Bhatt, S., Golding, N., Duda, K. A., Battle, K. E., Brady, O. J., . . . Hay, S. I. (2014). Global distribution maps of the leishmaniases. *Elife, 3*. doi:10.7554/eLife.02851

Tonui, W. K. (2006). Situational analysis of leishmaniases research in Kenya. *Afr J Health Sci, 13*(1-2), 7-21.

United To Combat Neglected Tropical Diseases. (2017). *Reaching a Billion Ending Neglected Tropical Diseases: A gateway to Universal Health Coverage*

Fifth progress report on the London Declaration on NTDs. United To Combat Neglected Tropical Diseases

Wamai, R. (2018). *Summary of population health survey 2018*.

Wamai, R. G., Wangombe, J., Ogembo, J. G., Pollastri, M. P., Nyakundi, H., Ogutu, B., . . . Oduwo, G. (2015). *Prevalence of Visceral Leishmaniasis in East Pokot District Kenya: An Epidemiological and Community Interactions*. 61st Annual meeting of the American Society of Tropical Medicine and Hygiene.

WHO. (2012). *Accelerating Work to Overcome the Global Impact of Neglected Tropical Diseases: A Roadmap for Implementation*. Retrieved from Geneva, Switzerland:

WHO. (2015). *INVESTING TO OVERCOME THE GLOBAL IMPACT OF NEGLECTED TROPICAL DISEASES Third WHO report on neglected tropical diseases*. Retrieved from Geneva, Switzerland:

WHO. (2017a). *WHO Bi-Regional Consultation on the Status of Leishmaniasis Control and Surveillance in East Africa*. Geneva, Switzerland

WHO. (2017b, 2017-08-03 14:35:03). WHO responds to visceral leishmaniasis outbreak in Kenya. *WHO*.

WHO. (2018, 2018-11-27 16:39:54). Epidemiological situation. *WHO*.

Wijers, D. J., & Minter, D. M. (1966). Studies on the vector of kala-azar in Kenya. V. The outbreak in Meru district. *Ann Trop Med Parasitol, 60*(1), 11-21.

WOLF-GIS APEX.

World Food Programme. (2015). *Baringo County: Capacity Gaps and Needs Assessment for Food Security Safety Nets and Emergency Preparedness and Response*. Retrieved from