Developing a critical mass of Data Scientists and Mathematical Modelers to Support NMCPs

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May 25, 2023
IDM Symposium, Seattle
Pictures taken during bi-weekly team presentations

20+ Members
A Gender – Balanced Team

At least one year to acquire research skills

Research | Ethics | Malaria Transmission | Control & Elimination Strategies | Presentations | Grant Applications
MosquitoDB

Mosquito Database Management System

www.mosquitodb.io

App in Google Store

Vector borne diseases

Immature

Adults

Laboratory analysis

Insecticide Resistance
Vector Control Optimization Model (VCOM)

Abstract

Background

Despite great achievements by insecticide-treated nets (ITNs) and indoor residual spraying (IRS) in reducing malaria transmission, it is unlikely these tools will be sufficient to eliminate malaria transmission on their own in many settings today. Fortunately, field experiments indicate that there are many promising vector control interventions that can be used to complement ITNs and/or IRS by targeting a wide range of biological and environmental mosquito resources. The majority of these experiments were performed to test a single vector control intervention in isolation; however, there is growing evidence and consensus that effective vector control with the goal of malaria elimination will require a combination of interventions.

Method and findings

We have developed a model of mosquito population dynamics to describe the mosquito life and breeding cycles and to optimize the impact of vector control interventions combinations at suppressing mosquito populations. The model simulations were performed for the main three malaria vectors in sub-Saharan Africa: Anopheles gambiae s.s., A. arabiensis and A. funestus. We considered areas having low, moderate and high malaria transmission, corresponding to entomological inoculation rates of 10, 50 and 100 infectious bites per person per year, respectively. In all settings, we considered baseline (ITNs coverage of 50% or 80% in addition to a range of other vector control tools to interrupt malaria transmission. The model was used to simulate the impact of different interventions, with the aim of exploring various combinations, and determining the best vector control strategy for malaria elimination.
Spatial repellents: The current roadmap to global recommendation of spatial repellents for public health use

Application of Vector Control Optimization Model (VCOM’s) on eave ribbons for malaria vectors control in Kilombero Valley, Tanzania

**Background**
- 2000 - 2015, malaria incidence decreased by 40% in SSA
- ITNs & IRS being the main drivers
- Still residual transmissions exist
- Impact of combining ITNs and eave ribbons was modelled
- Kilombero Valley – study area

**Objectives**
1. Assessing the impact of Eave ribbon + ITNs on transmission mediated by *An. funestus* & *An. arabiensis*.
2. Assessing the impact of Eave ribbon + ITNs on the combined transmission by *An. funestus* & *An. arabiensis*.

**Methodology**
- VCOMs was extended and updated
- Parameters extraction
- Simulating the impact of eave ribbons + ITNs on *An. funestus* & *An. arabiensis*
- Simulating the impact of eave ribbons + ITNs on the combined transmission

**Results**

**A.** The impact of Eave ribbon + ITNs on *An. arabiensis*.
- High coverage of eave ribbon (~ 60%) is needed

**B.** The impact of Eave ribbon + ITNs on *An. funestus*.
- Small coverage is needed (~ 20%)

**C.** The impact of Eave ribbon + ITNs on the combined transmission.
- High coverage is needed (60%)

**Presentation:** 11:00-1230

Elliot Bay
Investigating the impact of larviciding as a supplementary malaria vector control tool in rural South Eastern Tanzania: Simulation Study

INTRODUCTION

• The protective effect of insecticide-treated nets (ITNs) and indoor residual spraying (IRS) is limited by the fact that they target mosquitoes solely indoors
• Models can provide initial insights into combinations of interventions by exploring their synergies in a quantitative way, especially in the absence of empirical evidence

RESULTS

• The model is extended to see the impact of seasonality in the vector control:
  • Temperature
  • Rainfall

METHODOLOGY

• Project took place in Rufiji district, Tanzania
• 2 phases included: Baseline data and Intervention data used to estimate parameters
• Mathematical Model used to access the impact of larviciding

Ms. Gloria Salome G. Shirima
Research Scientist
BSc: Actuarial Sciences (UDSM)
MSc: Mathematical Sciences (AIMS, Rwanda)
PhD Student

Presentation: 145-315
Elliot Bay
Malaria Micro-stratification Dynamic Tool

- Under development
- Stratification - transmission
  - Low
  - Medium
  - High

- Stratification -
  - National
  - Sub-national level
  - Epidemiological indicators
  - Entomological indicators
  - Flexibility in data sources
  - Environmental factors
  - Other factors
  - Ability to re-define cut-off point
In the last decade, the malaria burden has substantially decreased globally. However, in recent years the decline in malaria burden has stagnated. Intensified efforts are needed, especially in high burden countries in Sub-Saharan Africa (Tanzania). The achievement of the past years are challenged by insufficient coverage rates in all interventions. Due to limited resources, it is important to define appropriate mixes of interventions according to different (Councils) strata. Targeted intervention at sub-national level in order to prioritize and efficiently allocate resources.

Motivation

Overall distribution of Councils by risk strata

Study Objectives

1. To predict the impact of the intervention as included in NMSP 2021-2025
2. To determine the most impactful and the most cost-effective intervention allocation.
3. To determine the appropriate mixes of interventions for meeting specific expected targets.
4. To suggest the alternative interventions which are most impactful and most cost-effective.

OpenMalaria Simulation platform

Nicholaus Mziray
Research Scientist
BSc: (SUA)
MSc: (AIMS)
PhD Student
PhD Scholarship (Swiss TPH & IHI)
A Dynamic Malaria Stratification R shiny tool

MOTIVATION

Malaria risk stratification can be utilised to guide intervention planning and resource allocation in malaria control and elimination initiatives. The current stratification process only uses epidemiological indicators to stratify risk. This project aims at automating and expanding the current process by creating a tool that includes entomological indicators. Creating a tool that allows policymakers and researchers to visualise malaria risk is essential to identify malaria high-risk locations in order to take appropriate action.

KEY INDICATORS

Epidemiological
- Test Positivity Rate
- Antenatal Care test positivity rate
- School Parasitological Malaria Survey prevalence rates
- Malaria Case Incidence Rates

Entomological
- Human biting rate
- Mosquito density
- Sporozoite rate
- Entomological inoculation rate

Miss Asiya Mbarawa
Research Officer

BSc: Computer Systems engineering (University of Sheffield, UK)
MSc: Data Science (Kings College London, UK) - Ongoing

Employment Status: March 2021
Support: 100%
Modelling to optimize malaria vector control at low mosquito population densities

Motivation

- Mosquito populations seem to be density-dependence, meaning per capita growth rate is fastest when density is very low. However, an inverse density-dependence known as Allee effect is also possible.
- The occurrence and relative importance of Allee effects in regulating mosquito populations is still unknown.
- Therefore, understanding the extent to which Allee effects impact mosquito populations is critical to predicting whether populations pushed close to extinction by interventions such as larvicide application will rebound or die out.

Low density population dynamics

![Graph showing per capita growth rate and population size with density dependence and Allee effect.]

Conroad, et al. (1999)

Study Objectives

Generally, to determine the effectiveness of malaria vector control intervention at low mosquito population densities through the combination of theoretical and statistical modelling approaches. Specifically:

1. To determine the role of density dependence and Allee effect in regulating mosquito population
2. To examine whether density-dependence or Allee effect impacts sustained or short-term intervention in regulating malaria vectors
3. To determine the trade-offs between density-dependence and Allee effect in regulating mosquito population

Mosquito’s life cycle

- Egg, $b_e$
- Early instar, $N_0$
- Late instar, $N_0$
- Pupa, $N_3$
- Adult, $N_A$

Mr. Andrea Kipingu
Research Scientist
PhD Student

BSc: with Education – SUA

MSc: Mathematical Sciences
AIMS – Rwanda

PhD: Infectious Diseases
Ongoing at UoG, UK

PhD scholarship 2020
Presentation: 145-315
Elliot Bay
Improving the Design of Vector Control Trials

University of Glasgow › School of Biodiversity, One Health & Veterinary Medicine

This project is no longer listed on FindAPhD.com and may not be available.

Click here to search FindAPhD.com for PhD studentship opportunities

Dr H Ferguson  📅 No more applications being accepted

Competition Funded PhD Project (Students Worldwide)

Presentation: 11:00- 12:30
Elliot Bay

Victoria Githu
Research Scientist

BSc: Actuarial Sciences
MSc: Mathematical Modelling
UDSM

Co- Team leader
Extending Vector Control Optimization Model (VCOM)

MosquitoDB: an on-going project to support proper data management for diverse entomological studies from various experiments, projects, and study sites.

. A secure app for storing, linking, sharing, and summarizing field and lab mosquito data, collected via paper or electronic forms in standardized formats.

Victor Mero, Msc
Data Scientist and Math Modeller
Co-Team Leader
Epidemiology PhD student (UC Berkeley)

Background

Further Studies

“Mathematical model of the malaria multi-species vectors sharing the same niche to predict the impact of combined vector control interventions for malaria transmission elimination.” – PhD research
**Motivation**

- Existing malaria surveillance systems in Tanzania are challenged with limited capacity to detect malaria cases aberration in traditionally rare occurrences of malaria.
- The systems now have massive multidimensional data (big data) for traditional analysis techniques that are supposed to detect and alert public health officials aren't sensitive and/or specific enough to catch such aberrations. Machine Learning techniques are adept to handling big data and discover hidden insights/patterns.

**Study Objectives**

- To strengthen malaria surveillance system by developing machine learning algorithm for early warning of aberration of malaria cases in low transmission areas to support malaria elimination intervention.

**Interoperability of MosquitoDB and DHIS2**

**Bernard Noel Mussa**

Bsc. Computer Science (UDSM)

MSc. Information and Communication Science and Engineering (NM-AIST)

Employment at IHI:

Research Scientist - Jan 2022

PhD in Data Science Student at University of Dar es Salaam (UDSM)
Assessing shifts in biting patterns of *Anopheles gambiae* and *Anopheles funestus*, the major malaria vectors in Southeastern Tanzania

**INTRODUCTION**

Long-lasting Insecticidal Nets (LLINs), and Indoor Residual Spraying (IRS) have been key vector control strategies in malaria control initiatives in Africa, including Tanzania. Due to long-term LLIN and IRS use, mosquitoes have evolved physiological and behavioral resilience to insecticides. Hence, residual malaria transmission has increased, endangering malaria elimination efforts. This study examines how mosquito-biting behavior changes could affect malaria epidemiology in Tanzania’s South Eastern area.

**METHODOLOGY**

A mosquito electrocuting trap (MET) was used to gather *Anopheles* mosquitoes from November 2019 to September 2020 in the districts of Rufiji, Kilwa, and Kibiti. Samples were collected weekly (18:00 - 06:00) from 22 villages, with three houses per village sampled over three days.

For each house, two METs were employed; one trap was set inside the house and the other was positioned 15 meters away outside the house. Each trap included a volunteer.

**RESULTS**

A total of 3,586 *Anopheles* mosquitoes were collected, 1,912 (53.32%) *Anopheles gambiae*, 1,666 (46.46%) *Anopheles funestus*, 7 (0.2%) *Anopheles coustani*, and 1 (0.03%) *Anopheles pharoensis*.

*Anopheles gambiae* exhibited a greater preference for outdoor biting, at a rate of 0.32 bites per person per hour during 20:00-21:00hr, increasing progressively through the night to reach a peak of 0.48 bites per person per hour during 00:00-01:00hr.
Introduction

- Global Technical Strategy for Malaria 2016–2030 is to ensure universal coverage for all people at risk of malaria using effective vector control with either LLINs or other core prevention tools such as indoor residual spraying.

Main Objective

- Aimed to determine factors related to methods used for malaria and mosquito control at the household level in Tanzania.

Methodology

- A cross-sectional survey involving primary school pupils and random sample of households around the schools was interviewed on malaria prevention, treatment, and control methods.
- We applied a generalized linear model (GLM) for poisson regression
- It models the probability of methods \( y \) available within household for a specific timeframe, assuming that \( y \) occurrences are not affected by the timing of previous occurrences of \( y \). This can be expressed mathematically using the following formula:

\[
P(y) = \frac{e^{-\mu} \mu^t}{y!} \quad \text{where} \quad y = 0, 1, 2, ...
\]
While insecticides-resistance is widely recognized to affect the effectiveness of ITNs, the most fundamental limitations of ITNs are; behaviors of mosquitoes and humans that allow vector populations to survive by feeding outdoors, feeding at times when people are active outside of their nets, and by feeding on animals.

**STUDY OBJECTIVES**

- To assess how national-scale climatic variation impacts the host-seeking behaviours of malaria vectors
- To quantify the influence of geographic climatic variation upon the proportion of human exposure to bites occurring indoors and outdoors
- To characterize common human activities that increase exposure to malaria vectors
- To determine how climate-associated geographic variations in livestock ownership affect the host choice of malaria vectors
- To predict expected changes in mosquito behaviours in response to climate change to guide adaptive intervention strategies

**METHODOLOGY**

- The study has been implemented in a rolling cross-sectional surveillance of malaria mosquito and human behaviours across 25 districts in diverse ecological settings in mainland Tanzania from January 2020 to date.
- Households are sampled for mosquito collections and Human behaviours surveys (Questionnaires, Human activities observations, and FGDs).
- Weather variables included: Temperature, Humidity, and windspeed
- Preliminary analyses are done by R programming and Stata.

Praise John Michael
Research Officer

BSc: Applied Statistics
Mzumbe University

MSC INTEREST: DATA SCIENCE/EPIDEMIOLOGY
Investigating factors associated with vectors densities, composition and biting pattern across different setting of Tanzania to Inform Control Strategies.

- Major Malaria interventions, such as ITNs and IRS, are becoming less effective due to changes in mosquitoes behavior and insecticide resistance.
- In Tanzania's northern, western, and southern regions, where malaria still caused significant child mortality, complimentary approaches are still needed to address the problem.
- This study aims to determine malaria vectors species abundance, and investigate their biting patterns.

Motivation

**Study Objectives**

1. To identify the species composition and relative abundance of malaria vectors in different districts of Tanzania.
2. To investigate the biting behaviors of the identified malaria vector species, including the time and location of their biting activity.
3. To assess the impact of housing conditions, agricultural practices, livestock rearing, and a house structure on Tanzania's distribution and abundance of malaria vector species.

**Biting Patterns, Time and Location**

![Biting Patterns Chart]

**Mosquito Species abundance**

![Mosquito Species Chart]

Selemani Mmbaga
Data Scientist
B.E. Information System and Network Engineering
SJUIT
Malaria is still a significant public health problem in Sub-Saharan Africa, including Tanzania. While surveillance measures have been put in place, forecasting future outbreaks remains a significant challenge, impeding effective interventions. Machine learning techniques can be used to improve outbreak forecasting and target interventions.

**Study Objective**

To use machine learning techniques to create accurate predictive models for malaria positivity rates in Rufiji, which will aid public health experts in developing effective malaria control strategies.

**Methodology**

A study was conducted in Rufiji district in southeastern Tanzania. This study employed epidemiological data and climatic data from January 2016 to October 2021.

**Results**

<table>
<thead>
<tr>
<th>Models</th>
<th>GRU</th>
<th>LSTM</th>
<th>XGBOOST</th>
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<tr>
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<td>1.2</td>
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<tr>
<td>R-square</td>
<td>0.99</td>
<td>0.98</td>
<td>0.97</td>
</tr>
</tbody>
</table>

**Work Architecture**

- Clinical Data
  - Demographics
  - Clinical History
- Lab Data
  - Blood tests
  - Serology
- Social Data
  - Contact History
- Environmental Data
  - Climate
- Machine Learning
  - Model Training
  - Predictive Analysis
- User Interface App.

Tajiri Laizer
Research officer.

BSc: Statistics, UDOM
Areas of interest
Machine learning, Bio statistics & epidemiology
BACKGROUND

- In 2016, Tanzania’s NMCP established Longitudinal National Malaria Vector Entomological Surveillance (MVES) across 62 sentinel sites – now reduced to 32 districts due to budget constraints.
- MVES aimed at periodically assessing malaria vector species composition, their abundance and infectious status, time and place of biting, resting and host preference across different seasonality to guide deployment of appropriate vector control interventions to assess their performance over time.

RESULTS

The findings on species compositions across different malaria transmission strata (i.e., very low, low, medium, and high) by laboratory identified species (i.e., Anopheles gambiae s.s., An. arabiensis, An. funestus). The changes on malaria species over time has helped assess the impact of vector control interventions on different malaria vectors and their dominance over the last 6 years at different districts.
EXTENDING EFFORTS TOWARDS NCDs ELIMINATION

OUR SCOPE

• Capacity building towards grants application for Jakaya Kikwete Cardiac Institute (JKCI)
• Getting involved in research

ONGOING RESEARCHES

• Risk factors and outcome of STEMI patients in Tanzania
• Mapping Clustered and Stratified risk factors and outcome of coronary artery disease in Tanzania

Mapping risk factors and outcome of coronary artery disease in Tanzania: Clustering and Stratification approach

Motivation

➢ Coronary artery disease (CAD) burden is alarming, mainly in Low- and middle-income countries, with 75% of premature deaths and 164 million disability-adjusted life years (DALYs) despite several interventions.
➢ Tanzania has regions with variety of culture and traditions that affects modifiable risk factors differently
➢ Here a retrospective study is conducted to identify and evaluate the distribution of symptoms and risk factors of coronary artery disease in Tanzania to recommend appropriately tailored interventions

General Objective

Overall to Map the clustered and stratified risk factors of Coronary artery disease in Tanzania

Preliminary Results

INHOSPITAL PREVALENCE OF CORONARY ARTERY DISEASE IN TANZANIA

Miss Neema Kailembo
Research Officer

B.A in Economics and Statistics – UDSM
Prospective Student
MSc in Health Economics and Decision Science
University College of London (UCL)
Short course: Spatial Data Visualization

- A One month program

- IHI, UDSM, NMCP - participants

- Enhancing Writing, presentation skills

- Dr. Amelia Bertozzi-Vila

- Collaborators are invited
Strengthening Vector Control Decision Making in Africa - Workshop

A. All Participants and facilitators  
B. Women represented  
C. Handling of certificates
Examples – selected projects
Supporting National Malaria Control Programs
Data Analysis support and training - NMCP
Stakeholder perspectives on a door-to-door intervention to increase community engagement for malaria elimination in Zanzibar

Fatza Abbas 1, 2*, April Monroe 3, Samson Kwiate 4, Mwinyi Khamis 5, Naomi Serbante 6, Abdul-Wahid Al-Matey 7, Fausta Mohamed 8, Fauza Mohamed 1 and Emmanuel Kigadayi 1

Abstract

Background: Malaria remains a major public health problem in sub-Saharan Africa. The 2021 World Health Organization (WHO) World Malaria Report indicates a slowing in the decline of malaria incidence since 2015. Malaria prevalence in Zanzibar has been maintained at less than 1% since 2012. However, from 2018 to 2019, the annual number of reported malaria cases has gradually increased from 4168 to 5295. Community engagement has been emphasized by the WHO for reducing malaria transmission. To better understand the potential for a door-to-door approach for malaria, a three-month pilot programme was carried out in this qualitative study aimed at understanding stakeholder experiences with the pilot programme and considerations for its implementation.

Methods: Through multistage sampling, four shekas (wards) — the lowest administrative structure — were selected by the study team. A door-to-door pilot intervention was conducted. The qualitative study was conducted after the pilot intervention and employed focus group discussions and in-depth interviews. Field notes were written on paper and audiosupplied using digital audio-recorders. Summaries were developed by integrating field notes with reviews of recordings; themes were developed based on the topics identified in a pilot. Responses for each theme were summarized using an iterative process.

Results: Most community members reported high levels of acceptance of door-to-door interventions. Some factors that might affect implementation of door-to-door include low risk perception of the disease, lack of education, poor hygiene and laziness.

Conclusion: The door-to-door intervention was perceived as helpful for promoting community engagement. There are several factors to consider including ensuring that OHAVs are provided with adequate education, regular supervision, and access to essential resources. Community leaders should be fully involved in choosing OHAVs that are acceptable to the community. To ensure sustainability, the government should allocate sufficient resources and improve coordination systems.

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Socio-demographic trends in malaria knowledge and implications for behaviour change interventions in Zanzibar

Faiza Abbas 1, 2*, Emmanuel Kigadayi 3, Fauza Mohamed 3, Mwinyi Khamis 1, John Mibaraka 4, Naomi Serbante 6, Abdul-Wahid Al-Matey 3, April Monroe 3 and Samson Kwiate 4

Abstract

Background: Zanzibar is among the few regions within East Africa that have documented a significant reduction of malaria morbidity and mortality. Despite tremendous gains over the past decade, malaria transmission still persists in Zanzibar. This study aimed at understanding levels of malaria knowledge to provide recommendations that can be used to reinforce and scale-up targeted malaria social and behavioural change interventions.

Methods: A descriptive cross-sectional survey was conducted through an administered questionnaire to 431 households, selected randomly. The interviewers were the household heads or professional representatives of adult residents aged 16 years and older. This study investigated the levels of knowledge about the causes, symptoms, and prevention of malaria in areas with high (≥1.5 per 1000) and low (<1 per 1000) incidence of local malaria cases. The Principal Component Analysis (PCA) was used to compute the composite variable for each category. Descriptive statistics were calculated to understand the proportion of variables of interest between low and high transmission areas. Multinomial logistic regression model was used to compare knowledge on malaria based on key variables.

Results: A total of 441 heads of households were interviewed. Respondents age, education level, and wealth status were significantly associated with variables in level of malaria knowledge. Older age was found to be significantly associated with low level of malaria knowledge (P < 0.001). The majority of study participants who had secondary and higher education levels had good knowledge of malaria (P < 0.001). Participants characterized as middle-income had good knowledge compared to those characterized as low-income (P < 0.001).

Conclusion: The study identified existing gaps in malaria knowledge in low and high transmission areas. Low levels of malaria knowledge were documented among elderly and populations with lower education and income levels. There is a need to extend mobilization, advocacy, and expand channels of communication to reach all community members. The reported gaps in knowledge are important to consider when designing strategies to engage communities in malaria elimination in Zanzibar. Tailored social and behavioural change interventions aiming to increase malaria knowledge could enhance the uptake of malaria prevention services in the community.

Keywords: Knowledge on malaria, Local malaria transmission, Incidence, Zanzibar. Tailored SBC Intervention

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Impact of IRS withdrawal: Should Tanzania withdrawal its IRS program?

Partners involvement

Lead author: NMCP Head of Vector Control Unit
Longitudinal National Malaria Vector Entomological Surveillance (MVES) (2017-2022)
Acknowledgements

Team members

NMCPs

Local & International Collaborators