PI: **Ernst, Kacey C**	Title: Identifying community-based solutions that improve insecticide-treated net (ITN)	
Received: 06/22/2011	FOA: PA10-070	Council: 01/2012
Competition ID: ADOBE-FORMS-B1	FOA Title: ACADEMIC RESEARCH ENHANCEMENT AWARD (PARENT R15)	
1 R15 AI100118-01	Dual:	Accession Number: 3404710
IPF: 490201	Organization: UNIVERSITY OF ARIZONA	
Former Number:	Department: College of Public Health	
IRG/SRG: ZRG1 PSE-B (90)A	AIDS: N	Expedited: N
Subtotal Direct Costs (excludes consortium F&A) Year 1: 299,846	Animals: N Humans: Y Clinical Trial: N Current HS Code: 30 HESC: N	New Investigator: N Early Stage Investigator: N
Senior/Key Personnel:	*Organization:*	*Role Category:*
Kacey Ernst Ph.D.	Arizona Board of Regents, The University of Arizona	PD/PI
Stephen Munga	Kenyan Medical Research Institute	Consultant
Mary Hayden	National Center for Atmospheric Research	Consultant

OMB Number: 4040-0001
Expiration Date: 06/30/2011

APPLICATION FOR FEDERAL ASSISTANCE
SF 424 (R&R)

3. DATE RECEIVED BY STATE:
State Application Identifier:

1. * TYPE OF SUBMISSION
☐ Pre-application ☒ Application ☐ Changed/Corrected Application

4. a. Federal Identifier:
b. Agency Routing Identifier:

2. DATE SUBMITTED:
Applicant Identifier:

5. APPLICANT INFORMATION
*** Organizational DUNS:** 806345617

* Legal Name: Arizona Board of Regents, The University of Arizona
Department:
Division:
* Street1: PO Box 3308
Street2:
* City: Tucson
County / Parish:
* State: AZ: Arizona
Province:
* Country: USA: UNITED STATES
* ZIP / Postal Code: 85722-3308

Person to be contacted on matters involving this application
Prefix:
* First Name: Sherry
Middle Name: L.
* Last Name: Esham
Suffix:
* Phone Number: (520) 626-6000
Fax Number: (520) 626-4137
Email: sponsor@email.arizona.edu

6. * EMPLOYER IDENTIFICATION *(EIN) or (TIN):* 1742652689A1

7. * TYPE OF APPLICANT: H: Public/State Controlled Institution of Higher Education
Other (Specify):
Small Business Organization Type ☐ Women Owned ☐ Socially and Economically Disadvantaged

8. * TYPE OF APPLICATION:
☒ New ☐ Resubmission
☐ Renewal ☐ Continuation ☐ Revision

If Revision, mark appropriate box(es).
☐ A. Increase Award ☐ B. Decrease Award ☐ C. Increase Duration ☐ D. Decrease Duration
☐ E. Other (specify):

* Is this application being submitted to other agencies? Yes ☐ No ☒ What other Agencies?

9. * NAME OF FEDERAL AGENCY: National Institutes of Health

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:
TITLE:

11. * DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:
Identifying community-based solutions that improve insecticide-treated net (ITN) use: A mixed-methods approach

12. PROPOSED PROJECT:
* Start Date: 04/01/2012
* Ending Date: 03/31/2015

*** 13. CONGRESSIONAL DISTRICT OF APPLICANT:** AZ-007

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION
Prefix:
* First Name: Kacey
Middle Name: C.
* Last Name: Ernst
Suffix: Ph.D.
Position/Title: Assistant Professor, Public Health
* Organization Name: Arizona Board of Regents, The University of Arizona
Department: College of Public Health
Division: Epidemiology and Biostatistics
* Street1: 1295 N. Martin Avenue
Street2: PO Box 245163
* City: Tucson
County / Parish:
* State: AZ: Arizona
Province:
* Country: USA: UNITED STATES
* ZIP / Postal Code: 85724-5163
* Phone Number: (520) 626-7374
Fax Number: (520) 626-2767
* Email: kernst@email.arizona.edu

15. ESTIMATED PROJECT FUNDING

a. Total Federal Funds Requested	376,116.00
b. Total Non-Federal Funds	0.00
c. Total Federal & Non-Federal Funds	376,116.00
d. Estimated Program Income	0.00

16. * IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ☒ PROGRAM IS NOT COVERED BY E.O. 12372; OR

☐ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious. or fraudulent statements or claims may subject me to criminal, civil, or administrative penalities. (U.S. Code, Title 18, Section 1001)

☒ *** I agree**

**** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.***

18. SFLLL or other Explanatory Documentation

Add Attachment | Delete Attachment | View Attachment

19. Authorized Representative

Prefix: * First Name: Leslie Middle Name: P.

* Last Name: Tolbert Suffix: Ph.D.

* Position/Title: Vice President for Research

* Organization: Arizona Board of Regents, The University of Arizona

Department: Division:

* Street1: PO Box 3308

Street2:

* City: Tucson County / Parish:

* State: AZ: Arizona Province:

* Country: USA: UNITED STATES * ZIP / Postal Code: 85722-3308

* Phone Number: (520) 626-6000 Fax Number: (520) 626-4137

* Email: sponsor@email.arizona.edu

*** Signature of Authorized Representative**: Mary Gerrow

*** Date Signed**: 06/22/2011

20. Pre-application

Add Attachment | Delete Attachment | View Attachment

424 R&R and PHS-398 Specific
Table Of Contents

OMB Number: 4040-0010
Expiration Date: 08/31/2011

Project/Performance Site Location(s)

Project/Performance Site Primary Location ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Arizona Board of Regents, The University of Arizona

DUNS Number: 8063456170000

* Street1: 1295 N Martin Avenue

Street2:

* City: Tucson County:

* State: AZ: Arizona

Province:

* Country: USA: UNITED STATES

* ZIP / Postal Code: 85719-0000 * Project/ Performance Site Congressional District: AZ-007

Project/Performance Site Location 1 ☐ I am submitting an application as an individual, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.

Organization Name: Kenyan Medical Research Institute

DUNS Number: 6440358910000

* Street1: P.O. Box 1578

Street2:

* City: Kisumu County:

* State:

Province:

* Country: KEN: KENYA

* ZIP / Postal Code: * Project/ Performance Site Congressional District:

Additional Location(s) Add Attachment Delete Attachment View Attachment

RESEARCH & RELATED Other Project Information

1. * Are Human Subjects Involved? ☒ Yes ☐ No

1.a If YES to Human Subjects

Is the Project Exempt from Federal regulations? ☐ Yes ☒ No

If yes, check appropriate exemption number. ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

If no, is the IRB review Pending? ☒ Yes ☐ No

IRB Approval Date:

Human Subject Assurance Number: 00004218

2. * Are Vertebrate Animals Used? ☐ Yes ☒ No

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ☐ Yes ☐ No

IACUC Approval Date:

Animal Welfare Assurance Number

3. * Is proprietary/privileged information included in the application? ☐ Yes ☒ No

4.a. * Does this project have an actual or potential impact on the environment? ☐ Yes ☒ No

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ☐ Yes ☐ No

4.d. If yes, please explain:

5. * Is the research performance site designated, or eligible to be designated, as a historic place? ☐ Yes ☒ No

5.a. If yes, please explain:

6. * Does this project involve activities outside of the United States or partnerships with international collaborators? ☒ Yes ☐ No

6.a. If yes, identify countries: Kenya

6.b. Optional Explanation:

7. * Project Summary/Abstract 1237-Abstract.pdf Add Attachment | Delete Attachment | View Attachment

8. * Project Narrative 1238-Narrative.pdf Add Attachment | Delete Attachment | View Attachment

9. Bibliography & References Cited 1239-References.pdf Add Attachment | Delete Attachment | View Attachment

10. Facilities & Other Resources 1240-Resources.pdf Add Attachment | Delete Attachment | View Attachment

11. Equipment Add Attachment | Delete Attachment | View Attachment

12. Other Attachments Add Attachments | Delete Attachments | View Attachments ☐

Tracking Number:GRANT10907252 Funding Opportunity Number:PA-10-070 Received Date:2011-06-22T19:05:16-04:00

Despite dramatic improvements, malaria remains a significant health problem in many regions of the world. As malaria programs move from control to elimination, there is an urgent need to understand barriers to and facilitators of the use of control measures. In this proposal, we focus on the most widely used control measure; bednets in a highland/low transmission and a lowland/high transmission. Our preliminary results indicate that in Kenya roughly 1 in 4 children under 5, the group most vulnerable to malaria, live in households that do not own a bednet. Additionally, even in net owning homes, 1 in 6 children under 5, do not sleep under a net. As Kenya and other programs expand their scope to distribute enough nets to cover all household members, much effort needs to go into understanding the prevalence of and factors related to disuse. The objective of the following proposal is to use qualitative and quantitative methods to determine the prevalence of ownership, misuse and disuse of bednets under field conditions and to identify modifiable risk factors.

We will use an ecological approach to assess not only individual level factors that drive bednet ownership and use but the social and environmental context in which these decisions are being made. Following focus group discussions with community members and key informant interviews with health clinic staff, government vector control staff and village and community leaders, we will conduct a cross-sectional survey that examines 1) perceived susceptibility to malaria 2) perceived severity of malaria 3) perceived benefits of ITN use 4) perceived barriers to ITN use 5) cues to action such as health promotion programs and 6) confidence in the subject's self-efficacy with regard to obtaining an ITN and its proper use. We will use remotely-sensed images and GIS to determine how these perceptions and practices vary geographically and if they correspond with actual risk as determined through parallel parasite prevalence surveys and pyrethrum spray catches of Anopheles. From the cross-sectional participants we will identify positive deviants, community members who own and use bednets regularly despite experiencing at least 75% of the factors associated with not owning or using a bednet. In-depth interviews will be conducted to determine their solutions and personal motivators that may be used to improve community bednet ownership and compliance.

Our approach is unique in its combination of rich qualitative data and the rigor and generalizability of established epidemiologic methods. Identifying what is already working in a community is more likely to be successfully implemented as a larger intervention. We expect that we will find that individuals who have personal loss due to malaria, have identified solutions to logistical issues with hanging bednets, have a higher perception of risk and who have greater access to household resources will be more likely to own and use a bednet. This research will help drive the development of targeted community-based interventions that should improve ITN ownership and use and ultimately reduce malaria transmission.

Malaria causes an estimated 800,000 deaths each year. Insecticide treated nets (ITN) are the most effective strategy to prevent malaria. This study will advance understanding of barriers and facilitators to ownership and use of ITN in malarious areas. We will use a mixed methods approach to identify simple solutions that will improve ownership and compliance with ITN use in western Kenya.

RESOURCES

FACILITIES: Specify the facilities to be used for the conduct of the proposed research. Indicate the performance sites and describe capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Under "Other," identify support services such as machine shop, electronics shop, and specify the extent to which they will be available to the project. Use continuation pages if necessary.

RESOURCES: UNIVERSITY OF ARIZONA

FACILITIES:

Laboratory:

Clinical:
NA

Animal:
NA

Computer:

Kacey Ernst
Dr. Ernst has two computers for use on the project. One which will be dedicated to the field collection data. There is full internet access available along with printers, fax machines, scanners, poster printers etc. that are available widely for use on the project.

Office:

Kacey Ernst
Dr. Ernst has office space and cubicle space for students who are working on the project. She is supported by administrative staff members in the Epidemiology and Biostatistics division as well as financial support from the business office who administer all grants and contracts.

Other:

General GIS and Satellite Imagery Resources Available
ArcGIS is loaded on all computers in the Main Library Information Commons which is attached to color and black and white printers and map plotters. These resources can be used by students to produce final products for presentation.

Arizona Remote Sensing Center (ARSC) --
ARSC encompasses digital image processing facilities for satellite and aerial video data, geographic information systems (GIS) for managing and analyzing map and image data, air photo interpretation equipment, aerial video systems, and a collection of satellite, aerial photography, and aerial video data for southern Arizona and the southwest and selected areas of Africa and South America.

Center for Applied Spatial Analysis (CASA)—
Geographic Information Systems research facility within the School of Geography and Development. As part of GD, CASA supports and develops research projects and encourages the wider use of GIS and related techniques in the social sciences through collaboration on grants, demonstration, training, teaching and internships.

RESOURCES: NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR)

The National Center for Atmospheric Research (NCAR) is a leader in research on climate and its impact on society and health. Its mission is to provide the university research and teaching community with advanced tools such as aircraft and radar to observe the atmosphere and assistance in interpreting it including

supercomputers access, computer models and user support. For the current project, Mary Hayden will be providing support from NCAR as an unpaid collaborator with the following resources:

Computer:
Computational facilities required for this project including: multiple laptops and desktop computers with appropriate graphical, word processing and statistical and GIS software; peripherals; printers; and network connections within the Research Applications Laboratory.

Office:
Dr. Hayden has an office in the facility in Boulder, CO. She is supported by the administrative staff of NCAR and has full access to photocopiers, fax machine and required office supplies.

Other:
Through Dr. Hayden we will have informal access to top researchers at NCAR.

RESOURCES: KENYAN MEDICAL INSTITUTE OF RESEARCH (KEMRI)

The Kenyan Medical Institute of Research (KEMRI) is one of the premier research centers in East Africa. The KEMRI compound in Kisian is shared with researchers from Centers for Disease Control and Prevention, Walter Reed Army Institute of Research, University of Pennsylvania, University of Minnesota, Case Western Reserve University, Michigan State University among many others.

Computer:
Computational facilities required for this project including: multiple laptops and desktop computers with appropriate graphical, word processing and statistical and GIS software; peripherals; printers; and internet network connections that will be accessible to the PI and student interns.

Office:
Dr. Munga has an office at the research station in Kisian. He is supported by administrative staff of NCAR and has access to required office supplies.

Other:
The dynamic atmosphere at KEMRI should not be an undervalued resource for this project. Researchers on malaria, HIV and tuberculosis from all across the globe converge here to conduct research. Informal gatherings are common with a high degree of academic exchange that is exciting and engaging to both the principal investigator as well as providing a wonderful opportunity for the student interns to learn more about the field and make contacts with potential mentors for further graduate work. In fact, it was through such exchanges that the principal investigator identified her mentors, Kim Lindblade and Chandy John for her doctoral work at the University of Michigan.

Institutional Support for Early Investigators and Development of Student Researchers:

The University of Arizona

The University of Arizona (UA) is the leading public research university in the American Southwest, and is an ideal interdisciplinary academic community for the proposed research project. UA is a land grant public university and a member of the Association of American Universities. UA has a 387-acre campus in Tucson, Arizona including 159 buildings on the main campus and 25 buildings at the adjacent Arizona Health Sciences Center. With greater than 37,000 students enrolled in 19 colleges and 12 schools, UA provides an amazing environment for interacting with students, faculty and researchers from many diverse disciplines. UA has 14 libraries including over 5 million print volumes. The University's commitment to research was recognized by its ranking in 2007 from the National Science Foundation as 15th among public and 23rd among all universities in

the United States for research and development expenditures with over $530 million in annual research funding.

The University is committed to providing a cadre of scientists and educators who, through interdisciplinary training, are able to develop new and imaginative methods of teaching and research, and create new fields of endeavors as evident by 14 recognized graduate interdisciplinary programs. To consolidate the University's standing as one of the top research universities in America, UA is dedicated to strengthening research and outreach in 9 interdisciplinary areas that are critical to Arizona's future through enhancing education and addressing social, cultural and economic needs.

The University of Arizona is dedicated to developing new faculty, providing small grant opportunities internally to assist the development of pilot projects for junior faculty. Dr. Ernst received a competitive SEED grant ($10,000) to generate preliminary data for the current proposal. They additionally dedicated funds to start-up her research agenda ($80,000) and included three full years of salary support. Tenure figures indicate that 90% of assistant professors going up for tenure, receive it at the University of Arizona. This demonstrates the high level of support for junior faculty that is held at the institution.

The Arizona Health Sciences Center (AHSC) is a 48-acre complex adjacent to UA. It includes the Colleges of Medicine, Nursing, Pharmacy and Public Health, the University Medical Center and 11 additional centers officially recognized by the Arizona Board of Regents. There are over 1500 students enrolled in these colleges. During fiscal year 2008, AHSC generated almost 128 million dollars in grants and contracts that can be applied to research, patient care, and education. The Arizona Health Sciences Library (AHSL), located within the University Medical Center, contains the state's largest collection of health information resources and is open 24 hours a day to UA employees. AHSL provides electronic full text access to almost 10,000 journals and there is a librarian dedicated to aiding researchers in public health. Inclusion of these 4 colleges within AHSC allows for ease of collaboration between the units and resource sharing of laboratories and educational facilities.

The Mel and Enid Zuckerman College of Public Health

The Mel and Enid Zuckerman College of Public Health (MEZCOPH) was established in January 2000 by the Arizona Board of Regents (ABOR) and was accredited in 2003 by the Council on Education for Public Health. Located within the 103,000 square-foot Roy P. Drachman Hall, MEZCOPH instructional space includes three lecture halls, two distributed learning classrooms, five interactive learning classrooms and a computer instruction classroom. Drachman Hall is also home to all administrative and support offices, academic divisions and research programs for the College. Laboratory space is provided in the Medical Research Building adjacent to Drachman Hall. This state-of-the-art facility, completed in Summer 2006, is adjacent to Drachman Hall and contains 6,225 net square feet of open, shared core facilities, wet labs, and faculty/student office space designed to maximize collaborative research and interaction among students and faculty. MEZCOPH also has an additional 4,000 square feet of wet-laboratory space in the Biomedical Research Laboratories building.

MEZCOPH is one of very few Colleges of Public Health in the country that award a Bachelor's of Science in Public Health. This makes it an ideal institution to develop future public health researchers. At the graduate level MEZCOPH offers Masters of Public Health (M.P.H.) and/or Master of Science (M.S.) degrees in Biostatics, Environmental and Occupational Health, Epidemiology, Family and Child Health, Health Behavior and Health Promotion and Public Health Policy and Management as well as a Public Health Certificate. As the M.P.H. is a professional degree many graduates of the program intend to seek immediate positions in a health department. Giving students experiences that will develop their research skills is highly encouraged at the College. Students who do have these research experiences as an M.P.H. student often enroll in doctoral level programs after graduation. But currently, funded research experiences for M.P. H. students are limited despite

student interest. Additionally, MEZCOPH also awards Ph.D. degrees in both Biostatistics and Epidemiology and a Dr.P.H. degree with a concentration in Maternal Child Health or Public Health Policy Management. The M.S./Ph.D. program in Environmental Health Sciences was approved by ABOR on May 4, 2009, and will enroll students in Fall of 2010. Historically, the College's budget is comprised of 70% extramural funds; these funds include NIH, CDC and other federal agencies as well as multiple contracts with the Arizona Department of Health Services and other local Health Departments. Research strengths within MEZCOPH are diverse, in keeping with the mission "to promoting the health of individuals and communities with a special emphasis on diverse populations and the Southwest."

MEZCOPH is the home institution for Dr. Ernst and provides an excellent atmosphere for faculty and student development.

Global Health Institute

The newly formed Global Health Institute (GHI) within MEZCOPH demonstrates the college's strong commitment to conducting research, teaching and service across the globe. This institute is born out of combined faculty and student interest in working in varied cultural and geographic contexts. University of Arizona leads the country in the number of returned Peace Corps volunteers and MEZCOPH ranks as one of their top two choices for seeking a degree. This will provide an excellent pool of students from which the MPH student interns can be chosen. Most of these students do not have research experience but do have the flexibility and personality to work in the proposed remote rural areas of Kenya. This is certainly a resource to the project as they can take on the role of junior mentor to the undergraduate student interns, giving them the experience of mentoring that can further develop them as future researchers.

OMB Number: 4040-0001
Expiration Date: 06/30/2011

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix: | * First Name: Kacey | Middle Name: C.
* Last Name: Ernst | Suffix: Ph.D.
Position/Title: Assistant Professor, Public Health | Department: College of Public Health
Organization Name: Arizona Board of Regents, The University of Arizona | Division: Epidemiology and Biostatistics
* Street1: 1295 N. Martin Avenue
Street2: PO Box 245163
* City: Tucson | County/ Parish:
* State: AZ: Arizona | Province:
* Country: USA: UNITED STATES | * Zip / Postal Code: 85724-5163
* Phone Number: (520) 626-7374 | Fax Number: (520) 626-2767
* E-Mail: kernst@email.arizona.edu

Credential, e.g., agency login: KCERNST

*** Project Role:** PD/PI | **Other Project Role Category:**

Degree Type:
Degree Year:

***Attach Biographical Sketch** 1234-Ernst_bio.pdf [Add Attachment] [Delete Attachment] [View Attachment]
Attach Current & Pending Support [Add Attachment] [Delete Attachment] [View Attachment]

PROFILE - Senior/Key Person 1

Prefix: | * First Name: Stephen | Middle Name:
* Last Name: Munga | Suffix:
Position/Title: Principal Research Officer | Department:
Organization Name: Kenyan Medical Research Institute | Division:
* Street1: P.O. Box 1578
Street2:
* City: Kisumu | County/ Parish:
* State: | Province:
* Country: KEN: KENYA | * Zip / Postal Code:
* Phone Number: 25405722923 | Fax Number:
* E-Mail: munga_os@yahoo.com

Credential, e.g., agency login:

*** Project Role:** Consultant | **Other Project Role Category:**

Degree Type:
Degree Year:

***Attach Biographical Sketch** 1235-Munga_biof.pdf [Add Attachment] [Delete Attachment] [View Attachment]
Attach Current & Pending Support [Add Attachment] [Delete Attachment] [View Attachment]

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Senior/Key Person 2

Prefix:		* First Name:	Mary	Middle Name:	
* Last Name:	Hayden			Suffix:	
Position/Title:		Department:			
Organization Name:	National Center for Atmospheric Research			Division:	
* Street1:	P.O. Box 3000				
Street2:					
* City:	Boulder	County/ Parish:			
* State:	CO: Colorado			Province:	
* Country:	USA: UNITED STATES			* Zip / Postal Code:	80307-3000
* Phone Number:	303-497-8116	Fax Number:			
* E-Mail:	mhayden@ucar.edu				

Credential, e.g., agency login:

*** Project Role:** Consultant **Other Project Role Category:**

Degree Type:

Degree Year:

***Attach Biographical Sketch**	1236-bio_haydenf.pdf	Add Attachment	Delete Attachment	View Attachment
Attach Current & Pending Support		Add Attachment	Delete Attachment	View Attachment

Tracking Number:GRANT10907252 Funding Opportunity Number:PA-10-070 Received Date:2011-06-22T19:05:16-04:00

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
Lawrence University	BA	1997	Chemistry/ Biology
University of Michigan	MPH	2001	Epidemiology
University of Michigan	PhD	2006	Epidemiology

A. Personal Statement

I have been working in Kenya on malaria related projects since I was an M.P.H. student in 2000. I have gained field experience in human surveys by designing and carrying out all aspects of a community-based case-control study while living in a remote village in Kenya. I managed all aspects of the study from hiring to quality control of a staff of 17 field assistants, lab personnel and clinicians. This was a multi-site study covering 17 villages in two sub-locations. I conducted entomological collections of Anopheles and *Ae. aegypti* through multiple methods including pyrethrum spray catches as outlined in this proposal, trapping and human landings. I gained laboratory experience conducting microscopy, PCR, ELISA and BioPlex assays to detect and genotype the malaria parasite in humans and mosquitoes. I am familiar with laboratory methods, protocols and interpretations. The use of geography and GIS has been present within most of my research and I have worked with remotely sensed data as well as mapped geographic features to include in spatial analysis. My work with anthropologists on tuberculosis in the Arizona-Mexico border as well as my current work with the Maricopa County Health Department examining questions related to personal belief exemptions for vaccinations, have developed my skills in qualitative methods. These experiences have taught me not only about these methods in isolation but how they intersect and can inform each other. While I do not claim to be an expert in all of these areas, I have learned enough about the methodologies to oversee and integrate a multidisciplinary research project such as this one.

As an assistant professor, a significant amount of my time has been spent developing and instructing graduate and undergraduate courses. I have overseen two undergraduate honors theses and M.P.H. internships of roughly 30 students. Several of these M.P.H students are currently working on developing manuscripts from their work (5). I also serve on doctoral student committees at the University of Arizona (7), The University of Colorado, Denver (1) and Maseno University in Kenya (2). My classes are very well received and students have commented that they appreciate my engaged mentorship and guidance throughout their academic career. As a strong mentor and experienced, though junior, researcher, I would be able to truly carry out the purpose of this R15 funding mechanism.

B. Positions and Honors

Positions and Employment

2000 Summer Research Fellow, U.S. Army Medical Research Unit, Kisian, Kenya

2001–2002 Graduate Student Instructor, Chronic Disease Epidemiology, Field Studies in Epidemiology, Biology and Human Affairs, University of Michigan, Ann Arbor, Michigan

2003–2006 Graduate Research Assistant, Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, Michigan (based in Kenya)

2007–2008 Influenza Epidemiologist, Office of Infectious Disease Services, Arizona Department of Health Services, Phoenix, Arizona

2008- Assistant Professor, Arid Land Studies, University of Arizona, Tucson, Arizona

2008- Assistant Professor, Division of Epidemiology and Biostatistics College of Public Health, University of Arizona, Tucson, Arizona

2008- Infectious Disease Society of America
2010- American Society of Tropical Medicine and Hygiene

C. Selected Peer-Reviewed Publications (most relevant to current project)

Most relevant to the current application

1. **Ernst KC**, Adoka SO, Kowuor DO, Wilson ML, John CC. Malaria hotspot areas in a highland Kenya site are consistent in epidemic and non-epidemic years and are associated with ecological factors. *Malar J.* 2006 Sep 13;5:78. (PMCID: PMC1586014)
2. Menge DM, **Ernst KC**, Vulule JM, Zimmerman PA, Guo H, John CC. (2008) Microscopy underestimates the frequency of *Plasmodium falciparum* infection in symptomatic individuals in a low transmission highland area. *American Journal of Tropical Medicine and Hygiene* 79 (2):173-7. (PMCID: PMC2590590)*
3. Cohen JM, **Ernst KC**, Lindblade KA, Vulule JM, John CC, Wilson ML Topography, land-cover, and elevation predict areas at risk for malaria within communities in a highland region of western Kenya. *Mal Journal* Jan 2008 17:40. (PMCID: PMC2276221)
4. **Ernst KE**, Lindblade, KA, Koech D, Sumba PO, Kuwuor D, John CC, Wilson ML. (2009) Environmental, socio-demographic and behavioral determinants of malaria risk in the western Kenyan highlands: a case-control study. *Tropical Medicine and International Health*. 14 (10), pp. 1258-1265. (PMCID in process)
5. Cohen JM, **Ernst KC**, Lindblade KA, Vulule JM, John CC, Wilson ML. Local topographic wetness indices predict household malaria risk better than land-use and land-cover in the western Kenya highlands. *Malar J.* 2010 Nov 16;9:328. (PMCID: PMC2993734)

- *Co-first authored paper.

Other recent publications

1. **Ernst KC,** Pogreba-Brown K, Rasmussen L, Erhart L. The Effect of Policy Changes on Hepatitis A Vaccine Uptake in Arizona Children (1995-2008). (In Press) *Public Health Reports*.**
2. Robinson, K **Ernst K**, Johnson B, Rosales C. The Health Status of Southern Arizona Border Counties: A Healthy Border 2010 Midterm Review. *Rev Panam Salud Publica* 28(5), 2010.**

** papers with student authors

D. Research Support

Ongoing Research Support

College of Public Health Ernst, Kacey (PI) 9/01/2010 –
Title: Identifying potential risk of Chagas transmission in southern Arizona: a one-health approach
Objective: This internally funded project is a pilot study that examines prevalence of *T. Cruzi* in triatomes, packrats, household pets and humans within a Tucson, AZ community with high levels of vector-human contact.
Role: PI and mentor

Principal Investigator/Program Director (Last, First, Middle): Ernst, Kacey C.

depth interviews and online surveys to examine factors that may promote the use of personal belief exemptions in Maricopa County in schools K – 12.

Completed Research Support

Center for Insect Science Grant — Ernst, Kacey (PI) — 10/15/2009- 10/15/2010
Aedes aegypti longevity at the edge of its range: implications for climate change and mosquito-borne disease.
Objective: The primary objective of this study was to refine the methods for quantifying *Ae. aegypti* chronological age, test them on field caught mosquitoes and develop and test a sampling strategy.
Role: PI

PIMSA Grant — Weaver, Tom (PI) — 1/1/2008 - 12/31/2010
Medical, Socio-cultural and Environmental Factors Related to Tuberculosis in the Mixtec Migrant Communities of Sonora and Arizona: A Bi-national Case Study.
The project's goal was to build collaborative ties with Universidad de Sonora to explore the burden of tuberculosis in immigrants and make suggested policy changes in access to treatment.
Role: Co-Investigator

NIH RO3 5R03AI056184-02 — Wilson, Mark (PI) — 10/15/2003 – 8/15/2006
Environmental determinants of malaria in the western highland of Kenya.
The project's goal was to conduct a case-control study to determine risk factors and spatial-temporal distribution of malaria cases in a high altitude community in western Kenya.
Role: Project Director

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
Egerton University, Kenya	BA	1995	Natural Resource Management
Moi University	MPH	1999	Medical Entomology
Moi University	PhD	2006	Medical Entomology

A. Personal Statement

I am a highly experienced technical advisor, researcher and public health manager who has worked predominantly in the area of malaria control. I have worked as a World Health Organization Technical Advisor to Kenya, and Botswana: providing technical support for evaluation of malaria vector control programs and epidemic preparedness and response and more specifically indoor residual spray and insecticide treated nets programs. I have been conducting monitoring and evaluation of the indoor residual spray in Budalangi, western Kenya. I am a co-principal investigator and a manager in several projects in western Kenya and provide technical, logistic, administrative and financial support in areas of insecticide resistance, evaluation of durable wall linings, and targeted malaria vector control. I have been a long term consultant for the International Centre for Insect Physiology and Ecology (ICIPE) and provide active technical support to technical staff including ensuring that their objectives are set, work plans developed and implemented, and their performance is regularly reviewed. Other duties include ensuring that all activities under the project are technically excellent. In 2007, I was a Senior Guest Researcher at the University of Bergen, Norway. I have had experience mentoring students and sit on the committees of five doctoral students at the Moi University (2),

B. Positions and Honors

Positions and Employment

2000-2001	Junior Research Fellow, The International Centre for Insect Physiology and Ecology (ICIPE) / Moi University, Eldoret, Kenya
2001 to 2002	Graduate Research Assistant, The International Centre for Insect Physiology and Ecology (ICIPE), Mbita, Kenya
2002 - 2006	Graduate Research Assistant, Kenyan Medical Research Institute (KEMRI) Kisumu, Kenya.
2006 – Oct 2009	Consultant, International Centre for Insect Physiology and Ecology (ICIPE) in collaboration with University of California, Irvine, Kisumu, Kenya.
August to Dec 2007	Senior Guest Research Fellow, University of Bergen (UIB), Norway.
Feb – March 2009	Temporary Advisor for Phase I Malaria Program Review (MPR), World Health Organization, Kenya
June 06 – July 2009	Senior Research Officer – KEMRI (CGHR). Kisian, Kenya
August 2009	Technical Advisor, World Health Organization (WHO) Botswana
May – June 2009	Technical Advisor, Malaria Program Review (MPR), WHO, Kenya.
Feb 2009 – Date	Principal Research Officer, KEMRI, Kisian, Kenya
Jan 2010 – date	Program Technical Director, The MENTOR Initiative, Special Initiative Program, Garissa.
May 2011	Technical Advisor, World Health Organization, Malaria Program Review, Uganda

1. Kweka EJ, Zhou G, Lee M-C, Gilbreath TM, Mosha F, **Munga S**, Githeko AK and Yan G Evaluation of two methods of estimating larval habitat productivity in western Kenya highlands. *Parasites & Vectors* 2011, 4:110
2. Atieli FK, **Munga S**, Ofulla VO and Vulule J. Wash durability and optimal drying regimen of four brands of long-lasting insecticide-treated nets after repeated washing under tropical conditions. Mal J. 2010, 9: 248
3. **Munga S**, Yakob L, Mushinzimana E, Zhou G, Ouna T, Minakawa N, Githeko K and Yan G. 2008. Land Use and Land Cover Changes and Spatiotemporal Dynamics of Anopheline Larval Habitats during a Four-Year Period in Western Kenya Highlands. *American Journal of Tropical Medicine and Hygiene* 2009, 81: 1079–1084.
4. Yousif E Himeidan Guofa ZhouLaith Yakob L, Yaw Afrane Y, **Munga S**, Atieli H, El-Rayah E, Githeko AK, and Guiyun Yan Habitat stability and occurrences of malaria vector larvae in western Kenya highlands. *Malaria Journal* 2009, 8:234
5. **Munga S**., N. Minakawa, G. Zhou, A.K. Githeko and G. Yan. 2007. Survivorship of immature stages of *Anopheles gambiae* s.l. (Diptera: Culicidae) in natural habitats in western Kenya highlands *J. Med. Entomol*. 44: 758 - 764.
6. Zhou, G, **Munga S**, Minakawa N., Githeko A., and G. Yan. 2007. Spatial relationship between adult malaria vector abundance and environmental factors in western Kenya highlands. *Am. J. Trop. Med. Hyg*. 77: 29 – 35.
7. **Munga**, **S**., Minakawa N, Zhou G, Mushinzimana E, Okeyo-Owuor, J.B., Githeko A. K. and G. Yan. 2006. Association between land cover and habitat productivity of malaria vectors in the western Kenyan highland *Am. J. Trop. Med. Hyg.* 74: 69-75.
8. **Munga**, **S.,** Minakawa N, Zhou G, Okeyo-Owuor, J.B., Githeko A. K. and G. Yan. 2006. Effects of larval competitors and predators on oviposition behavior of *Anopheles gambiae* s.s. *J. Med. Entomol.* 43: 221-224.
9. **Munga**, **S**., Minakawa N, Zhou G, Okeyo-Owuor, J.B., Githeko A.K. and G. Yan. 2005. Oviposition site preference and egg hatchability of *Anopheles gambiae* s.s: Effects of land cover types. *J. Med. Entomol*. 42: 993-997.
10. **Munga S,** Mushinzimana E, Minakawa N, Zhou G, Okeyo-Owuor JB, Githeko AK and Yan G. 2006. Spatio-temporal variations in the distribution of anopheline larval habitats in western Kenya highlands. *Am. J. Trop. Med. Hyg.* 75: Suppl 5.
11. **Munga S,** Mushinzimana E, Minakawa N, Zhou G, Okeyo-Owuor JB, Githeko AK and Yang G. 2005. Spatial distribution and productivity of anopheline larval habitats in western Kenya highlands. *Am. J. Trop. Med. Hyg.* 73: Suppl 6.
12. Minakawa N, **Munga S**, Atieli F, Mushinzimana E, Zhou G, Githeko A.K. and G. Yan. 2005. Spatial distribution of anopheline larval habitats in western Kenya highlands: Effects of land cover and topography. *Am. J. Trop. Med. Hyg*. 73: 157-165.
13. E. Mushinzimana, **S. Munga**, N. Minakawa, L. Li, Feng C., L. Bian, U. Kitron, C. Schmidt, L Beck, G. Zhou, A. K. Githeko, and G. Yan. 2006. Landscape determinants and remote sensing of Anopheline Mosquito Larval Habitats in the western Kenya highlands *Malaria Journal*. 5:13.
14. **Munga**, **S.**, Githeko AK, Githure JI and G. Yan. 2009. Response of *Anopheles gambiae* s.l. (Diptera: Culicidae) to larval habitat age in western Kenya highlands *Mal. Journal* (Submitted).

Role: Co-Investigator

The MENTOR Initiative/ COMIC RELIEF Richard Allan (PI) 1/2010 - Current
Building Sustainable and Effective Malaria Control for Vulnerable Communities in Kenya
Objective: To implement malaria control services and their utilization at facility and community level, effective epidemic risk reduction and to reduce the overall burden of malaria in communities living in Garissa District, North Eastern Province Kenya
Role: Co-Investigator

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors in the order listed on Form Page 2.
Follow this format for each person. **DO NOT EXCEED FOUR PAGES.**

NAME	POSITION TITLE
Hayden, Mary Helen	Scientist-I
eRA COMMONS USER NAME (credential, e.g., agency login)	

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	MM/YY	FIELD OF STUDY
University of Kiel, Germany	BA equiv.	1977	Islamic Studies
Metropolitan State College, Denver, CO	BA	1984	German and Meteorology
University of Colorado	MA	1992	Geography (climatology)
University of Colorado	PhD	2003	Health and Behavioral Sciences
University of Colorado, CU Trauma, Health and Hazards Center	Postdoctoral Fellow	2003-2006	Weather, climate and health hazards
National Center for Atmospheric Research, Institute for the Study of Society and Environment	Postdoctoral Fellow	2006-2009	Weather, climate and health

A. Personal Statement

Dr. Hayden is a social scientist with expertise in conducting focus groups and designing field surveys. She has significant experience working with engaging communities in vector-borne disease ecology studies. She will provide guidance on the qualitative analysis and development protocols for focus group discussions and in-depth interviews.

B. Positions and Honors

Positions and Employment

2009 – present Scientist I, National Center for Atmospheric Research, Boulder, CO
2007 – present Guest Researcher**,** Division of Vector-Borne Infectious Diseases, CDC. Ft. Collins, CO
2010 - present Adjunct Assistant Professor, University of Colorado, School of Public Health
2003 – 2005 Senior Research Associate, University of Colorado, Health and Behavioral Sciences, Denver, CO
1999 - 2003 Chair, Department of Geography, Geology, and Astronomy; Pikes Peak Community College, Colorado Springs, CO
1996 - 2003 Faculty, Department of Geography, Pikes Peak Community College, Colorado Springs, CO
1996 - 1999 Adjunct Assistant Professor, Department of Geography and Environmental Studies, University of Colorado, Colorado Springs, CO

Other Experience and Professional Memberships

2008 to 2011 Commissioner, Commission to Engage African Americans on Climate Change (CEACC)
2007 to 2011 Societal Impacts Board, American Meteorological Society
2003 to present Scientific Advisory Board, Border Infectious Diseases Surveillance Program, CDC
2005 to present Member, American Society of Tropical Medicine and Hygiene
2010 to present Member, American Public Health Association
2006, 2009, 2011 Organizer, Climate and Health Colloquia, National Center for Atmospheric Research

Honors

2007	American Public Health Association, National 2007 APHA Public Health Promotion Contest: Best Print Materials
2006	Gorgas Memorial Institute Research Award, American Society of Tropical Medicine and Hygiene
2003	Outstanding Ph.D. student, University of Colorado, Denver

C. Selected peer-reviewed publications (in chronological order).

1. Spiegel J, Bennett S, Hattersley L, **Hayden MH**, Kittayapong P, Nalim S, Wang D, Zielinski-Gutierrez E, and Gubler D. (2005). Barriers and bridges to prevention and control of dengue: the need for a social-ecological approach. *EcoHealth 2 (4):* 273-290

2. Zielinski-Gutierrez EC and **Hayden MH.** (2006) A model for defining West Nile virus risk perception based on ecology and proximity. *EcoHealth 3(1)*: 28-34

3. Moreno R, **Hayden MH**, Janes C, and Anderson G. (2006). A web-based multimedia spatial information system to document *Aedes aegypti* breeding sites and dengue fever risk along the US-Mexico border. *Health and Place* 12(4):715-27

4. Barnes LR, Gruntfest EC, **Hayden MH**, Schultz DM and Benight, C. (2007) False Alarms and Close Calls: A Conceptual Model of Warning Accuracy. *Weather and Forecasting,* 22(5):1140-1147

5. Moreno-Sanchez R, Anderson G, Cruz J and **Hayden MH** (2007) The potential for the use of Open Source Software and Open Specifications in creating web-based cross-border health spatial information systems. *The International Journal of Geographical Information Science* 21(10): 1135-1163.

6. Hayden MH, Drobot S, Radil S, Benight C, Gruntfest EC and Barnes LR. (2007) Information Sources for Flash Flood Warnings in Denver, CO and Austin, TX. *Environmental Hazards* 7(3): 211-219

7. Benight C, Gruntfest E, **Hayden MH,** Drobot S. (2007) Trauma and Short-Fuse Weather Warning Perceptions. *Environmental Hazards* 7(3): 220-226

8. Ramos M, Mohammad H, Zielinski-Gutierrez E, **Hayden MH**, Robles Lopez JL, Fournier M, Rodríguez Trujillo A, Burton R, Brunkard J, Anaya-Lopez L, Abell A, Kuri-Morales P, Smith B, Munoz J, Waterman S, and the Dengue Serosurvey Working Group. (2008) Epidemic Dengue and Dengue Hemorrhagic Fever at the Texas-Mexico Border: Results of a household-based seroepidemiological survey, December 2005. *American Journal of Tropical Medicine and Hygiene. 78(3):* 364-369

9. Hayden MH, Uejio C, Walker K, Ramberg F, Moreno-Sanchez R, Rosales C, Gameros M, Mearns LO, Zielinski-Gutierrez E and Janes CR. (2010) Microclimate and Human Ecological Factors in the Divergent Ecology of *Aedes aegypti* along the Arizona, U.S./Sonora, MX Border. *EcoHealth* doi: 0.1007/s10393-010-0288-z

10. Wilhelmi OV and **Hayden MH**. (2010) Connecting people and place: a new framework for reducing urban vulnerability to extreme heat. *Environ. Res. Lett.* **5** 014021. doi: 10.1088/1748-9326/5/1/014021

11. Schultz DM, Gruntfest EC, **Hayden MH,** Benight CC, Drobot S and Barnes LR. (2010) Decision Making by Austin, Texas Residents in Hypothetical Tornado Scenarios. *Weather, Climate and Society.* 2(3): 247-252

12. Morss RE and **Hayden MH.** (2010) Storm surge and “certain death”: Interviews with Texas coastal residents following Hurricane Ike. *Weather, Climate and Society* 2(3):172-187

D. Research Support

Ongoing Research Support

Project Title: "The Vector Mosquito *Aedes aegypti* at the Margins: Sensitivity of a Coupled Natural and Human System to Climate Change"; Source of Support: NSF-CNH; Period Covered: 8/1/10-7/31/13; Affiliation: co-PI Goal: Model the current and future abundance of the dengue vector mosquito *Aedes aegypti* in eastern Mexico via field data collected along an altitudinal transect in eastern Mexico.

Project Title: "Modeling Plague in Uganda"; Source of Support: Department of Health and Human Services - CDC; Period Covered: 09/01/09-01/31/12; Affiliation: co-PI

Goal: Develop low-literacy plague materials; conduct workshops to train traditional healers to recognize plague.

Project Title: "System for Integrated Modeling of Metropolitan Extreme Heat Risk (SIMMER)"; Source of Support: NASA; Period Covered: 7/1/10-6/30/13; Affiliation: Co-PI
Goal: To quantify current and future extreme heat vulnerability, primarily in Houston, as a function of environmental and socio-economic drivers.

Project Title: “A prototype Earth-gauging system integrating weather and health data to manage meningitis”. Source of Support: Google Predict and Prevent; Period Covered: 10/15/2008 – 10/14/2011. Affiliation: co-I.
Goal: Conduct human ecological studies concurrent with development of weather forecast capability in northern Ghana.

Completed Research Support

NA16GP2615 PI: Janes 4/1/2002 – 3/31/2005
National Oceanic and Atmospheric Administration (NOAA), Office of Global Programs, Climate Variability and Human Health. Project title: The Potential for the Emergence of Dengue Fever in the SW US/NW Mexico
Role: coPI

DG133RO5SE6357 PI: Hayden 11/1/2005 – 10/31/2006
NOAA Supplemental Funding. Project title: The Potential for the Emergence of Dengue Fever in the SW United States/NW Mexico

PAHO0700001001 PI: Hayden 4/1/2007 – 8/31/2008
Pan American Health Organization. Project title: The Role of Waste Tires in the Risk of Dengue Fever in Brownsville, TX and Matamoros, MX

Budget Justification

Personnel

Kacey C. Ernst: Dr. Ernst (3.0 person months in year 1 and 2.82 person months in years 2-3) will serve as the principal investigator and will oversee the design of the project. She will also be conducting the bulk of the analyses outlined in the proposal. She will oversee the statistical analyses. She will act as supervisor for all students that go into the field. She will obtain and maintain all IRB approvals needed for the project. In addition, she will be responsible for ensuring all reports and products are submitted to NIH in a timely manner and will be responsible for disseminating results through publications and presentations.

Graduate and undergraduate student: (2 positions at 2.4 person months each for all three years) This is funding for one graduate student and one undergraduate student to conduct a research project in the study site. They will be charged with carrying out research related to the objectives of the proposed research under the direct oversight of Dr. Ernst, Dr. Munga and Maurice Agawo. This will include literature reviews, protocol development and data analysis. Students will be encouraged to propose their own parallel research questions. If their own research is proposed, they will be the primary lead on developing protocols, obtaining IRB approval and collecting data. This will provide six students the chance to conduct international research projects over the course of the study.

Consultants:

Stephen Munga: Dr. Munga is a well-established Kenyan research scientist with the KEMRI group in stationed in Kisian. He will oversee the entomological sub-aims of the study and will act as the liaison between Kenyan IRB and Scientific Review Committees. He will mentor and train students on the entomological components of the grant. Dr. Munga will receive a consultant fee equivalent to 25% of his salary each year (Year 1, $7000; Year 2, $7000; Year 3, $7500).

David Koech: David Koech works for the Kenyan Ministry of Health and will be instrumental in identifying key informants for interview, establishing protocols in government clinics located in the study sites, coordinating efforts between the community members and the research team (Year 1, $2400; Year 2, $2500; Year 3, $2000).

Graduate Student Maseno: Maseno University is one of the top Kenyan Universities and has a well-established malaria research program. We will work with one of the doctoral level students in sociology or anthropology to provide local context and understanding of focus group interview and key informant interview results ($2000 all three years).

Equipment:

Study Vehicle: The two study sites are approximately 3 hours apart and about 3.5 hours from Kisumu. We will require regular transportation for the program manager, students, PI and collaborators to and between study sites. Rental car costs for the duration of the project would far exceed the cost of purchasing and maintaining a project vehicle. At the end of the project the vehicle will be transferred over for use at the Kenyan Medical Research Institute, for further use

in malaria research as that organization requires. Permitted drivers will include the PI, the program manager, and KEMRI collaborator Stephen Munga. ($6500 in Year 1).

Supplies:

Software licenses: Software licenses are requested for conducting the statistical analysis associated with the project (ArcGIS, SAS and ERDAS Imagine) for the PI computer and the two student laptops. These licenses must be renewed each year.

Fuel/ Vehicle Maintenance: Frequent travel will occur between the highland and lowland sites and Kisumu, where our collaborating investigators live and work. A modest budget for car maintenance and fuel is requested. Costs also include the price of vehicle insurance for the three year period. $2000 for all three years

Malaria Drugs: Although drugs are currently provided free of charge at the local government health clinics, they are not always in stock. This will ensure that if we identify someone with malaria over the course of the study that there will be treatment available for them at the clinic. ($1200 all three years)

Malaria Diagnosis Supplies: This will include microscope slides, lancets, filter paper for blood spot collection and reagents. We will provide diagnostic supplies throughout the course of the study. (Year 1, $2000; Year 2, $1000; Year 3, $1200)

Office and Computer Supplies: This will cover duplication costs for surveys, in-depth interview protocols, and field data collection supplies, pens, notepads etc. ($360 each year for three years).

Pyrethrum Spray Catch Supplies: To determine the relative indoor resting densities of mosquitoes we will conduct PSC in a subset of houses in the cross-sectional survey. Spray guns, kerosene, sheets and collection vials will be needed. ($3000 Year 2).

Travel:

Round trip flights to Kenya: The PI, two students and the NCAR collaborator, Mary Hayden, will each travel to Kenya during the summer of each year. Round trip tickets to Kenya range from $1600 to $2000 each during the summer season. ($7000 all three years)

In-country travel: Cost to provide housing and board for the PI, two students and Mary Hayden during stay. This will also include fees such as flights between Kisumu and Nairobi as well as visa fees. Cost is budgeted to vary over the years but it will realistically be similar for all three years. (Year 1, $7000; Year 2, $6500; Year 3, $8000)

Conference travel: Cost to support the PI and two students to attend conferences for presentation of research findings during Year 2 and Year 3. If surplus funds are available at the end of Year 1, conference travel will be provided for the first two student interns. (Year 2 $3000, Year 3 $4000)

Other:

Field Assistants: Community members will be hired as field assistants throughout the duration of the project. In year 1, we will hire 5 field assistants to cover the 5 sublocations (2 lowlands, 3 highlands). In Year 2 and Year 3 we will require more field assistants to conduct the cross-sectional survey and in-depth interviews with positive deviants. (Year 1 $7200, Year 2 and 3; $11,520).

Participant incentives: We will provide a small compensatory gift for the time of focus group participants, key informants, cross-sectional participant households and positive deviant interviews. This will be a small household item such as sugar, flour, tea, soap etc. that will be determined during the focus group interview. (Year 1, $1000; Year 2, $4000; Year 3, $1200)

Cell phone credit: To ensure all staff have access to timely communication, we will budget for cell phone credit. ($500 all three years).

Program Manager: Maurice Agawo will act as the program manager for the project. Maurice will be in charge of coordinating all on-the ground field activities, training field assistants on PSC, managing funds when the PI is out of the country and ensuring continuity between sites. (Year 1, $6000; Year 2, $6000; Year 3, $6500)

Transcription/ Translation: We will require all in-depth interviews and focus groups to be translated. We will also require that all survey tools, consent forms and other documentation be translated into Swahili, Kinandi and Luo, the three dominant non-English language groups. More is budgeted for the years with a high level of in depth interviews and focus groups. (Year 1, $3750; Year 2, $1000; Year 3, $3500)

Database manager: This individual will develop the database entry program for the cross-sectional survey and the demographic/ census data for the study. (Year 1, $2500; Year 2, $2000; Year 3, $2000).

Clinical Officer top up: As we will require diagnosis of clinical malaria during the course of the study we will pay a supplement to the current clinical officers at the sites government health facilities for the extra work that they will be doing related to the project. It will also ensure that we have continuity between the field and the health center. ($3000 all three years).

Laptop: We will purchase two project laptops that student interns will use while on the project year (June to end May). These laptops will be passed to the incoming interns for the following year. ($2500 Year 1).

Computer support and maintenance: Maintenance of the PI computer while working on the project.

Publication fees: To ensure wide dissemination of research results we will publish in peer-reviewed journals. (Year 1, $1000; Year 2, $1800; Year 3, $2750).

RESEARCH & RELATED BUDGET - Cumulative Budget

		Totals ($)
Section A, Senior/Key Person		[redacted]
Section B, Other Personnel		[redacted]
Total Number Other Personnel	6	
Total Salary, Wages and Fringe Benefits (A+B)		[redacted]
Section C, Equipment		6,500.00
Section D, Travel		49,500.00
1. Domestic	7,000.00	
2. Foreign	42,500.00	
Section E, Participant/Trainee Support Costs		
1. Tuition/Fees/Health Insurance		
2. Stipends		
3. Travel		
4. Subsistence		
5. Other		
6. Number of Participants/Trainees		
Section F, Other Direct Costs		145,118.00
1. Materials and Supplies	21,080.00	
2. Publication Costs	5,550.00	
3. Consultant Services	34,400.00	
4. ADP/Computer Services	648.00	
5. Subawards/Consortium/Contractual Costs		
6. Equipment or Facility Rental/User Fees		
7. Alterations and Renovations		
8. Other 1	4,550.00	
9. Other 2	5,000.00	
10. Other 3	73,890.00	
Section G, Direct Costs (A thru F)		299,846.00
Section H, Indirect Costs		76,270.00
Section I, Total Direct and Indirect Costs (G + H)		376,116.00
Section J, Fee		

PHS 398 Cover Page Supplement

OMB Number: 0925-0001

1. Project Director / Principal Investigator (PD/PI)

Prefix:
* First Name: Kacey
Middle Name: C.
* Last Name: Ernst
Suffix: Ph.D.

2. Human Subjects

Clinical Trial? ☒ No ☐ Yes

* Agency-Defined Phase III Clinical Trial? ☐ No ☐ Yes

3. Applicant Organization Contact

Person to be contacted on matters involving this application

Prefix:
* First Name: Sherry
Middle Name: L.
* Last Name: Esham
Suffix:

* Phone Number: (520) 626-6000
Fax Number: (520) 626-4137
Email: sponsor@email.arizona.edu

* Title: Director, Sponsored Projects Services

* Street1: PO Box 3308
Street2:
* City: Tucson
County/Parish:
* State: AZ: Arizona
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 85722-3308

PHS 398 Cover Page Supplement

4. Human Embryonic Stem Cells

* Does the proposed project involve human embryonic stem cells? ☒ No ☐ Yes

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: http://stemcells.nih.gov/research/registry/. Or, if a specific stem cell line cannot be referenced at this time, please check the box indicating that one from the registry will be used:

Cell Line(s): ☐ Specific stem cell line cannot be referenced at this time. One from the registry will be used.

Tracking Number:GRANT10907252 Funding Opportunity Number:PA-10-070 Received Date:2011-06-22T19:05:16-04:00

OMB Number: 0925-0001

PHS 398 Research Plan

1. Application Type:

From SF 424 (R&R) Cover Page. The response provided on that page, regarding the type of application being submitted, is repeated for your reference, as you attach the appropriate sections of the Research Plan.

*Type of Application:

☒ New ☐ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

2. Research Plan Attachments:

Please attach applicable sections of the research plan, below.

1. Introduction to Application (for RESUBMISSION or REVISION only)		Add Attachment	Delete Attachment	View Attachment
2. Specific Aims	1241-SA.pdf	Add Attachment	Delete Attachment	View Attachment
3. *Research Strategy	1242-ResSt.pdf	Add Attachment	Delete Attachment	View Attachment
4. Inclusion Enrollment Report		Add Attachment	Delete Attachment	View Attachment
5. Progress Report Publication List		Add Attachment	Delete Attachment	View Attachment

Human Subjects Sections

6. Protection of Human Subjects	1243-Humnsubj.pdf	Add Attachment	Delete Attachment	View Attachment
7. Inclusion of Women and Minorities	1244-womeninc.pdf	Add Attachment	Delete Attachment	View Attachment
8. Targeted/Planned Enrollment Table	1245-enrolltbl.pdf	Add Attachment	Delete Attachment	View Attachment
9. Inclusion of Children	1246-childinc.pdf	Add Attachment	Delete Attachment	View Attachment

Other Research Plan Sections

10. Vertebrate Animals		Add Attachment	Delete Attachment	View Attachment
11. Select Agent Research		Add Attachment	Delete Attachment	View Attachment
12. Multiple PD/PI Leadership Plan		Add Attachment	Delete Attachment	View Attachment
13. Consortium/Contractual Arrangements		Add Attachment	Delete Attachment	View Attachment
14. Letters of Support	1247-LOS_final.pdf	Add Attachment	Delete Attachment	View Attachment
15. Resource Sharing Plan(s)		Add Attachment	Delete Attachment	View Attachment

16. Appendix Add Attachments | Remove Attachments | View Attachments

Specific Aims

Project Goals: Our overall goal is to determine multi-level social and environmental factors related to bednet ownership and use in two disparate transmission zones in western Kenya. We will translate this information into community-based interventions to improve bednet ownership and use of available bednets.

Key Observations: Despite dramatic improvements over the last decade, malaria remains a significant threat to the health and lives of millions of people [1]. While multiple control strategies exist, the most commonly implemented strategy is the use of bednets, specifically insecticide treated bednets (ITN). When used properly, ITN can reduce the incidence of malaria by as much as 50% [2]. As part of a concerted effort to reduce malaria transmission, over 500 million long-lasting insecticide treated bednets (LLIN) have been distributed to malaria endemic regions [1]. While some research has been conducted to determine the logistics of bednet distribution, fewer have examined what comes after an individual receives their bednet [3]. Evidence indicates that disuse of nets is not uncommon [4-9] and our preliminary data from Kenya indicates that as many as 1 in 6 children under 5 who have a bednet in the home are sleeping without a net. The reasons for not owning a net or not using available nets are likely complex and vary by cultural, social and environmental factors. Kenya is now gearing up to distribute enough nets to cover all household members at the ratio of one net per two people [10]. If research is not conducted to investigate and mediate determinants of disuse of distributed nets, these efforts may have a less than optimal impact on malaria transmission.

Specific Aims: We will pursue three aims to determine factors related to bednet ownership and use.

Aim 1: Use qualitative methods, focus group discussions and key informant interviews, to determine factors related to ITN ownership, use of the ITN and intra-household distribution. Hypothesis: Focus group discussions will reveal that individuals who do not own or use bednets will have fewer economic resources, less knowledge about malaria transmission, more difficulties in hanging bednets, express discomfort in using bednets, have lower perceived risk of malaria and its severity and less confidence in the effectiveness of bednets. Key informants will indicate that the opportunity to resell bednets, lapse in government supply, distrust in the government and limited access to the health clinic influence bednet ownership and use/disuse.

Aim 2: Determine the generalizability of themes identified through focus groups and in depth interviews (SA 1) and how the prevalence of ITN outcomes varies over a heterogeneous landscape. Hypothesis: We hypothesize that we will identify at least one-quarter of the households without a bednet and of those that own a bednet at least 15% will not use their ITN regularly. Greater rates of ownership and use will be found in the higher transmission lowland study site. Factors similar to those identified in SA1 will be found in the wider community. We further hypothesize that a community members perceived risk of malaria will correlate highly with their actual risk as determined by parasite prevalence and pyrethrum spray catches.

Aim 3: Use the positive deviance approach to explore why some households reported ITN use despite experiencing barriers identified in SA1 and SA2. Hypothesis: Individuals who own or use bednets despite experiencing barriers as identified through SA2 will have developed solutions to logistical difficulties in using bednets, will have overcome cultural issues with using the bednets and will have a more accurate perception of malaria transmission, risk and the ability of bednets to minimize this risk.

Design Overview: We will conduct focus group discussions with community members and key informant interviews with government health officials and community leaders to determine themes related to ITN ownership and use (SA1). We will then implement a cross-sectional survey to determine the generalizability of these themes. We will use remotely-sensed images and GIS to determine how these perceptions and practices vary geographically and if they correspond with actual risk determined through parasite prevalence surveys and pyrethrum spray catches of Anopheles (SA 2). We will identify positive deviants from the cross-sectional survey, community members who own and use bednets regularly despite experiencing at least 75% of the factors associated with not owning or using a bednet. We will conduct in-depth interviews to determine their solutions and motivators that may be used to maximize community bednet ownership and use (SA 3).

Impact: A critical barrier to reducing malaria transmission is the community participation in effective control strategies. We will be one of the first teams to investigate and identify multi-level cultural, social, behavioral and environmental factors related to bednet ownership and use. Our innovative use of the positive deviant method will identify community-based solutions that can be translated into broader scale interventions in future research.

A. Significance

A.1. Overview:

Malaria is the most significant vector-borne disease world-wide. In 2010, there were more than 247 million cases of malaria and an estimated 800,000 deaths [1]. Recent evidence indicates that at least in some regions, malaria deaths may be even higher than previously estimated [11]. Within the last decade, incremental steps have been taken towards elimination and eventual eradication of malaria. The Roll Back Malaria (RBM) Initiative launched in 1998 by the World Health Organization (WHO), Unite for Children (UNICEF), United Nations Development Program (UND), and the World Bank developed a strategic plan to reduce malaria morbidity and mortality; the Global Malaria Action Plan. The plan specified that control measures including insecticide treated nets (ITN), indoor residual spray and in some cases environmental control measures reach 80% of all households in endemic countries by 2010, a goal yet to be achieved.[1] Of these three suggested control measures, the distribution of ITN, specifically LLIN, has been the core focus of most malaria control programs. Use of ITN is considered to be one of the strongest strategies in the fight against malaria, reducing malaria incidence by an estimated 50% in endemic areas [2] and lowering all-cause mortality and morbidity rates in young children [12-14]. A staggering number of nets have been distributed in the years following the RBM Initiative, enough to protect 580 million people [1].

Most ITN distribution programs stop at the point of distribution. Rigorous follow-up studies of continued ownership, consistent use and barriers associated with using ITN for malaria control and persistence of insecticide under field conditions have been limited. Determining the level of disuse and identifying proposed solutions is critical to the success of malaria control programs. The actual level of disuse and misuse of nets (e.g. using nets for chicken coops, garden fencing, resale, fishing nets) is hotly contested as rigorous research has not been conducted in this area and some researchers indicate that this type of ill-founded information could hurt malaria control efforts [15]. Yet if disuse is a significant problem, and it appears from our preliminary research that it could be, not addressing these issues would have even more serious impacts on malaria control efforts. A recent review article determined that the current evidence is too weak to make any recommendations towards interventions to improve ITN compliance, citing poor study design and lack of research dedicated to this area [3]. As countries move towards elimination, knowledge of detailed dynamics of malaria control, implementation of control measures and impact on transmission is essential. If even small pockets of transmission remain in areas that are slated for elimination, resurgence could occur as it did in the 1960s, negating all efforts that are being made to reduce the worldwide malaria burden. Our research will explicitly determine the levels of misuse and disuse in two communities in western Kenya.

A critical research objective in the Malaria Research Agenda released by NIAID, is to "Better understand "field reality" (conditions in the field), including parasite, vector, behavioral, social, environmental, and other factors that contribute to changing malaria epidemiology and the use and effectiveness of interventions in the field." [16]. The following proposal will address this objective by 1) identifying behavioral and social barriers to ITN ownership and use, 2) identifying community-based solutions to barriers to ITN ownership and 3) developing strategies to implement interventions on a wider-scale.

A.2. Malaria in Kenya:

Kenya has the fifth highest burden of malaria in the world [17]. There were 9.7 million reported cases of clinical malaria in 2007, accounting for 30% of outpatient consultations [18]. Malaria causes an estimated 20% of deaths under age 5 in Kenya and is transmitted in all regions [18]. The variability in levels of transmission across Kenya represents a microcosm of what is occurring globally. Parasite prevalence in children under 5 is estimated at 17% in endemic areas, 1.4% in areas of seasonal malaria transmission (arid and semi-arid lowlands), 1% in epidemic prone areas, and 0.4% in malaria-free/ low risk transmission areas [18, 19]. We

[1] Please note that we will be using the terms ITN and bednet somewhat interchangeably throughout the proposal. As there is a distinct difference between protection conferred by ITN, untreated bednets and LLIN, we will distinguish these three categories in the analyses of data from this study.

propose to work in two different transmission zones where the use and impact of ITN are likely different [20]. This will allow us to make comparisons between areas of very different transmission risk, mimicking the transition many communities will make as control measures are intensified.

A.3. Malaria Control in Kenya:

Kenya has taken considerable steps to reduce the burden of malaria in the past decade by participating in and expanding control programs that include the use of ITN, but significant gaps remain in achieving targets. Kenya participates in the Rollback Malaria Initiative and on a national level, the Kenyan Ministry of Health developed the Kenyan National Malaria Strategy (KNMS) through the National Malaria Control Program (NMCP) [10]. In 1999, under the first KNMS, Kenya's Division of Malaria Control (DoMC) of the Ministry of Health (MoH) first recommended that nets should be provided to vulnerable populations at no charge [21]. Prior to implementation of KNMS, access to nets was limited. Since that time, both government and non-governmental organizations have led major ITN distribution programs. Data from sentinel districts demonstrate the efficacy of ITN use; children under 5 years of age using nets have a 44% lesser chance of dying than those who do not use a net. Data from a Demographic Surveillance Site in western Kenya showed a decline in parasite prevalence among children under 5 years of age from over 80% in 1999 to 26% in 2008, which coincides with the introduction of ITN and Artemisinin-Based Combination Therapy (ACTs) in that area [18]. The most recent report from the Demographic and Health Survey for Kenya [22] found that 61% of households nationwide own at least one mosquito net (treated or untreated), and 56% report owning at least one insecticide-treated net (ITN). Nationwide, 51 percent of children under 5 years of age and 53 percent of pregnant women slept under a mosquito net the night prior to the interview [22].

The Kenyan Ministry of Health recently updated the KNMS 2007 - 2017 [10]. The overall objective is a two-thirds reduction in malaria prevalence in the different epidemiological zones. To achieve this, one of the primary objectives is to attain 80% coverage of all households with appropriate control. This includes the continued distribution of ITN as a priority for decreasing malaria transmission and decreasing morbidity and mortality in pregnant women and young children. To reach the targeted level of 80% of individuals sleeping under an ITN, barriers to ITN ownership and use must be resolved.

A.4. Factors Associated with ITN Ownership and Use

To reduce malaria risk, individuals must not only own but use their ITN properly. Ownership, the first step in prevention, has been strongly associated with household wealth [6, 23-27]. It is not surprising then that free distribution of ITN has had more success in reducing disparities in Kenya while social marketing and subsidized low cost ITN were less effective at reducing these disparities [25]. Other factors traditionally associated with ITN ownership include education level of household head [6, 23, 24] region of residence [28] and presence of an individual from a high risk group in the household [23].

While high bednet coverage has been shown to have indirect community effects [29, 30], the greatest reduction in risk is at a household level to those sleeping under them [31]. Ensuring that limited ITN are used by high risk groups or used at all requires solutions more complex than the distribution of free ITN. One in five households owns an ITN that is not being used, even when household members are sleeping without an ITN [1]. This disconnection between ITN ownership and subsequent use raises an important question that has begun to receive more attention in recent years. Much is still unclear and reasons are likely culturally and contextually variable, but lack of use, or misuse, of ITN is widely reported [4-9]. Individuals have consistently reported using ITN for nuisance reduction of mosquitoes but not to prevent malaria [4, 7, 8, 32, 33], likely due to lack of knowledge about malaria transmission and lower perceived risk of the disease [7, 32, 34]. It has also been reported that ITN have been used for purposes other than as a bednet including as fishing nets [7, 35]. Many of the reasons for not using an ITN are linked to cultural beliefs. In Kenya, white ITN resemble shrouds and sleeping under them was reported as bad luck [34] or physical discomfort associated with high temperatures and lack of air circulation [3]. Some research also indicates that even when ITN are used, it may not be pregnant women and children under 5 who are sleeping under them [36, 37]. While current recommendations promote use of ITN by all household members, when there are limited numbers, high risk

groups should still be the priority for ITN use. This lack of use, particularly in areas where transmission is low, is a monumental hurdle that must be overcome if control efforts are to transition into elimination.

A.5. Malaria Risk Perception.
As indicated in the previous sections, malaria parasite prevalence and thus risk of incident infection has gone down dramatically in the past decade. This change in risk will likely influence how malaria is perceived and the measures individuals will take to control malaria. Additionally, increases in ITN coverage have led to overall declines in mosquito populations [38] and a shift in the composition of the Anopheles species away from the more endophilic *An. gambiae* s.s. towards the more exophilic *An. arabiensis* [39]. This may lead to more transmission occurring during time spent out of doors in areas with higher ITN coverage. To date, no study has examined the community perception of this changing risk in relation to ITN coverage.

Community perceptions of monthly malaria risk have recently been shown to mirror actual diagnoses of malaria in Gussia, Kenya [40]. A study of the perception of high risk *An. gambiae* s.l. breeding sites revealed that community members were able to correctly identify that most habitats were man-made, though knowledge of vector bionomics was very limited [41]. Malaria transmission clusters highly around breeding sites and can result in persistent foci of transmission [42-45]. The use of bednets has also been shown to cluster but not in direct correspondence to actual malaria risk but rather to indicators of mosquito density [33]. We will explore whether there is a correlation between geographic risk perception and actual risk as it varies over a landscape and if this modifies the degree to which bednets are owned or used. We will further explore if community members notice a shift in vector feeding patterns and how this impacts their use of bednets. If indeed community members have recognized that transmission may be more likely to occur out of doors or that levels of malaria transmission are now lower, this could alter their approach to malaria control and has implications for the sustainability of ITN as an isolated malaria control strategy.

A.6. Implications for Research Needs.
Insecticide treated nets are at the core of reducing malaria morbidity and mortality. While the potential for new technologies such as vaccines and genetically modified mosquitoes is growing, these technologies are at best years away from being fully implemented in the field. As current strategies turn from malaria control to elimination in sub-Saharan Africa, it is critical to identify subpopulations that either lack access to ITN or who, despite ownership of ITN, do not use them regularly. Acknowledging and recognizing both barriers and promoters of ITN ownership and use is critical to the success of malaria campaigns. Currently very little is known about the efficiency, acceptability and engagement of community members in malaria control efforts. These are highlighted as critical gaps in knowledge that need to be addressed before elimination and eventually eradication of malaria can be achieved [46, 47].

B.1. Innovation.

- *We will use a mixed-methods approach to identify barriers and promotors of ITN use.* This strategy will allow us to identify more complex relationships than traditional cross-sectional or case-control studies. It will also allow us to determine the generalizability of these themes to the broader community, which is often not possible with strictly qualitative research.

- *We will use the positive deviance approach to determine community-level strategies to overcome barriers to ITN ownership and use.* The usual problem-solving approach in public health is to focus on identifying reasons for low ITN coverage or use in the community and rely on experts to put forth solutions. These "solutions" often encounter resistance because they are not culturally acceptable or logistically feasible. We will employ a multi-stage approach to identify "positive deviants", those individuals who despite the odds, as determined through analysis of cross-sectional data, [Specific Aim 2], own and use their ITN regularly to prevent malaria. In-depth interviews will be held with selected individuals to determine their solutions with the intent of disseminating this knowledge throughout the community. The positive deviance approach has been shown to reveal more complex behaviors influencing health outcomes (Lapping, 2002 #37) and has been successfully applied to other intractable problems such as childhood malnutrition, birth outcomes and poor infant health [48-51]. It has not been applied previously to malaria control efforts.

- *Our study sites are located in high transmission and low transmission areas that have not had prior intensive malaria research conducted.* It is likely that perceptions of severity and risk of infection varies by level of transmission. Identifying how communities with higher levels of transmission approach malaria control as compared to those with low levels of transmission may shed light onto the potential transitions that could take place as overall malaria levels decline. We will determine if people with low disease burden, but severe outcomes, approach controlling malaria differently than those who have high disease burden but less severity and how this differs by age of those at risk of clinical malaria. Many of the previous studies of ITN use have been conducted in sites under investigation for malaria for years, while this is excellent for many research agendas, individuals residing in heavily researched communities may have more knowledge and respond differently to malaria control than the general population. Our sites are newly developed and may better represent general communities.

- *We will conduct a spatial analysis of malaria risk perception and actual malaria transmission risk.* Household perception of risk will likely be one factor strongly associated with the use of bednets or other malaria control measures. We will explicitly examine whether perception of risk at the household level accurately reflects relative transmission as it varies across the landscape.

C. Approach

C.1.1. Preliminary Data

C.1.1.1. Factors Related to Bednet Use:

The principal investigator conducted a population-based case-control study that examined malaria risk in Kipsamoite and Kapsisiywa sublocations in the Nandi District of western Kenya in 2004 [52]. A total of 1488 people were surveyed. A retrospective analysis of ITN in this population demonstrated very low ITN use at the time; 15% (n = 172) of people reported owning a net in their household and 52% (n=90) of those were treated nets. Use of these nets was low with about one-third of individuals owning a net sleeping under it the night prior with use increasing to just over half for children under the age of 5. Transmission is highly seasonal in this area so it would be expected that our data collected during the high transmission period would reflect the higher use period in the community of bednets. While it is almost certain that bednet coverage has improved since that time, perceptions and behaviors regarding ITN use may not. Consistent with other studies, a multivariate analysis revealed that households were more likely to own a bednet if they were in the wealthiest quartile (OR = 4.8 (2.9, 7.9)) and if the female household head had higher than a high school education (OR = 2.3 (1.4, 4.0)). A multivariate model of use of these nets revealed that in households owning bednets, participants were more likely to use the bednet if they were under age 5 years (OR = 3.4 (1.7, 6.8)), reported a high level of nuisance insects (OR = 2.7 (1.2, 5.9)), slept in a bed (OR=2.7 (1.2, 6.1) and also used mosquitoes coils (OR=7.3 (1.4, 38.5)). Conversations with individuals in the community revealed that many people wanted bednets but didn't know where to obtain them or couldn't afford them. Those who did own bednets said that they did not always use them as they didn't like putting them up and down.

C.1.1.2. Development of Proposed Study Site:

We are proposing to work in a neighboring highland community, Kapkangani and in Miwani, Kenya, an adjacent lowland site. The principal investigator worked in the lowland site in 2001 and has maintained contact with community members and former field research team members. These two study sites are currently under development. In late 2010, the PI went to Kenya to meet with village chiefs and elders to garner support for malaria research in the community. Presentations were made to the community and study sites were censused and mapped. The Kapkangani site was completed in February 2011 (Figure 1). A total of 4892 households have been mapped in the three sublocations in Kapkangani location and 515 households were mapped in Miwani in two

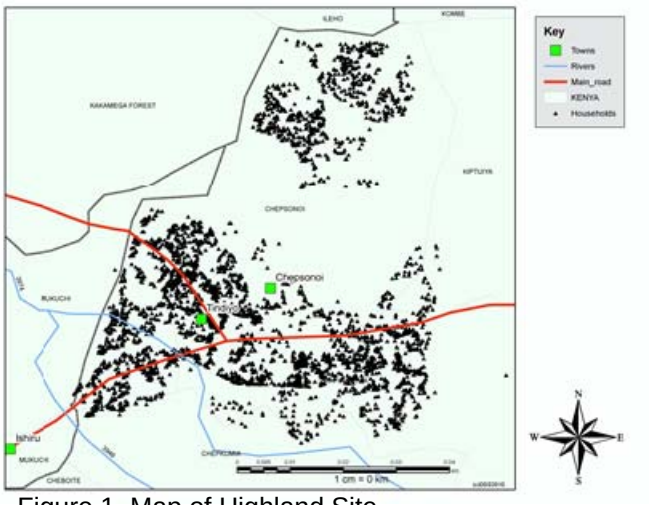

Figure 1. Map of Highland Site

sublocations, Kaber West and Kabar Central. Mapping in additional lowland communities in the Miwani area is ongoing.

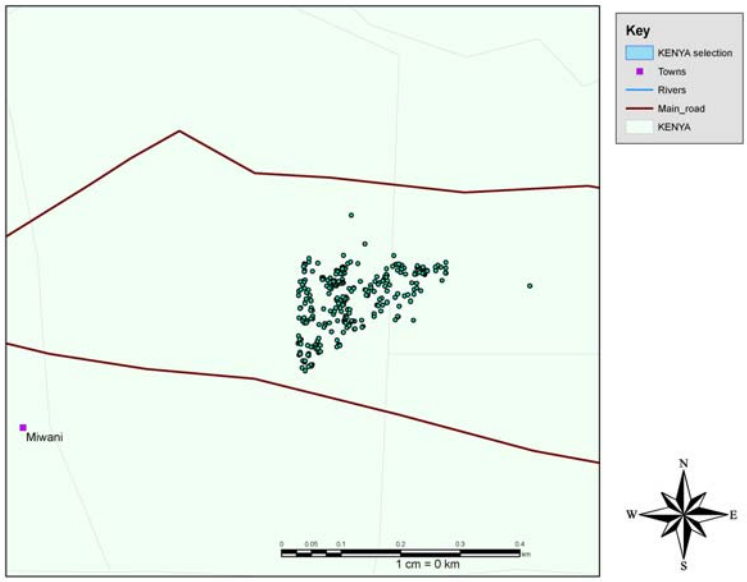

Figure 2. Map of lowland study site

C.1.1.3. Informal Qualitative Findings:
Informal key informant interviews were conducted while on site with area clinic staff and district health personnel. Nursing staff with the governmental ITN distribution program indicated that women receiving ITN during prenatal and postnatal visits are selling them once off clinic grounds for the equivalent of $1-$2 USD. Misuse of ITN was noted while walking through the study site communities. In the lowland Miwani site health clinic personnel indicated that community members used ITN for fencing around vegetable gardens. We saw evidence of this practice while walking through the study sites (Figure 3). In the highlands, bednets were reportedly used to cover juvenile tea plants and to line tea collection baskets. Whether these were old nets deemed no longer effective is not known, however the ITN used for the fencing in Figure 3 appeared intact. Village elders indicated that there was still a general lack of community awareness of why ITN should be used year-round particularly in the highland areas. Public health officials from the Nandi District Health office in the highlands also indicated that barriers to ownership may be on the rise as cuts to donor funding reduced the number of available ITN. The age limit for free distribution was lowered from under 5 years of age to under 1 year of age. This on the ground information runs counter to current government policy of providing a net for every two household members. Families who had not already received ITN for older children would be at a disadvantage for obtaining ITN. Some information was also gathered on indoor residual spray. In years past, all houses have been sprayed but in the most recent year, only focal spraying was conducted. This led to distrust among community members because of a lack of understanding about why only certain people had their homes sprayed, and it generated a heated discussion during the community meeting attended by the PI and collaborators.

Figure 3. ITN being used as fencing in lowland site (Taken 8-2010)

C.1.1.3. Malaria in Highland Region of Proposed Study Site:

A review of clinical records conducted by nursing personnel indicated that there are still significant numbers of malaria cases reporting to the clinic. These are lab confirmed cases by microscopy (Figure 4). While there is some variability by sublocation (Figure 5) all have incidence rates exceeding 70 per 1000 during at least one month of the year. These are likely an underestimate of the true malaria burden that remains in this area. A study conducted by the PI and collaborators indicates that microscopy misses nearly 20% of cases that can be detected using PCR [53]. In addition, these data are biased towards individuals who have the ability and resources to travel to the clinic when they are ill. Data on the malaria burden in the lowland sites are currently being collected.

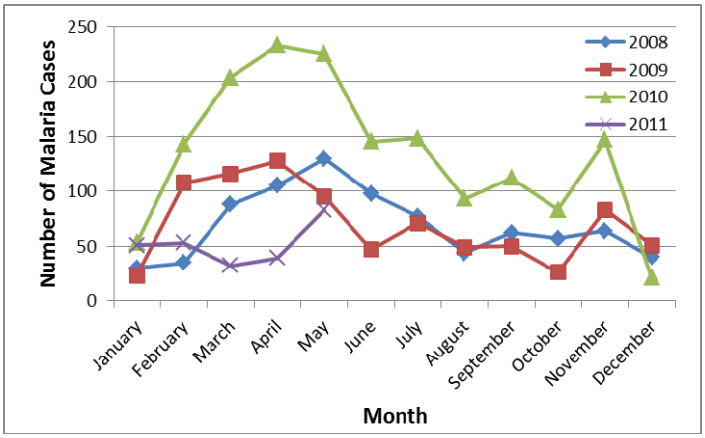

Figure 4. Malaria cases by year and month (2008-2011) Kapkangani location, Kenya: the highland site

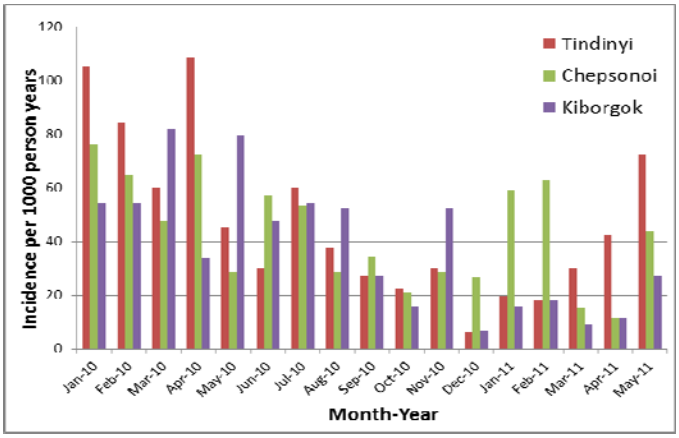

Figure 5. Malaria incidence January 2010 to present in the three Kapkangani sublocations

C.1.1.4. Analysis of Kenyan Demographic and Health Survey Data:

We recently completed an analysis of Kenyan Demographic and Health Survey data delineating factors associated with bednet use outcomes in children under 5. We compared three non-use outcomes to children who did sleep under any bednet (ITN or otherwise). The non-use categories were 1) household did not own a bednet of any kind 2) household did own bednet(s) and all were used but not for that child (intra-household distribution) and 3) household did own bednets and at least one of the bednets in the household was not being used (disuse) (to be submitted, July 2011). Our results underscored the complexity of factors underlying ITN ownership and use and we found that factors associated with the three non-use categories differed. Key findings included a persistent association with ITN ownership and wealth despite free ITN distribution systems in Kenya; individuals in the highest wealth quintile were five times more likely to own a bednet than those in the lowest quintile. Mothers who accessed antenatal services or treatment for a health problem were also more likely to own ITN. We also identified an apparent marginalization of children whose mothers were peripheral household members (i.e. nieces, grandchildren, daughters-in-law). The magnitude of this association was greatest in the analysis of intra-household distribution of nets. When all ITN were used in a home, children whose mothers were peripheral household members were nearly 4 times more likely to sleep without an ITN than children of household heads. These results indicate that despite free distribution ITN may still not be reaching some of the most vulnerable populations. Our results also indicated that risk perception may be a driving factor for actual use of owned bednets as children residing in highland areas and in communities where fever was not a trigger to seek medical care, were more likely to sleep without a bednet. Logistical difficulties were also implicated as individuals residing in homes with poorer structural indicators were less likely to own and use ITN even after adjustment for wealth and other potential confounders.

C.2.1. Specific Aim 1: To determine factors related to ITN ownership, use of the ITN and intra-household distribution.

C.2.1.1. Summary of Aim 1 Approach

Focus groups and key informant interviews will be held in Miwani, Kenya and Kapkangani, Kenya to explore concepts surrounding ITN ownership and use. We will use the socio-ecological model of health to frame the semi-structured interview guide and explore both contextual and individual level factors related to ITN ownership and ITN use. We will explicitly explore factors related to ITN/ bednet ownership, the factors that determine if nets get used and how households determine who sleeps under a limited number of nets.

C.2.1.2. Study Sites

Kapkangani, Kenya is located in Nandi District in the western Kenyan highlands. Altitude ranges from approximately 1600m – 2100 m. Malaria transmission in this area is low and unstable with acute seasonal peaks generally after the peak rains in April-May. The population is primarily indigenous Kalenjin people and Luhya settlers from neighboring highland areas. The primary occupation is rural subsistence agriculture, while

some work as casual laborers on local tea estates. By contrast, Miwani, Kenya is located on the Kano Plain in western Kenya, 30 km east of Kisumu. Altitude is approximately 1200m above sea level. Malaria transmission in this area is holo-endemic and occurs year-round. People are primarily of the Luo tribe and are subsistence farmers with some casual labor in the nearby sugarcane plantations. Prior to initiation of research, all mapped households will be updated and births, deaths, outmigration and inmigration will be recorded and the census with adjusted accordingly. Age and sex of all occupants will be recorded. Current demographic surveillance data indicates a total of 4892 households in Kapkangani and 515 households in Miwani.

C.2.1.3. Focus groups discussions (FGD).
Field assistants will be trained using established methods [54]. Four focus groups discussions (FGD) will be held for residents in Kapkangani, Kenya and four focus groups will be held for residents of Miwani, Kenya. Approximately 6-8 participants will be chosen to reflect differing ages, gender and parental status. In Miwani, Kenya, we will include men and women who have young children, those at most risk of malaria as well as older people who have great influence in family decision making in the discussions. In Kapkangani, Kenya, malaria is seasonal and people of all ages can experience severe illness when infected. We will choose participants to reflect the general community and include participants from both young adult through older age groups. All FGDs will be tape recorded and notes will be taken to ensure accuracy in translation and content. Topics to be discussed will follow the socio-ecological model with a nested individual-level health belief model and include 1) perceptions of the severity of malaria 2) perceptions of risk of malaria and how this has changed since malaria control efforts have increased 3) perceived benefits of ITN use 4) perceived barriers to ITN use 5) cues to action such as health promotion programs and public media campaigns and 6) confidence in the subject's ability to obtain an ITN and use it properly.

C.2.1.4. Key informant interviews (KII)
To gain more insight into the environmental context of ITN ownership and use we will conduct in-depth one on one interviews with individuals at multiple levels including 1) church leaders 2) village chiefs 3) village elders to provide local community perspectives. We will gain more information from local health care providers and government policy makers by interviewing 1) nurses 2) clinical officers 3) district health officers and 4) vector control staff. A snowball sampling approach will be employed to identify further key informants for interviews [55].

C.2.1.5. Data Analysis of FGD and KII
FGDs data will be translated and transcribed into Nvivo 9.0 for analysis. Data will be coded and themes and subthemes will be identified by investigators. We will use a combination of content and thematic analysis, both allowing themes to emerge from the data while analyzing by pre-determined themes. Pre-determined themes will include assessments of the key components of the health belief model as referenced in C.2.1.3. We will also explore perceptions of changing risk from five years prior when malaria control efforts were just being ramped up to present. We will target identification of changes in vector behavior as a sub-category that determines risk perception.

C.2.1.6. Potential Challenges and Proposed Solutions
There may be resistance/ reluctance of participants to reveal their true use of ITN. In addition, there has been some resistance to admitting to owning a bednet in preliminary studies as there is anticipation that they may get one free if they state that they do not currently have a net. We will work with local community field assistants and health workers to identify the most appropriate strategy to improving the quality of data obtained. This will include the use of both experienced focus group facilitators as well as a local field assistant who can help contextualize and clarify inconsistencies. In addition we will make clear that no nets will be distributed at this point in the project and that if we do distribute nets all individuals would be included regardless of current ownership as many nets may be aging out of effectiveness. Further, all focus groups will be held in the local language to ensure participation across all educational levels. This will require translation of all interviews into English prior to analysis. We will have at least two translators independently translate the content of focus group discussions. Inconsistencies will be reviewed by a third translator to ensure accuracy of the results. Most of the key informants will likely speak English and while this will make translation easier we will still ensure that transcription is conducted by local Kenyan staff to ensure correct interpretations.

Specific Aim 2. Determine the generalizability of themes identified through focus groups and in depth interviews (SA 1) and how the prevalence of ITN outcomes varies over a heterogeneous landscape.

C.2.2.1. Summary of Aim 2 Approach

To determine the generalizability of themes identified in focus groups and in-depth interviews, we will conduct cross-sectional surveys in the two study sites in Year 2. A combination of open and closed-ended questions will be used to quantify and explore hypotheses related to ITN ownership and use. We will also determine the spatial distribution of the four major outcomes as they relate to a variable landscape and actual level of transmission.

C.2.2.2. Study Design

A cross-sectional survey will be implemented in Year 2. Index households listed in updated census data will be drawn with sample proportional to size for each village, to ensure a sample distributed across all ecological classes. Field assistants will conduct household surveys (HHS) in the index household as well as up to three households within the 100m boundary of the index household. The HHS will have two components, an orally administered questionnaire and an observational assessment (OS) of bednets, housing structure and surrounding environment (Table 1).

C.2.2.3. Sample size determination

Sample sizes for Miwani, Kenya and Kapkangani, Kenya are different and reflect the estimated ITN ownership and use in these areas. In Miwani, we assumed 65% of households will own at least one ITN yielding a required sample size of 494 households. To obtain a comparable number to examine use we assume that 65% of households will use their bednets and multiply 494*1/.65 = 760. We assume an estimated 50% of households in Kapkangani will own nets and 50% of these ITN will be used, yielding an estimated 416 households for ownership and 624 households for use. All sample size calculations were calculated to reflect the number of households required to detect an OR = 1.75 with power = 0.80 and alpha = 0.05. All estimates of ownership and use are conservative to ensure adequate sample size for analysis. We are using households as the unit of observation for all sample size calculations as this will provide the minimum households needed for analysis of household level ITN ownership. For analysis of interhousehold use the unit of analysis will be the individual household members. This will result in a sample size of an estimated 4500 individual residents in the combined total households from Miwani and Kapkangani.

C.2.2.4. Prevalence of parasitemia

During the cross-sectional survey, household members will be asked to provide a fingerprick blood sample for testing via standard microscopic techniques. Those testing positive will be treated. Blood spots will also be taken on filter paper and archived for future analysis.

C.2.2.5. Indoor resting density

Indoor resting densities will be determined for a random sub-sample of 35% of the households chosen for the cross-sectional study. Established entomological survey methods using pyrethrum spray catches will be followed. This will allow us to validate our predictions of higher vector activity as it is relates to the micro-environmental variables assessed in C.2.2.2 and Table 1.

C.2.2.6. Potential Explanatory Variables:

We provide an initial short list of variables identified in preliminary studies and literature review (Table 1.)

Table 1. Short list of potential factors related to bednet ownership and use

Variable	Rationale	Source	Ownership/ Use/ Both
Individual Factors			
Age	Risk perception	HHS	U
Relationship to household head	Access to resources	HHS	B
Education level of individual	Knowledge about malaria and control	HHS	B

Sleeping space	Ability to hang the net in personal sleeping area	HHS	U
Sleeping arrangement	Individual sleeps with higher risk individual more likely to be using an ITN (i.e. pregnant woman or child < 5 years.	HHS	U
Female Household Head Factors			
Education level	Knowledge about malaria and control	HHS	B
Access to antenatal services and health care	Access to freely distributed nets	HHS	B
Control over purchasing	Ability to travel to obtain nets or purchase them	HHS	O
Understands how malaria is Transmitted	Perceived value of using the ITN	HHS	B
Knows where to obtain nets	Ability to obtain a net for use	HHS	O
Knows someone who has died from Malaria	Perception of severity	HHS	B
Believes bednets are effective at preventing malaria	Perceived value of using the ITN	HHS	B
Household Environment			
Have had case of malaria within past Year	Risk perception	HHS	B
Indoor residual spray	Perception of reduced need for net	HHS	B
Indoor permeability to mosquitoes and other insects (i.e. screens)	Allows access to nuisance insects that may influence use of nets.	HHS/ OS	B
Housing construction and quality	Structural integrity to hang nets	HHS/ OS	B
Household lot vegetation	Vector density and perceived/ actual risk	HHS/ RS	B
Distance to different ecological classes: swamps, rivers, forests	Vector density and perceived/ actual risk	RS/ GIS	B
Bednet Factors			
Color of the net	White nets have been associated with funeral shrouds	HHS/ OS	U
Integrity of the net (holes)	Perceived protective capability of the net	HHS/ OS	U
Size of the net	Difficulty in hanging or too small to cover sleeping area	HHS/ OS	U
Community-level factors			
Level of malaria transmission in the community	Perceived risk of malaria	CD/ HHS	B
Deaths attributable to malaria in the community	Perceived severity of contracting malaria	CD	B
Knowledge, attitude and practices of malaria control in community leaders	Leaders may directly or indirectly encourage use of malaria control measures	HHS/ KII	B
Altitude/ Topography	Perceived/ Actual risk	RS/ GIS	B
Climate/ Weather	Comfort/ discomfort in sleeping under net	RS	B

HHS = Household survey; OS = Observational Data; CD = Clinic Data; KII = Key Informant Interview; GIS = Geographic Information System Data; RS = Remotely-sensed data

C.2.2.7. Data Analysis

C.2.2.7.1. Overall Approach: Correlation matrices will be generated to evaluate which variables are related to ITN ownership or use. Those variables found to be significant will be analyzed for multi-co linearity. Adjustments will be made accordingly by standardization around the mean, or by selection of the best variable. A logistic regression model will be constructed to analyze the relationships between each specific bednet outcome and suspected risk factors. Then, a variogram will be computed of the standardized residuals to estimate spatial auto-correlation. The function will be defined and applied to the standard errors of the parameters from the logistic regression model. This will increase the value of the standard errors and parameters determined to have nominal significance will be removed.

Separate analyses for ITN ownership and use will be conducted. For ITN ownership, we will use household-level analyses, households without ITN will be designated as "cases," and households that have at least one ITN will be considered as "controls" for the purposes of logistic regression analysis. For ITN use, we will determine for each household the individuals that slept under an ITN the night before the interview. An exchangeable correlation matrix will be used to adjust for correlation among members of the same household while those from different households will be considered independent of each other. Moran's I statistics will be used to assess model residuals for spatial autocorrelation in ArcGIS (v. 9.1 ESRI, Redlands, CA).

C.2.2.7.2. Spatial distribution of ITN Ownership/ Use and Perceived and Actual Risk: As part of the HHS individuals will be asked questions to establish their perception of the risk of malaria transmission during the sampling period. A categorical variable will be generated for risk perception (low, medium, high) and compared to actual risk as defined by 1) malaria transmission within the household cluster in question and 2) relative Anopheles densities as defined by pyrethrum spray catches. Clustered households will be used to look at inter and intra correlations between risk perception, ownership and actual use in multiple spatial levels.

C.2.2.8. Potential challenges and proposed solutions:

We may identify index households that do not have residents within a 100m boundary. If this is the case, we will still use that household as its own "cluster". This would, in fact, allow us to explicitly explore differences based on varying population densities. Additionally, we may have index households who participate but whose neighbors are unwilling to participate. In this case we will keep the index household data but will redraw another index household to replace the one with incomplete data. To prevent these types of refusals as much as possible, we will hold community meetings with village elders and residents to explain the research and answer any questions and concerns that they may have. Garnering support of the community in this fashion can greatly improve response rates.

Specific Aim 3: Use the positive deviance approach to explore why some households reported ITN use despite experiencing barriers identified in SA1 and SA2.

C.2.3.1 Summary of Aim 2 Approach

Individuals who use an ITN despite reporting at least 75% of factors determined to be associated with lack of use of ITN will be administered semi-structured interviews to determine more complex motivations and behaviors that facilitate use of the ITN.

C.2.3.2. Identifying the Positive Deviants

Factors associated with using an ITN the night before interview will be ranked according to the strength of their association. We will look in the database from the cross-sectional survey to identify individuals who report experiencing at least 75% of factors associated with lack of ITN use yet still report using ITN the night before interview. These community members will be approached to ask if they are willing to participate in an in-depth interview.

C.2.3.3. Data collection

We will conduct a semi-structured interview in the home of the identified positive deviants. We will request that both the male and female household head are interviewed. This will be done separately or together depending on what is deemed appropriate by cultural standards and to ensure open dialogue. We are particularly

interested in looking for individuals that report having factors that are associated with logistical difficulties of ITN use but still use their ITN. For example, those who do not sleep in a bed but still use their ITN may have developed simple solutions to make it easy to use the ITN. We will additionally be looking for things like personal stories that may serve as scenarios or case studies during education programs for the wider community.

C.2.3.4. Potential challenges and proposed solutions

We expect that this aim should be well-received by the community as it will serve to highlight households that are contributing to the health of their families and the community by preventing malaria. There may, however, be some confusion in the community as to why these individuals are being singled out for interview. As stated previously, clear, open communication with the community is the best strategy to mitigate these types of concerns. Before the implementation of SA3, we will explain the next aspect of the study is following a selection of individuals to learn more about potential solutions.

C.3. Educational Development

Although not a required component of an R15 proposal, we have included here a brief description of the training to be conducted. We will provide the opportunity for 3 BS students and 3 MPH students to work overseas with the principal investigator and the investigative team for 2.5 months each summer. Students will have the experience of conducting field research. While in Kenya, students will have the opportunity to meet scientists working for CDC, WRAIR and other Universities at the Kenyan Medical Research Institute in Kisian, Kenya. Many of these MPH students may go on to pursue doctoral level degrees and this is an excellent way for them to network and identify further research ideas that can be carried out during their doctoral work. We will also collaborate with a University of Maseno doctoral student. This close connection between a Kenyan graduate student and the MPH students will expose them to the educational systems outside of their own institution. This will also further ties between the principal investigator and Maseno University. She is currently a member of two doctoral committees for Maseno University students pursuing malaria research. I have budgeted additional travel for each MPH student to attend a conference of their choice to present their findings. This experience will allow them to develop as professionals and expose them to issues in the broader field of public health.

C.4. Evaluation of Methods and Feasibility

Community engagement is one of the first hurdles to conducting research of this nature. We have already allied with the elders and government officials in these areas. The principal investigator has resided in rural highland areas of western Kenya for over a year and in urban areas for two and a half years. She has developed relationships with the Kenyan Medical Research Institute (the premier health research institute in Kenya), the Kenyan Ministry of Health, and Maseno University that will greatly facilitate the execution of all aspects of this project. Dr. Munga is a well-respected scientist at KEMRI who will act as the on-site co-investigator for the project. The proposed program manager, Maurice Agawo, is highly experienced having worked for the Walter Reed Army Institute of research for nearly 20 years. He has led many field projects for research scientists over the years. The principal investigator plans to spend up to three months each year of the project in Kenya working with the team and graduate students to develop protocols and trainings.

C.5. Future studies and potential for parallel studies:

This first study is seen as an initial step to addressing multiple questions about the evolution of malaria transmission and control in high and low transmission settings. The natural next step will be to test interventions suggested by the results of this proposal. We expect that these may entail structural changes to make using ITN easier, education campaigns, which we may propose be implemented through the school system; i.e. using health messengers or more intensive social marketing through personal profiles of the impact of malaria.

The methods used in this study will allow us to explore not only the questions explicitly outlined in this proposal but many other questions surrounding malaria transmission as it is occurring in sites with different transmission dynamics. As all households have been mapped, we can address questions about spatial clustering of cases and identify factors that may facilitate foci of transmission. Specifically, we can test the model developed in

preliminary studies to determine if topographically-derived wetness indices correlate with transmission even under control conditions [56, 57]. Understanding these dynamics can lead to the development of more rigorous surveillance and treatment protocols when cases are identified during elimination campaigns.

The highland site is bisected by a major roadway and the mobility of people on the periphery is greater than that of individuals in the interior. Working with partners such as Dr. Chandy John, we can develop proposals to look at the genetic diversity in populations with varying degrees of spatial mobility. Potential for introduction of new strains could be explicitly examined as individuals move between the lowland and highland areas.

C.6. Timeline of Proposed Research.

Table 2. Timeline for proposed research .

Activity	2012	2013	2014	2015
IRB approval (University of Arizona)	----------			
IRB approval (KEMRI)		----------		
Field assistant training		---		
Focus group discussions (FGD) and KII		**-----**		
Transcription and Analysis of focus group discussions		-------		
Development of survey tool			--	
Cross-sectional survey			-------	
Analysis Cross-Sectional			---	
Positive Deviant Interviews			----	
Transcription/ Analysis In-depth Interview			----	
Focus groups/ pilot test suggested interventions			-----	
Develop manuscripts and new proposals			----------	

- Each dash represents roughly one month

Human subjects.

1. **Human Subjects Involvement:** The primary contact with individuals during this survey will be through orally administered surveys (SA 2), in-depth interviews (SA1 and SA 3) and focus group discussions (SA2). We will also be conducting standard malaria testing using fingerprick blood sampling methods and collecting filter paper blood spots for future genotyping of the parasite.

2. **Source of Materials:** Focus group interviews will be held at the local clinics or sublocation chief's office, whichever setting is considered more acceptable to the focus group participants (SA 1). Key informant interviews will be arranged individually at the interviewee's convenience, they will choose the setting for the interview (SA 1). The cross-sectional survey will take place at the participant's home as will follow-up in-depth interviews with the identified positive deviants (SA 3). If any positive deviant participant prefers to be interviewed at a different location we will accommodate them (SA 3). We will identify participants receiving LLIN at the clinic and will follow up with them after one week to determine use of LLIN and factors that may be preventing them from using the LLIN.

3. **Risks to the subjects**: The risks to participants are minimal.

   SA1. In focus groups, sharing their knowledge, or lack thereof, may make some participants uncomfortable. We will however, be asking for volunteers, so those individuals who do not like to share information in a group setting may be unlikely to participate. Individuals will be told they can choose to leave the discussion at anytime. For key
   SA2: Malaria blood testing procedures will incur the most risk, but this is still minimal as these are very standard procedures that require minimal blood collection. The primary risks associated with this testing include mild discomfort with the fingerpoke and potentially mild swelling at the site of the poke. To minimize discomfort and minimize risk of cross-contamination with blood products we will use single use spring-loaded needle lancets. For the survey administration (SA 2) there are no foreseen risks to the subjects other than mild inconvenience to answer questions and allowing someone to conduct pyrethrum spray catches in their home. The outcomes of interest, bednet ownership/ use and malaria, are not associated with stigma and most explanatory data should not be sensitive in nature and will include demographics, individual relationships to household head, knowledge, attitudes and practices of malaria and malaria control, household structure, environmental assessments etc. The most sensitive questions will likely be those relating to socioeconomic position, access to resources and for the women perhaps their relationship to other household members if it is a strained relationship. While these questions may make subjects somewhat uncomfortable, none of these questions should lead to any physical risk for the participants and only minimal emotional risks.
   SA3: We will be conducting in depth interviews. While there is the potential for uncomfortable questions (e.g. finances, support from spouse, loss of a loved one to malaria) individuals who are properly implementing bednet use may actually feel happy to share their knowledge.

4. **Adequacy of protection against risks**:

   SA 1: Focus group participants will be volunteers from the community recruited at village meetings or the health center (SA 1). Key informants will be recruited by email, personal contact or phone call to schedule an appointment for a meeting. They will be allowed to decline at any time (SA 1). All interviews and focus groups will be taped and transcribed and translated into English. When we are assured that all transcriptions are accurate we will destroy the recordings (SA 1).
   SA 2: Household heads will be approached after selection from the census using clustered random sampling. Female household heads will be the primary interviewee as this is standard in the literature and they are more likely to know the details of the household. For all parts of the study consent forms will be translated into Luhya, Luo, Kinandi and Swahili and back-translated to ensure that participants understand the forms they are signing. Participants who are literate can read their forms if not the field assistants will read the forms for them. They will sign or make a mark to indicate they understood the consent. Children ages 12 to 18 will be asked to assent to a finger prick blood test. For children under age 12 we will obtain

parental consent. Any participant identified with parasites in their blood through standard microscopy will be provided malaria treatment free of charge. We will work with government clinic staff in each of the study sites to ensure that a health officer is present to review the results of the blood smears and provide the proper malaria medications as needed.
SA 3: Positive deviants will be identified and we will conduct an in depth interview in the home. Similar protocols as above will be followed with written consent obtained, recording of the interview, transcription/ translation and destruction of audio recordings.

For all aspects of the study participants may choose to stop at any time and we will assure them it will not affect them at all if they wish to skip a question or truncate the interview.

5. **Potential benefits of the proposed research to the study subjects and others:** Households participating in focus groups (SA1), key informant interviews (SA1) or in-depth interviews (SA3) will receive reimbursement for travel expenses and a small gift valued at approximately $10. Households participating in the cross-sectional survey will be given a small token of appreciation, likely a household good. Focus group participants will be asked to assist in determining the token but it will likely be tea, sugar, flour, beans, soap or some other small item that can benefit the entire household; amount not exceeding $5. Participants will also be guaranteed available malaria medication in the clinics if anyone in the community is diagnosed with malaria over the course of the study. As we will treat all individuals harboring parasites identified in the cross-sectional survey we may also reduce overall transmission, albeit temporarily, in the study sites. As these sites still have fairly high transmission, this could avert some cases of malaria.

6. **Importance of the knowledge to be gained:** Understanding factors that impede the use of standard malaria control measures, such as the use of insecticide treated nets as targeted here, is critical if malaria control and eventually elimination programs are to be successful at reducing malaria transmission. Further, our ultimate goal will be to identify and promote simple community-based solutions that may already be used by a sub-group of the population. These solutions are likely to be more readily accepted and could yield better results than other strategies to identify solutions. Since risks to the subjects of this study are minimal, the benefits of this study for this population both at present and potentially in the future greatly outweigh any risks.

Inclusion of Women/ Minorities

SA 1: We will strive to achieve a balanced sex ratio for focus group discussions to determine relative reported factors related to bednet ownership and use. For the key informant interviews neither women nor minorities will be explicitly sampled or excluded from this study. Key informants will be chosen based on qualifications and position (e.g. clinical officers, nursing staff, village elders, sublocation chiefs).

SA2: Households will be chosen using clustered random sampling while we expect that the majority of interviews will be conducted with the female household head, it is possible that there are some households without a female head and in those cases we will interview the male head of the house. All household members willing to be tested for malaria will be included regardless of age or sex.

SA3: Positive deviants will be identified from the cross-sectional survey. We will interview both the male and female household heads if the household has them.

For all specific aims, it is expected that all participants will be Kenyans of African descent, though there may be a few of other racial groups.

Program Director/Principal Investigator (Last, First, Middle): Ernst, Kacey Clarice

Targeted/Planned Enrollment Table

This report format should NOT be used for data collection from study participants.

Study Title: Identifying community-based solutions to improve bednet use: A mixed-methods approach

Total Planned Enrollment: 6000

TARGETED/PLANNED ENROLLMENT: Number of Subjects			
Ethnic Category	**Sex/Gender**		
	Females	**Males**	**Total**
Hispanic or Latino	0	0	0
Not Hispanic or Latino	0	0	0
Ethnic Category: Total of All Subjects *	0	0	0
Racial Categories			
American Indian/Alaska Native	0	0	0
Asian	0	0	0
Native Hawaiian or Other Pacific Islander	0	0	0
Black or African American	3,000	3,000	6,000
White	0	0	0
Racial Categories: Total of All Subjects *	3,000	3,000	6,000

* The “Ethnic Category: Total of All Subjects” must be equal to the “Racial Categories: Total of All Subjects.”

Inclusion of Children

Children residing in households chosen for the cross-sectional survey in SA 2 will be included in the analysis of whether or not they slept under a net and will also be requested to participate in the serosurvey to determine if they harbor malaria parasites. Parental consent will be obtained from those under age 12 years and assent will be obtained from those 12 to 18 years of age.

References

1. World Health Organization, *World Malaria Report 2010*, 2010.
2. Lengeler, C., *Insecticide-treated bed nets and curtains for preventing malaria.* Cochrane database of systematic reviews, 2004(2): p. CD000363.
3. Pulford, J., et al., *Reported reasons for not using a mosquito net when one is available: a review of the published literature.* Malaria Journal, 2011. **10**: p. 83.
4. Adongo, P.B., B. Kirkwood, and C. Kendall, *How local community knowledge about malaria affects insecticide-treated net use in northern Ghana.* Tropical Medicine & International Health, 2005. **10**(4): p. 366-378.
5. Belay, M. and W. Deressa, *Use of insecticide treated nets by pregnant women and associated factors in a pre-dominantly rural population in northern Ethiopia.* Tropical medicine & international health : TM & IH, 2008. **13**(10): p. 1303-13.
6. Oresanya, O.B., M. Hoshen, and O.T. Sofola, *Utilization of insecticide-treated nets by under-five children in Nigeria: Assessing progress towards the Abuja targets.* Malaria Journal, 2008. **7**: p. -.
7. Baume, C.A., R. Reithinger, and S. Woldehanna, *Factors associated with use and non-use of mosquito nets owned in Oromia and Amhara Regional States, Ethiopia.* Malaria Journal, 2009. **8**: p. -.
8. Atkinson, J.A., et al., *A qualitative study on the acceptability and preference of three types of long-lasting insecticide-treated bed nets in Solomon Islands: implications for malaria elimination.* Malaria Journal, 2009. **8**: p. -.
9. Ng'ang'a, P.N., et al., *Bed net use and associated factors in a rice farming community in Central Kenya.* Malar J, 2009. **8**: p. 64.
10. Division of Malaria Control, *National Malaria Strategy 2009 - 2017*, 2009, Kenyan Ministry of Public Health and Sanitation: Nairobi, Kenya.
11. Dhingra, N., et al., *Adult and child malaria mortality in India: a nationally representative mortality survey.* Lancet. **376**(9754): p. 1768-74.
12. Nevill, C.G., et al., *Insecticide-treated bednets reduce mortality and severe morbidity from malaria among children on the Kenyan coast.* Tropical medicine & international health : TM & IH, 1996. **1**(2): p. 139-46.
13. Phillips-Howard, P.A., et al., *Efficacy of permethrin-treated bed nets in the prevention of mortality in young children in an area of high perennial malaria transmission in western Kenya.* The American journal of tropical medicine and hygiene, 2003. **68**(4 Suppl): p. 23-9.
14. Howard, S.C., et al., *Evidence for a mass community effect of insecticide-treated bednets on the incidence of malaria on the Kenyan coast.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 2000. **94**(4): p. 357-60.
15. Eisele, T.P., J. Thwing, and J. Keating, *Claims about the Misuse of Insecticide-Treated Mosquito Nets: Are These Evidence-Based?* PLoS medicine, 2011. **8**(4): p. e1001019.
16. NIH Malaria Working Group, *NIAID Research Agenda for Malaria*, 2008, NIH. p. 39.
17. Roll Back Malaria, *Global Malaria Action Plan*, 2008.
18. Kenyan Ministry of Health, *Kenya national malaria indicator survey 2007.* . 2008 [cited 2011 6/10].
19. Ye, Y., et al., *Fever treatment in the absence of malaria transmission in an urban informal settlement in Nairobi, Kenya.* Malaria Journal, 2009. **8**: p. 160.
20. Gu, W. and R.J. Novak, *Predicting the impact of insecticide-treated bed nets on malaria transmission: the devil is in the detail.* Malaria Journal, 2009. **8**: p. 256.
21. Guyatt, H.L., et al., *Free bednets to pregnant women through antenatal clinics in Kenya: a cheap, simple and equitable approach to delivery.* Tropical medicine & international health : TM & IH, 2002. **7**(5): p. 409-20.
22. Kenya National Bureau of Statistics and ICF Macro, *Kenyan Demographic and Health Survey 2008-2009*, 2010, KNBS and ICF Macro.: Calverton, Maryland.
23. Astatkie, A. and A. Feleke, *Utilization of insecticide treated nets in Arbaminch Town and the malarious villages of Arbaminch Zuria District, Southern Ethiopia.* Ethiopian Journal of Health Development, 2009. **23**(3): p. 206-215.
24. Noor, A.M., et al., *Wealth, mother's education and physical access as determinants of retail sector net use in rural Kenya.* Malar J, 2006. **5**: p. 5.

25. Noor, A.M., et al., *Increasing coverage and decreasing inequity in insecticide-treated bed net use among rural Kenyan children.* PLoS Med, 2007. **4**(8): p. e255.
26. Agha, S., et al., *The impact of a hybrid social marketing intervention on inequities in access, ownership and use of insecticide-treated nets.* Malaria Journal, 2007. **6**: p. -.
27. Matovu, F., et al., *How equitable is bed net ownership and utilisation in Tanzania? A practical application of the principles of horizontal and vertical equity.* Malaria Journal, 2009. **8**: p. 109.
28. Babu, B.V., S. Mishra, and B.K. Swain, *Personal-protection measures against mosquitoes: a study of practices and costs in a district, in the Indian state of Orissa, where malaria and lymphatic filariasis are co-endemic.* Ann Trop Med Parasitol, 2007. **101**(7): p. 601-9.
29. Hii, J.L., et al., *Area effects of bednet use in a malaria-endemic area in Papua New Guinea.* Transactions of the Royal Society of Tropical Medicine and Hygiene, 2001. **95**(1): p. 7-13.
30. Hawley, W.A., et al., *Community-wide effects of permethrin-treated bed nets on child mortality and malaria morbidity in western Kenya.* American Journal of Tropical Medicine and Hygiene, 2003. **68**(4): p. 121-127.
31. Gosoniu, L., et al., *Spatial effects of mosquito bednets on child mortality.* BMC Public Health, 2008. **8**: p. 356.
32. Atkinson, J.A.M., et al., *Community participation for malaria elimination in Tafea Province, Vanuatu: Part I. Maintaining motivation for prevention practices in the context of disappearing disease.* Malaria Journal, 2010. **9**: p. -.
33. Thomson, M., et al., *Geographical perspectives on bednet use and malaria transmission in the Gambia, west Africa.* Social Science & Medicine, 1996. **43**(1): p. 101-112.
34. Chuma, J., et al., *Towards achieving Abuja targets: identifying and addressing barriers to access and use of insecticides treated nets among the poorest populations in Kenya.* BMC Public Health, 2010. **10**: p. -.
35. Minakawa, N., et al., *Unforeseen misuses of bed nets in fishing villages along Lake Victoria.* Malaria Journal, 2008. **7**: p. -.
36. D'Alessandro, U., et al., *Nationwide survey of bednet use in rural Gambia.* Bull World Health Organ, 1994. **72**(3): p. 391-4.
37. Mugisha, F. and J. Arinaitwe, *Sleeping arrangements and mosquito net use among under-fives: results from the Uganda Demographic and Health Survey.* Malaria Journal, 2003. **2**: p. -.
38. Bayoh, M.N., et al., *Anopheles gambiae: historical population decline associated with regional distribution of insecticide-treated bed nets in western Nyanza Province, Kenya.* Malaria Journal, 2010. **9**: p. 62.
39. Russell, T.L., et al., *Impact of promoting longer-lasting insecticide treatment of bed nets upon malaria transmission in a rural Tanzanian setting with pre-existing high coverage of untreated nets.* Malaria Journal, 2010. **9**: p. 187.
40. Nyamongo, I., *Malaria Risk and Ecological Change in Gusii: What Can We Learn from Hospital Data and Community Narratives?* International Journal of Humanities and Social Science, 2011. **1**(6): p. 34-42.
41. Mutuku, F.M., et al., *Distribution, description, and local knowledge of larval habitats of Anopheles gambiae s.l. in a village in western Kenya.* Am J Trop Med Hyg, 2006. **74**(1): p. 44-53.
42. Ernst, K.C., et al., *Malaria hotspot areas in a highland Kenya site are consistent in epidemic and non-epidemic years and are associated with ecological factors.* Malaria Journal, 2006. **5**: p. 78.
43. Carter, R., K.N. Mendis, and D. Roberts, *Spatial targeting of interventions against malaria.* Bulletin of the World Health Organization, 2000. **78**(12): p. 1401-11.
44. Peterson, I., et al., *A temporal-spatial analysis of malaria transmission in Adama, Ethiopia.* The American journal of tropical medicine and hygiene, 2009. **81**(6): p. 944-9.
45. Gemperli, A., et al., *Spatial patterns of infant mortality in Mali: the effect of malaria endemicity.* American journal of epidemiology, 2004. **159**(1): p. 64-72.
46. *A research agenda for malaria eradication: monitoring, evaluation, and surveillance.* PLoS medicine, 2011. **8**(1): p. e1000400.
47. *A research agenda for malaria eradication: cross-cutting issues for eradication.* PLoS medicine, 2011. **8**(1): p. e1000404.
48. Ndiaye, M., et al., *Impact of a positive deviance approach to improve the effectiveness of an iron-supplementation program to control nutritional anemia among rural Senegalese pregnant women.* Food Nutr Bull, 2009. **30**(2): p. 128-36.

49. Guldan, G.S., et al., *Weaning practices and growth in rural Sichuan infants: a positive deviance study.* J Trop Pediatr, 1993. **39**(3): p. 168-75.
50. Mackintosh, U.A., D.R. Marsh, and D.G. Schroeder, *Sustained positive deviant child care practices and their effects on child growth in Viet Nam.* Food Nutr Bull, 2002. **23**(4 Suppl): p. 18-27.
51. Ahrari, M., et al., *A positive deviance-based antenatal nutrition project improves birth-weight in Upper Egypt.* J Health Popul Nutr, 2006. **24**(4): p. 498-507.
52. Ernst, K.C., et al., *Environmental, socio-demographic and behavioural determinants of malaria risk in the western Kenyan highlands: a case-control study.* Tropical medicine & international health : TM & IH, 2009. **14**(10): p. 1258-65.
53. Menge, D.M., et al., *Microscopy underestimates the frequency of Plasmodium falciparum infection in symptomatic individuals in a low transmission highland area.* The American journal of tropical medicine and hygiene, 2008. **79**(2): p. 173-7.
54. Maynard-Tucker, G., *Conducting focus groups in developing countries: skill training for local bilingual facilitators.* Qual Health Res, 2000. **10**(3): p. 396-410.
55. Patrick, B. and W. Dan, *Snowball Sampling: Problems and Techniques of Chain Referral Sampling.* Sociology Methods and Research, 1981. **vol. 10** (no. 2): p. 141-163
56. Cohen, J.M., et al., *Topography-derived wetness indices are associated with household-level malaria risk in two communities in the western Kenyan highlands.* Malaria Journal, 2008. **7**: p. 40.
57. Cohen, J.M., et al., *Local topographic wetness indices predict household malaria risk better than land-use and land-cover in the western Kenya highlands.* Malaria Journal, 2010. **9**: p. 328.

NCAR

National Center for
Atmospheric Research

Research Applications Laboratory

3450 Mitchell Lane, Boulder, CO 80301 USA
Phone: 303-497-8422 Fax: 303-497-8401
www.ral.ucar.edu

June 22, 2011

Dr. Kacey Ernst
Assistant Professor
1295 N. Martin
Campus PO Box: 245211
Drachman Hall A246
University of Arizona
Tucson, AZ 85724

Dear Dr. Ernst,

I write this letter in enthusiastic support of the proposed research project entitled " Why aren't ITN being used to prevent malaria?: A multi-site assessment of the prevalence and driving factors behind ITN compliance in Kenya". Malaria is a complex natural and human disease system that typically is addressed in operationally focused research projects rather than ones attempting to evaluate the efficacy of interventions through social and behavioral applications. I therefore am very excited about this cross-cutting proposal which has great potential to further our knowledge of how the system responds to different natural and human stressors in multiple climatic and transmission zones. This project will both address basic questions applicable to a wider range of vector-borne diseases and generate knowledge that may help prevent and control malaria.

Sincerely,

Mary H. Hayden, Ph.D.
Research Scientist
National Center for Atmospheric Research
Boulder, CO

KENYA MEDICAL RESEARCH INSTITUTE

Centre for Global Health Research, P.O. Box 1578-40100, KISUMU Kenya
Tel: (254) (057) 22923/24, Email: cvbcr@kisian Website: www.kemri.org

7th JUNE 2011

KACEY ERNST
Assistant Professor
1295 N. Martin
Campus PO Box: 245211
Drachman Hall A246
Tucson, AZ 85724

Dear Sir,

RE: SUPPORT LETTER FOR COLLABORATION

This is to inform you that I am willing to collaborate with you on this proposed grant. Further to this, KEMRI as an institution is also willing to support the proposed study by offering the required structures, institutional support and facilities to conduct this study. Currently, I am a Principal Research Officer and offer technical and administrative support besides being a Principal Investigator and Co-PI on several research programs.

Having trained and worked as a Medical Entomologist for several years, the work experience and knowledge I have gained in different settings would be crucial in ensuring the success of the proposed study. My current interests are in fields of long lasting insecticides treated materials (durable linings, LLINs etc) for control of malaria vectors.

Thanks in advance

Stephen Munga, PhD.
PRINCIPAL RESEARCH OFFICER, KEMRI
AND TECHNICAL DIRECTOR,
The MENTOR Initiative, GARISSA

PHS 398 Checklist

OMB Number: 0925-0001

1. Application Type:

From SF 424 (R&R) Cover Page. The responses provided on the R&R cover page are repeated here for your reference, as you answer the questions that are specific to the PHS398.

* Type of Application:

☒ New ☐ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

Federal Identifier:

2. Change of Investigator / Change of Institution Questions

☐ Change of principal investigator / program director

Name of former principal investigator / program director:

Prefix:
* First Name:
Middle Name:
* Last Name:
Suffix:

☐ Change of Grantee Institution

* Name of former institution:

3. Inventions and Patents (For renewal applications only)

* Inventions and Patents: Yes ☐ No ☐

If the answer is "Yes" then please answer the following:

* Previously Reported: Yes ☐ No ☐

4. * Program Income

Is program income anticipated during the periods for which the grant support is requested?

☐ Yes ☒ No

If you checked "yes" above (indicating that program income is anticipated), then use the format below to reflect the amount and source(s). Otherwise, leave this section blank.

*Budget Period	*Anticipated Amount ($)	*Source(s)

5. * Disclosure Permission Statement

If this application does not result in an award, is the Government permitted to disclose the title of your proposed project, and the name, address, telephone number and e-mail address of the official signing for the applicant organization, to organizations that may be interested in contacting you for further information (e.g., possible collaborations, investment)?

☒ Yes ☐ No