CAN A LOW-COST EDUCATIONAL INTERVENTION RESULT IN A CHANGE IN CHIKUNGUNYA KNOWLEDGE AND PREVENTION PRACTICES? DEVELOPING AND TESTING AN INTERVENTION TO PREVENT CHIKUNGUNYA IN RURAL TAMIL NADU, INDIA

by

Erin Michelle Reynolds

An Abstract

Of a thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Epidemiology
in the Graduate College of
The University of Iowa

December 2012

Thesis Supervisor: Assistant Professor Anne Wallis

ABSTRACT

CHIK is a viral infection transmitted by the *Aedes aegypti* mosquito which causes an illness with symptoms of severe joint pain, high fever, and rash. The joint pain can continue for months, causing disability and economic strain on families. This study included implementation of a baseline needs assessment, and development, implementation, and evaluation of an experimental community-based educational intervention in rural Tamil Nadu, India. A total of 184 households, across 12 purposively sampled villages (six intervention and six control), participated in the needs assessment between August and December 2010. The experimental community-based educational intervention was implemented between December 2010 and August 2011, in the six intervention villages. A total of 180 households, from the same 12 villages, participated in the post-intervention evaluation. A randomized block design with repetition was used to test whether there was a change in CHIK knowledge scores from baseline to post-intervention in the treatment group. A model including respondent variables, household larval status, household container larval status, recent experience with CHIK, numbers of livestock, socioeconomic position (SEP) variables, and water variables were used to predict CHIK knowledge scores in rural Tamil Nadu. Respondent age, measures of luxury amenities and water source were statistically significant predictors of knowledge in this model. The CHIK knowledge score increased from 9.0 to 9.4 in the intervention group ($p=0.6457$) and from 8.5 to 9.2 in the control group ($p=0.393$), showing that the educational intervention did not increase CHIK knowledge in the intervention group. Although

this low-cost intervention, utilized in a resource poor area of Tamil Nadu, India did not result in an increase of CHIK knowledge, the process of developing the educational intervention may provide a template for future interventions. Future studies should investigate methods of sustainability in the use of educational messages.

Abstract Approved: _____
Thesis Supervisor

_____
Title and Department

_____
Date

CAN A LOW-COST EDUCATIONAL INTERVENTION RESULT IN A CHANGE IN CHIKUNGUNYA KNOWLEDGE AND PREVENTION PRACTICES? DEVELOPING AND TESTING AN INTERVENTION TO PREVENT CHIKUNGUNYA IN RURAL TAMIL NADU, INDIA

by

Erin Michelle Reynolds

A thesis submitted in partial fulfillment
of the requirements for the Doctor of
Philosophy degree in Epidemiology
in the Graduate College of
The University of Iowa

December 2012

Thesis Supervisor: Assistant Professor Anne Wallis

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

_____

PH.D. THESIS

_____

This is to certify that the Ph.D. thesis of

Erin Michelle Reynolds

has been approved by the Examining Committee
for the thesis requirement for the Doctor of Philosophy
degree in Epidemiology at the December 2012 graduation.

Thesis Committee: _____
Anne B. Wallis, Thesis Supervisor

_____
James C. Torner

_____
Tara C. Smith

_____
Paul Greenough

_____
Miriam B. Zimmerman

To my family and friends, your support has meant everything to me

ACKNOWLEDGMENTS

While a dissertation is the primary work of a single person, there is a whole cast of supporting characters that makes the work possible. So a gigantic thanks to all my family and friends for supporting me over the last several years.

This research would not have been possible without the support of Meenakshi Mission Hospital and Research Centre. I would like to thank Dr. Umashankar Subramanian for his time and patience. I also want to convey my gratitude to my wonderful data collectors: Valli, Devi, Saranya, Priya, Aburose, Kuwaitha, Pashpavalli, Vinothini, Ruth, Begum, Rajivgandhi, and Viji. I honestly would have been lost without the extraordinary hard work and patience of Rosemary Christian.

I would also like to thank my dissertation committee for their support and advice. In particular, I would like to express my appreciation to Dr. Anne Wallis for her unending encouragement and friendship. Special thanks to Soman Puzhankara for all his help. He has been a friend, cultural guide, and Tamil translator.

And finally, I must acknowledge my absolutely amazing family. My mom and dad, who have been with me through the ups and the downs, always willing to listen to endless talk about my thesis, and patiently waiting for their daughter to graduate. Thanks to my cousin, Claire Ehlinger, for designing a Chikungunya coloring book! And to my sister, Heather Wilmoth, thank you for good-naturedly reading countless drafts and always being there to talk as I worked my way through the long process of completing this project. And, of course, I must

acknowledge my cat, Nina. She kept my lap warm during the hundreds of hours of data entry and writing. Writing this thesis would have been much more stressful without a cat to keep me company.

ABSTRACT

CHIK is a viral infection transmitted by the *Aedes aegypti* mosquito which causes an illness with symptoms of severe joint pain, high fever, and rash. The joint pain can continue for months, causing disability and economic strain on families. This study included implementation of a baseline needs assessment, and development, implementation, and evaluation of an experimental community-based educational intervention in rural Tamil Nadu, India. A total of 184 households, across 12 purposively sampled villages (six intervention and six control), participated in the needs assessment between August and December 2010. The experimental community-based educational intervention was implemented between December 2010 and August 2011, in the six intervention villages. A total of 180 households, from the same 12 villages, participated in the post-intervention evaluation. A randomized block design with repetition was used to test whether there was a change in CHIK knowledge scores from baseline to post-intervention in the treatment group. A model including respondent variables, household larval status, household container larval status, recent experience with CHIK, numbers of livestock, socioeconomic position (SEP) variables, and water variables were used to predict CHIK knowledge scores in rural Tamil Nadu. Respondent age, measures of luxury amenities and water source were statistically significant predictors of knowledge in this model. The CHIK knowledge score increased from 9.0 to 9.4 in the intervention group ($p=0.6457$) and from 8.5 to 9.2 in the control group ($p=0.393$), showing that the educational intervention did not increase CHIK knowledge in the intervention group. Although this low-cost intervention, utilized in a resource poor area of Tamil Nadu, India

did not result in an increase of CHIK knowledge, the process of developing the educational intervention may provide a template for future interventions. Future studies should investigate methods of sustainability in the use of educational messages.

TABLE OF CONTENTS

LIST OF TABLES x

LIST OF FIGURES xiii

LIST OF ABBREVIATIONS xvi

CHAPTER 1-INTRODUCTION 1
CHAPTER 2-BACKGROUND AND SIGNIFICANCE 5

2.1 Chikungunya: a reemerging disease 5
2.2 Mosquito vectors 6
2.3 Identification and prevention 7
2.4 GIS and health 7
2.5 Individual and community risk factors 8
2.6 Socioeconomic position and health 9
2.7 Behavior change theory and evaluation 11
2.8 Significance 12

CHAPTER 3-RESEARCH DESIGN AND METHODS 14

3.1 Overview of study design 14
3.2 Definition and conceptualization of key variables 16
3.2.1 Outcome variables 16
3.2.2 Confounder and effect modifiers 17
3.3 Study population 19
3.3.1 Study location 19
3.3.2 Household selection 21
3.3.3 Study participants 22
3.4 Data Sources 22
3.4.1 Tamil Nadu rural household health survey 22
3.4.2 Tamil Nadu chikungunya evaluation survey 22
3.5 Data Collection and Management 23
3.5.1 Consent process 23
3.5.2 Questionnaire administration 24
3.5.3 Intervention and evaluation 24
3.5.4 Evaluation questionnaire (version 2.0) 25
3.5.5 Larval survey 27
3.5.6 GIS 28
3.6 Principal component analysis 28
3.6.1 PCA variable selection 29
3.6.2 Coding of variables 30
3.6.3 PCA methods 32
3.6.4 Reliability of indexes 33
3.6.5 Reproducibility 33
3.7 Statistical considerations 34

3.7.1 Power analysis and sample size 34
3.7.2 Statistical analysis 35
3.8 Potential methodological limitations 36

CHAPTER 4-STUDY AREA DESCRIPTION 40

4.1 Intervention villages 40
4.1.1 Varapur 40
4.1.2 Kurumbalur 41
4.1.3 Kattayanpatti 42
4.1.4 Ariyandipatti 42
4.1.5 Keeranipatti 43
4.1.6 Sadayanpatti 44
4.2 Control villages 45
4.2.1 Gopalapacheri 45
4.2.2 Kirungakkottai 45
4.2.3 Sirumaruthur 46
4.2.4 Thennammalpatti 47
4.2.5 S.V. Mangalam (Sadurvedamangalam) 48
4.2.6 Anaikaraipatti 49

CHAPTER 5-RESULTS 50

5.1 Overview of study population 50
5.2 Specific aim 1 50
5.2.1 Summary of baseline demographic characteristics of the study population 50
5.2.2 PCA 60
5.2.3 Summary of health statistics of the study population 67
5.3 Specific aim 2 72
5.4 Specific aim 3 73
5.4.1 Summary of household characteristics 73
5.4.2 Summary of dwelling characteristics 74
5.4.3 Summary of water characteristics 76
5.4.4 Health models 78
5.4.5 GIS 86
5.5 Conclusions 102

CHAPTER 6-DISCUSSION 105

6.1 Introduction 105
6.2 Specific aim 1 106
6.3 Specific aim 2 107
6.4 Specific aim 3 108
6.5 SEP and Water index 110
6.6 Culture and epidemiology 112

6.7 Data issues 114
6.7.1 Missing data 114
6.7.2 Translation 115
6.7.3 Variable meaning 116
6.8 Limitations 117
6.8.1 Study village selection 117
6.8.2 Data collectors 118
6.8.3 Sampling bias 118
6.8.4 Study delays 119
6.8.5 Resources 121
6.8.6 Disease prevalence 121
6.9 Barriers 123
6.10 Generalizability 123
6.11 Recommendations 124
6.12 Future studies 125
6.13 Conclusions 127

APPENDIX 129

A.1 University of Iowa Institutional Review Board Approval 130
A.2 Meenakshi Mission Hospital and Research Centre Ethics Approval 131
A.3 Tamil Nadu Rural Household Health Survey 132
A.4 Tamil Nadu Chikungunya Evaluation Survey 143
A.5 Educational Intervention 153

REFERENCES 190

LIST OF TABLES

Table

1.	*Ae. Aegypti* indices' descriptions	7
2.	Current literature on Chikungunya	8
3.	Coding of PCA variables	31
4.	Evaluation Research Design	38
5.	Pre-intervention household characteristics	51
6	Pre-intervention household characteristics between the intervention and control groups	54
7.	Pre-intervention dwelling characteristics	55
8.	Pre-intervention dwelling characteristics between the intervention and control groups	56
9.	Pre-intervention water characteristics	58
10.	Pre-intervention water characteristics between the intervention and control groups	59
11.	Unrotated SEP PCA results	61
12.	Rotated SEP PCA results	62
13.	Reliability statistics for SEP PCA	63
14.	Scoring factors and percentage of households owning an asset: comparison of most poor to least poor	64
15.	Unrotated water PCA results	66
16.	Rotated water PCA results	66
17.	Reliability statistics for water PCA	67
18.	Scoring factors and percentage of households owning an asset for water index: comparison of most poor to least poor	68
19.	Pre-intervention CHIK knowledge	68

20. Pre-intervention group differences for knowledge of CHIK..... 69

21. Pre-intervention associations with knowledge of CHIK..... 69

22. Pre-intervention Analysis of Variance for Source of CHIK knowledge and knowledge of symptoms..... 70

23. Pre-intervention Analysis of Variance for Source of CHIK knowledge and knowledge of transmission..... 71

24. Pre-intervention Analysis of Variance for Source of CHIK knowledge and knowledge of prevention..... 71

25. Pre-intervention larval statistics..... 72

26. Household characteristics comparison pre- and post-intervention..... 75

27. Dwelling characteristics comparison pre- and post-intervention..... 77

28. Description of water variables comparison pre- and post-intervention 78

29. Baseline CHIK knowledge Comparison Pre- and Post-Intervention.... 79

30. CHIK knowledge scores for study villages pre- and post-intervention.. 81

31. Solution for random effects of villages nested within treatment group by pre- and post-intervention status..... 83

32. Test of fixed effects for model of CHIK knowledge score..... 83

33. Least squares means of CHIK knowledge scores simple differences among treatment groups for pre- and post-intervention..... 84

34. Larval statistics Comparison Pre- and Post-Intervention..... 85

35. Research results..... 103

A1. Data dictionary for needs assessment survey..... 169

A2. Data dictionary for evaluation survey..... 172

A3. Method of scoring CHIK knowledge score variable..... 175

A4. CHIK knowledge score categories..... 176

A5. Pre-intervention household characteristics among the 12 study villages..... 177

A6. Post-intervention household characteristics among the 12 study villages..... 179

A7. Post-intervention household characteristics between the intervention and control groups..... 181

A8. Pre-intervention dwelling characteristics among the 12 study villages. 182

A9. Post-intervention dwelling characteristics among the 12 study villages 183

A10. Post-intervention dwelling characteristics between the intervention and control groups..... 184

A11. Pre-intervention water characteristics among the 12 study villages..... 185

A12. Post-intervention water characteristics among the 12 study villages.... 187

A13. Post-intervention water characteristics between the intervention and control groups..... 189

LIST OF FIGURES

Figure

1. Geographical distribution of CHIK virus (above) and global distribution of secondary vector *Ae. Albopictus* (below)..... 5

2. Conceptual model of program impact..... 12

3. Conceptual Model for Community Intervention..... 14

4. Map of Tamil Nadu and Sivagangai District..... 20

5. Varapur map (left) and village photo (right)..... 41

6. Kurumbalur map (left) and village photo (right)..... 41

7. Kattayanpatti map (left) and village photo (right)..... 42

8. Ariyandipatti map (left) and village photo (right)..... 43

9. Keeranipatti map (left) and village photo (right)……..…… 43

10. Sadayanpatti map (left) and village photo (right)……..…... 44

11. Gopalapacheri map (left) and village photo (right)..... 45

12. Kirungakkottai map (left) and village photo (right)..... 46

13. Sirumaruthur map (top left) and village photo (top right and bottom)…. 47

14. Thennammalpatti map (left) and village photo (right)……..... 48

15. S.V. Mangalam map (left) and village photo (right)..... 48

16. Anaikaraipatti map (left) and village photo (right)..... 49

17. Examples of typical house with tile roof (top) and cement roof (bottom) 55

18. Photographs showing examples of public water taps..... 57

19. Scree Plot for SEP PCA..... 60

20. Scree Plot for Water PCA..... 65

21. Photographs of intervention at a local school (left) and community meeting (right)..... 73

22. Stem leaf plot and normal probability plot of residuals for normality assumption test..... 82

23. Varapur map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 87

24. Kurumbalur map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 88

25. Katayanipatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 89

26. Ariyandipatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 91

27. Keeranipatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 93

28. Sadayanpatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 94

29. Gopalapacheri map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 95

30. Kirungakkottai map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 96

31. Sirumaruthur map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 98

32. Thennammalpatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 99

33. S.V. Mangalam map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 101

34. Anaikaraipatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK..... 102

LIST OF ABBREVIATIONS

Ae.	Aedes
ANOVA	Analysis of variance
BI	Bretaux index
CHIK	Chikungunya
CI	Container index
GI	Galvanized iron
GIS	Geographic Information System
GPS	Global positioning system
HH	Head of household
HI	House index
ITT	Intention-to-treat
KAP	Knowledge, attitudes and practices
MMHRC	Meenakshi Mission Hospital and Research Centre
MTC	Meenakshi Telemedicine Centre
PCA	Principal component analysis
PI	Principal investigator
RCC	Reinforced cement concrete
SEP	Socioeconomic position

CHAPTER 1-INTRODUCTION

Between January 2006 and August 2007, an estimated 1.4 million people in India developed chikungunya (CHIK) fever. CHIK fever first appeared in 1952 on the boarder of Tanganyika (now Tanzania) and Mozambique.[1] The CHIK virus is a vector-borne virus of the genus *Alphavirus* in the family *Togaviridae*. The virus is spread primarily by the *Aedes aegypti* mosquito, a tropical mosquito also capable of transmitting dengue, yellow fever, and Ross River viruses. The CHIK virus causes an acute febrile state with rash and debilitating joint pain that often continues for months. “Chikungunya” means “that which bends up” in the Makonde language and that is an excellent descriptor for this disease best known for the severe, long lasting joint pain.[1] There is no vaccine and no known cure.

To date, very little information has been available on individual or community risk factors associated with CHIK infection. In fact, most of the vertical or government-initiated vector control programs (such as fogging or indoor residual spraying) have shown little impact on long-term vector disease rates. Moreover, these programs lack sustainability at the community level as there was strong distrust for outsiders coming into the community and little understanding of what the program was meant to accomplish.[2] Therefore this project aimed to develop a program that would get affected communities involved in disease prevention efforts. Thus, the objective of this study was to test a community-based intervention to improve knowledge, recognition, and awareness of CHIK, increase use of prevention methods, reduce mosquito larval breeding sites, and

ultimately reduce rates of CHIK and other infections linked to stagnant water, insect vectors, and poor hygiene. The central hypothesis was that the use of a needs assessment to understand community knowledge and community-based approaches would increase community buy-in to the intervention and increase knowledge. The long-term effect would be to reduce the rates of CHIK infection. The *long-term goal* of this project is to reduce rates of CHIK viral infection in the Madurai region of Tamil Nadu, India.

Aim 1. Perform a comprehensive needs assessment to identify gaps in CHIK knowledge and prevention practices, and establish a baseline data set.

Aim 2. Develop and implement an experimental community-based intervention.

Aim 3. Evaluate the experimental community-based intervention.

Hypothesis 3a: CHIK knowledge and prevention practices will increase in intervention villages compared to control villages.

Hypothesis 3b: Larval indices will decrease in intervention villages compared to control villages.

Hypothesis 3c: GIS will be able to identify locations within a village that increase risk for CHIK infection.

Working in concert with the Meenakshi Mission Hospital and Research Centre (MMHRC), a demographic and health survey was administered in villages in rural Tamil Nadu to assess knowledge of CHIK, baseline CHIK prevalence,

and the need for vector control. A larval survey was conducted to establish baseline levels of vector populations. Latitude and longitude information was collected for each household and important locations (such as health clinic, workplace, and water sources) were noted within each village and entered into a geographic information system (GIS).

An educational intervention was developed based on multiple conversations with village nurses, MMHRC staff, the results of the needs assessment, and focus groups with village residents.

We assessed changes in knowledge and prevention of CHIK, prevalence of CHIK and larval indices after the educational intervention. GIS mapping was used to identify any clustering of pre- and post-intervention patterns in larval and disease outcomes, CHIK knowledge, and to map geographic risk/protective factors, residents, and resources. One group of six villages received the educational intervention (i.e., intervention villages) and another group of six villages, matched for sociodemographic and geographic factors, that did not receive the intervention served as controls (i.e., control villages).

The immediate objective of this study was to develop a prevention and education program for the Madurai region of Tamil Nadu, India that could then be used by local communities and public health practitioners to prevent CHIK. The methods for this project were designed so that they could be applied to other rural communities to control the spread of CHIK. These approaches may also be easily extended beyond CHIK prevention to preventing other vector-borne diseases such as dengue fever, yellow fever, and Japanese encephalitis.

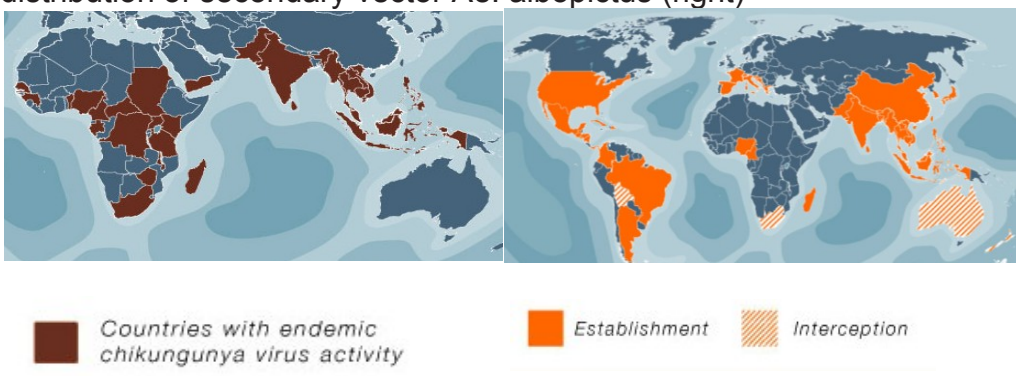
Providing individuals with the tools to prevent CHIK will increase self-efficacy and allow them a measure of control over their own health that is often lacking in vertical programs.

CHAPTER 2-BACKGROUND AND SIGNIFICANCE

2.1 Chikungunya: a reemerging disease

Chikungunya (CHIK) is a single stranded, positive sense RNA virus from the family *Togaviridae* which is most closely related to the O'nyong-nyong, Mayaro, Ross River and Semliki Forest viruses.[3] CHIK fever is a disease that has traditionally taken a backseat to the more familiar and deadly vector-borne diseases such as dengue fever, yellow fever, and malaria. With the reemergence of CHIK in the 2005-2007 epidemic that swept through the southwest Indian Ocean islands to the Indian subcontinent, and Italy, this disease has demonstrated its potential to reach all parts of the globe. While CHIK is endemic in parts of Africa and Southeast Asia (Figure 1, left), capable vectors (*Ae. aegypti* and *Ae. albopictus*) are present in most parts of the world (Figure 1, right). The ease of international travel and transport provides the opportunity for CHIK to be introduced to non-tropical regions, as shown by the 2007 outbreak of CHIK fever in Northern Italy involving 217 confirmed cases.[4]

Figure 1. Geographical distribution of chikungunya virus (left) and global distribution of secondary vector Ae. albopictus (right)



2.2 Mosquito vectors

The *Aedes* species of mosquitoes is the primary vector for CHIK virus. *Ae. aegypti* is primarily an urban mosquito which prefers to breed in artificial water storage containers.[2a, 5] *Ae. albopictus* (also known as the Asian tiger mosquito) is a rural mosquito more likely to be found in natural settings (tree stumps, discarded coconut shells) or discarded objects (used tires).[5-6] While *Ae. aegypti* is the primary vector responsible for CHIK infections, studies have shown that a single mutation in the wild type strain of CHIK increases the ability of *Ae. albopictus* mosquitoes to transmit the virus.[7] *Ae. albopictus* is considered one of the most invasive mosquito species worldwide, with the capability to survive considerably harsher climates than the *Ae. aegypti*.[8] With global warming increasing the range of potential habitats, *Ae. aegypti* and *Ae. albopictus* will have the opportunity to spread even further.

Larval surveys are a simple method of establishing the risk of a household or community for contracting a vector- borne disease. Three indices are commonly used in larval surveys: House Index (HI), Container Index (CI), and the Breteau Index (BI) (Table 1).[2a, 6, 9]

Historically, a BI index greater than 50 has been used to indicate elevated risk for epidemics of yellow fever or dengue at the community level, but a more recent study estimates that a lower BI of between five and fifty may represent a risk for an outbreak.[10] Epidemic thresholds have not been developed to represent CHIK risk.

Table 1. *Ae. Aegypti* indices' descriptions[9]

HI	Percentage of houses examined that have larvae of *Ae. aegypti* in at least some containers.
CI	Percentage of water-holding containers examined that contain larvae of *Ae. aegypti*.
BI	Total number of containers with larvae of *Ae. aegypti* per 100 houses

2.3 Identification and prevention

CHIK infection can easily be mistaken for dengue fever or malaria in countries where many diseases present with both fever and joint pain. While diagnostic tests exist, they are not always available in resource-constrained regions. Symptomatic diagnosing is common, but may lead to misestimation of the actual burden of disease due to CHIK. The fever and rash often resolves within a week, but the joint pain can continue to plague affected individuals for weeks to months, leading to prolonged morbidity and economic loss.[11] Prevention primarily consists of vector control and personal protection against mosquito bites.

2.4 GIS and health

Geographic information systems (GIS) provide a platform in which geographical information can be collected, imputed, manipulated, and utilized to search for spatial patterns in exposure or disease distribution. GIS can help inform decisions on resource allocation, vector management, disease surveillance and disease control.[12] GIS can be used to identify and prioritize high risk areas for intervention, thus saving time and money.[13]

2.5 Individual and community risk factors

Two studies from the island of Mayotte in the Indian Ocean identified socioeconomic position (SEP) as a strong risk factor for acquiring CHIK.[14] Demographic characteristics, place of residence, type of housing, education levels and household sanitation were also shown to play a role in the Mayotte Island epidemic.[14] When considering methods of prevention, personal control factors (perceived controllability and effectiveness of protective actions) have been identified as important predictors of CHIK infection.[14a] Accurate knowledge of vector control and self-protective behaviors were also significant variables in this study.[14a]

Table 2. Current literature on Chikungunya

Author	Design	Population (n)	Results
Raude[14a] (2009)	Cross-sectional survey	Mayotte Island 420 households, 888 individuals.	Estimated prevalence for epidemic ~38%. Place of birth, education, and household size are associated with disease frequency. Cognitive variables (perceived controllability and effectiveness of protective actions) were important. Accurate knowledge of vector control and self-protective behavior were significant. Behavioral variables were not identified as significant which may be due to media campaigning prior to survey. Multiple correspondence analyses showed that CHIK attitudes and beliefs (both indigenous and biomedical) were shaped by sociodemographic variables. Logistical regression identified cognitive variables and environmental factors in the predictive models with most of the sociodemographic variables only explaining a small part of the variance.
Sissoko[14b] (2008)	Cross-sectional survey	Mayotte Island Seroprevalence survey of 316 and 629 pregnant women. Community survey of 2235 individuals.	Prior to the epidemic, seroprevalence in pregnant women was 1.6% while after the epidemic that rate rose to 26%. In the community survey, 25.8% were identified with presumptive CHIK. The male: female ratio was 0.85 and the mean age was 26 for those with presumptive CHIK and 20 for those without presumptive CHIK.

2.6 Socioeconomic position and health

It is well established that better health is generally associated with social advantage. However, understanding these associations, including the application to specific health problems, and the degree of association, has been under study by social epidemiologists for more than a century. Social epidemiology accepts the notion that societies are stratified in many ways and that these strata can be associated with varying degrees of economic, political, and social advantage. One key dimension of social stratification is SEP. SEP is a broad term that may include the many social and economic factors that influence social status.[15]

Measurement of SEP may depend upon data availability and on a study's theoretical framework. Measures that have been used, either singly or as composites, include occupation (e.g., the United Kingdom's National Statistics Socio-Economic Classification, or NS-SSEC), educational attainment, income, wealth, and housing characteristics. It is recognized that classification of SEP may differ across ethnic groups and regions; therefore, the same indicator that reflects SEP in the UK may not accurately reflect SEP in India.[16]

Measures of income, wealth, social deprivation, and poverty have all been utilized as measures of economic position, yet they contribute in different ways toward a person's ability to access health care or understand health education.[15] When considering the use of income as a measure of SEP, it may be important to look beyond income and include family assets. Wealth is the difference between assets and liabilities, or the net worth of a family, with family assets including: bank accounts, stocks, mutual funds, houses, and consumer durable

assets.[17] Wealth provides better access to health care and acts as a financial cushion if health expenditures increase dramatically or the household experiences poor economic times.

Most countries use a threshold for economic deprivation, below which, a person is considered to be poor. The definition of absolute poverty used by the World Bank and United Nations is less than ~$1 USD per day.[16] Indian below the poverty line (BPL) status is based on the cost of a basket of goods that satisfies a set of caloric calculations done in 1973, with anyone unable to afford this classified as BPL.[18] In India, more than a quarter of the rural population is classified as BPL.[18] With only periodic revisions for inflation, the current cutoff line is considered to be an extreme underestimation of the number of families in India that live in poverty.[18] Surveys are conducted to determine the cutoff point and numbers of BPL cards allocated per district, but distribution of cards is left to government functionaries, allowing for corruption of the process.[19] As a result, BPL status alone is a misleading measure of SEP in India.[20]

In India, social caste has traditionally been used as a proxy for SEP.[21] Scheduled castes and scheduled tribes have been nationally recognized as disadvantaged groups; however, outlawing of the caste system and decline in the use of caste combined with the increased importance of assets and wealth, make caste a poor proxy.[21-22] Tiwari, et al. reviewed existing measures of SEPs in India and found them to be out-of-date.[23] Indeed, the four measures they cited were all published in the 1960s and 1970s.[24] In response, Tiwari and colleagues developed a 7-indicator scale which included house, material possessions,

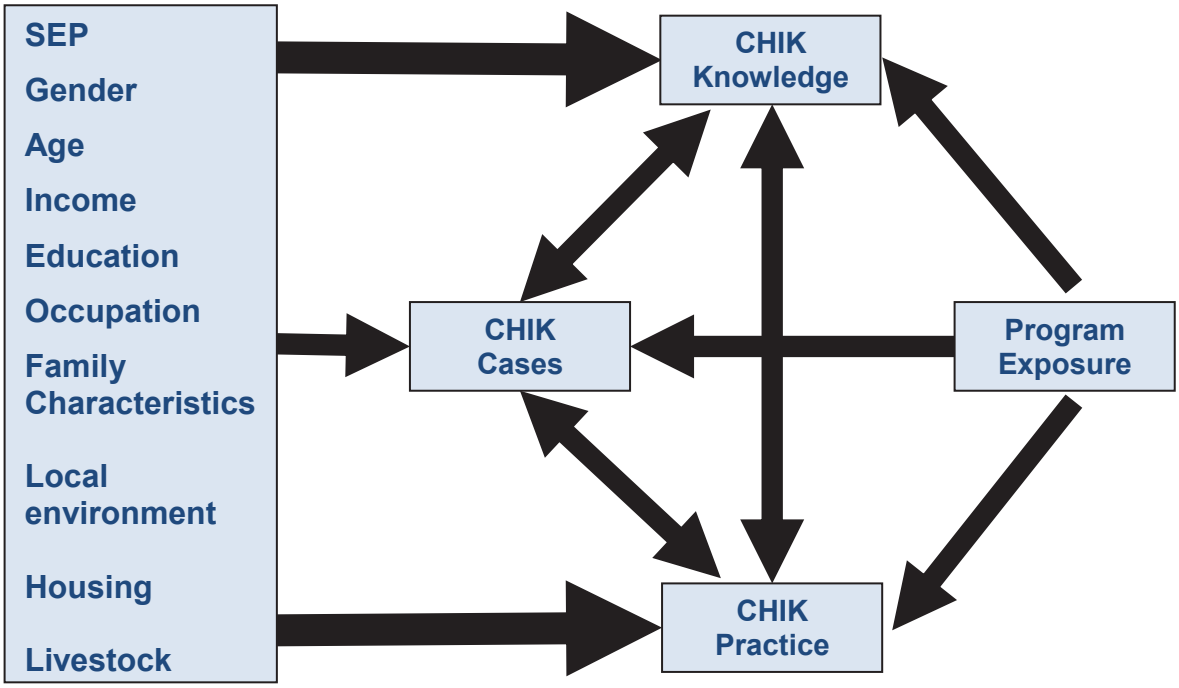
education, occupation, monthly income, land, social participation, and understanding. They validated their instrument in rural and urban areas of Lucknow district, Uttar Pradesh. They recommended that such scales should be updated every 5 years and developed and tested separately in different regions of India. At present, there is no known SEP scale for southern India.

2.7 Behavior change theory and evaluation

Behavioral change theory underpins the design of any intervention and helps to explain how a proposed intervention will change behavior.[25] For example, an increase in awareness of the connection between mosquitoes and CHIK may lead to an increase in vector control behaviors. Whether one is measuring change due to stimuli, accessing the mental process, studying human motivation, or observing human behavior, change may occur in many ways. As a result, many behavioral change models exist to help describe the process underlying the relationship between health and behavioral change.

In the health belief model, individuals are more likely to change when they believe they are at risk for the disease, the disease is severe, and they will benefit from the change. For this model, the needs assessment will identify how much the community knows about CHIK and what aspects need to be highlighted in the informational section of the intervention to help people understand the risk, severity of the disease, and benefits associated with CHIK prevention. In figure 2, we see that SEP factors, which may act as barriers to adopting change, are expected to directly impact program exposure and knowledge, and to indirectly affect prevention practices.

Figure 2. Conceptual model of program impact[25]



In the theory of reasoned action, behavior is determined by knowledge (beliefs), attitudes and social norms. In order for an intervention to change behavior, knowledge and attitudes must first be changed. Social norms come into play in many behaviors and it is possible to evaluate the effects of interventions on social networks in addition to individuals.[25]

2.8 Significance

CHIK disappeared from many parts of the world in the mid-1970's due to extensive vector control programs that came close to eradicating the *Aedes* and *Anopheles* mosquitoes capable of transmitting many diseases such as malaria, dengue fever and yellow fever. Vertical vector control programs have been used

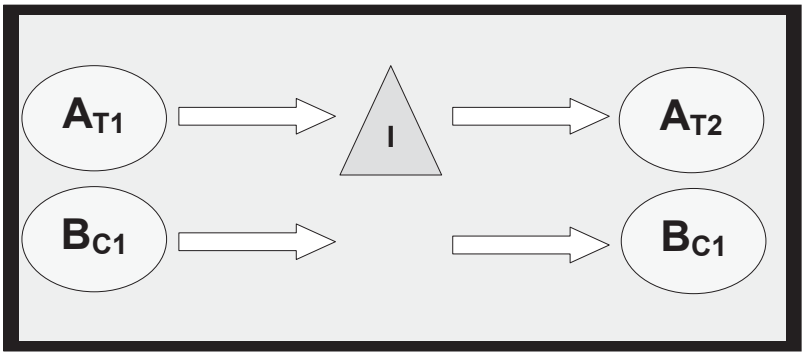
often for these diseases, but without strong community buy-in, they lack sustainability.[2a] This allowed CHIK to reemerge in 2006 in an epidemic that spread from the islands of the Indian Ocean to the subcontinent of India and as far as Italy. Due to the widespread presence of a secondary mosquito vector, *Ae. albopictus*, in many non-tropical countries, CHIK has become a threat to many places not previously affected. This includes parts of Europe and the United States, making prevention in endemic countries even more important. This study will add significantly to the current literature, providing information on assessing current gaps in CHIK knowledge in a rural population. Additionally, the methods for developing, implementing, and evaluating the educational intervention will be useful in providing a template for future educational interventions in other at-risk areas.

CHAPTER 3-RESEARCH DESIGN AND METHODS

3.1 Overview of study design

An experimental community-based intervention with six treatment villages and six control villages in Tamil Nadu, India, was conducted between December 14, 2010 and December 10, 2011. The intervention was developed based on formative research collected during a needs assessment conducted in the same region of India.

Figure 3. Conceptual Model for Community Intervention



A and B represent households in the treatment (T) or control (C) area pre (1) and post (2) intervention (I).

This study was developed based on the idea that rural villagers in Tamil Nadu lacked general knowledge of chikungunya (CHIK) transmission and prevention methods. This idea was based on formative research conducted in this same region during a previous trip to India in early 2010. It would be important to identify those gaps in knowledge (Aim 1) using the Tamil Nadu rural household health survey. Once the gaps in knowledge and practices were identified; that information was used to develop an educational intervention (Aim

2). Once the intervention was completed, we tested the hypotheses that CHIK knowledge and prevention practices, evaluated by the Tamil Nadu chikungunya evaluation survey, would increase in the intervention villages compared to the control villages (Aim 3, hypothesis a), that larval indices would decrease in the intervention village compared to the control village (Aim 3, hypothesis b), and that geographic information systems (GIS) could be used to detect spatial patterns and identify areas at high risk of CHIK infection by collecting latitude and longitude at each household (Aim 3, hypothesis c). Specific aims 1, 2, and 3 combined to test the central hypothesis that the use of needs assessment to understand community knowledge and community-based approaches would increase community buy-in and enhance our ability to reduce rates of CHIK infection.

Our local partner in this study was the Meenakshi Mission Hospital and Research Centre (MMHRC), a non-profit organization dedicated to providing the community of Madurai, India, with high-quality medical care at an affordable cost. MMHRC also maintains several peripheral health centers in remote rural regions in order to help serve outlying villages. MMHRC's local knowledge and familiarity with conditions in the rural areas surrounding Madurai were extremely useful when designing and administering the educational intervention. MMHRC provided technical support to this project, including lodging and transportation. Local nursing assistants from MMHRC, fluent in Tamil, were employed throughout the project. The intervention was developed with input from the

community and MMHRC, with the implementation driven by the community with support from the researcher.

This study was approved by the University of Iowa Institutional Review Board (See Appendix 1) and the Ethical Committee for MMHRC (See Appendix 2). The study was granted a waiver of elements of consent and a waiver of signature.

3.2 Definition and conceptualization of key variables

3.2.1 Outcome variables

3.2.1.1 CHIK knowledge

Knowledge of CHIK cause, symptoms and methods of prevention were measured as the primary outcome of this study.

3.2.1.2 Larval measurement

The presence of larvae and the three larval indices (House index (HI), Container index (CI), and Bretaux index (BI)) were calculated for each household and used for GIS mapping to estimate risk of exposure to CHIK. In addition to using the larval indices for GIS risk mapping, this variable is also used as a measure of exposure to the educational intervention. One aspect of the educational intervention educates the community about the importance of covering water containers or preventing rain water collection is discarded containers around the household. Larval indices were selected as a measurement of increased knowledge of prevention based on it being a logical step in the natural history of the development of the mosquito. While the educational background of the study area is low and it may be difficult to expect

the community to learn the life cycle of the mosquito, prevention at the mosquito larvae stage is easier and more cost-effective than methods of prevention targeted at adult mosquitoes, so it is worth the additional effort to educate about larval prevention methods.

3.2.1.3 Household disease status

A household was considered positive if the household had at least one case of CHIK since Pongal (January 14, 2010). The Pongal holiday was selected as it comes at the beginning of the year, and is a major event in southern India that should allow for clear dating of an illness.

3.2.2 Confounder and effect modifiers

Several key variables were measured as potential confounders or effect modifiers. These variables may relate to knowledge of CHIK, exposure to CHIK virus, or may allow for increased ability to prevent CHIK.

3.2.2.1 Age

This variable may be a confounder, an effect modifier, or on the causal pathway to knowledge regarding CHIK. Age may also be related to an increase in risk for having experienced CHIK infection. As individuals age, they have a greater number of years of potential exposure to CHIK which increases the chances that they become infected. Knowledge of CHIK may be gained through firsthand experience with the disease. Age-related behaviors, such as employment opportunities, might place the individual in positions that increase or decrease exposure to infection. Age is difficult to measure in rural areas were

births may not take place in a hospital setting and births may go unregistered. There may be bias associated with this variable.

3.2.2.2 Education

This variable may be a confounder, an effect modifier, or on the causal pathway to knowledge regarding CHIK. Formal education may increase knowledge of CHIK through science or health related courses. Education may also increase a person's exposure to sources of information regarding CHIK, such as newspapers or internet sites. Education was a difficult variable to measure in this rural community.

3.2.2.3 Gender

This variable may be a confounder or an effect modifier. While there is no biologic plausibility for greater susceptibility to disease for one gender, there are many variables related to gender (e.g., occupation and education) that may result in a greater likelihood of exposure to infection and education.

3.2.2.4 Occupation

This variable may be a confounder, an effect modifier or on the causal pathway to knowledge regarding CHIK and may also result in an increase or decrease in exposure to CHIK.

3.2.2.5 Housing characteristics

The type of materials used in housing construction, the type of toilet facility utilized by the household and type of water storage may affect exposure to CHIK.

3.2.2.6 Economic variables

The economic status of the family may be an effect modifier in this study, allowing persons with more resources to access better education or provide increased ability to protect against exposure to CHIK.

3.2.2.7 Prior experience with CHIK

Personal or family experience with CHIK may be a confounder, an effect modifier, or on the causal pathway to knowledge regarding CHIK.

3.2.2.8 Livestock

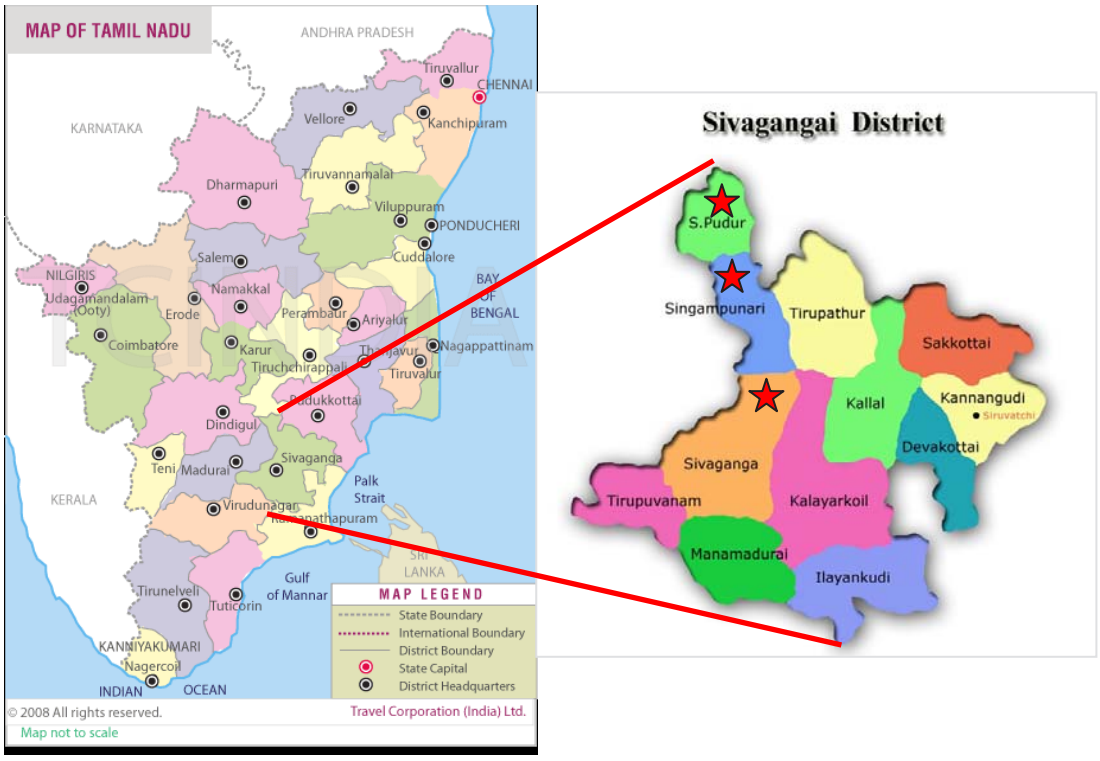
Mosquitoes are attracted to vertebrate animals based on five indicators, including: (1) heat, (2) moisture, (3) odor, (4) carbon dioxide, and (5) visual cues.[26] *Ae. aegypti* mosquitoes have a strong preference for human hosts compared to animal hosts, based primarily on human secretion of lactic acid.[27] There is potential that livestock kept in and around the house may draw mosquitoes (increased carbon dioxide) to the area to then feed on the preferred human host.

3.3 Study population

3.3.1 Study location

The study was conducted in the rural Sivaganga district of Tamil Nadu, India. This study was cluster randomized, as the nature of the location and the educational intervention made randomization of individuals inappropriate. The study was conducted in the Sivaganga district blocks S Pudur, Singampunari,

Figure 4. Map of Tamil Nadu and Sivagangai District



and Sivaganga (Figure 4). S Pudur has 21 panchayat villages[1] with a total of 10,821 households.[28] The average number of households in the panchayat villages of this block is around 600. Twelve panchayat villages similar in terms of size, governing district, geographical characteristics and ethic group were selected from the blocks for both the intervention and control regions. Anaiyur, a semi-urban panchayat town located in adjacent Madurai district, was used to pilot test the survey instruments. Anaiyur has a population of 38,302 and is located near MMHRC.

[1] A panchayat is a type of local government found at the village or small town level.

3.3.2 Household selection

Twelve villages were selected from the S Pudur, Singampunari, and Sivaganga blocks (six for the intervention and six for the control). Each set of six villages was clustered, with a distance of between fifteen and twenty kilometers separating the intervention and control clusters. The original methods detailed that within each panchayat village, 15 households would be randomly selected to participate in the study. Starting from a central location in each village, the study team spread outwards, selecting the first available household. After the first household, houses were selected by utilizing a two-house buffer and alternating sides of the street. This plan was difficult to implement as villages were not laid out along straight lines with ‘streets’. Villages often had many meandering paths, with houses laid out in random patterns. As a result, the every second house, alternating sides of the street method was inappropriate. In the field, a new household selection method was adopted, designating that very near neighbors were not selected for enrollment. Should a selected house have no eligible study subjects, the study team attempted to enroll the next available house. The study team attempted to enroll study households from all regions of the village. This was occasionally not possible due to environmental issues such as flooding or extreme heat. In one case, the sampling was inappropriate due to miscommunication with the liaison. During the original needs assessment, the eastern half of village with two clusters of houses, separated by one kilometer was sampled, while during the evaluation the western half was sampled. This

was not discovered until after the enrollment and data collection had been completed.

3.3.3 Study participants

One adult female member of each household was asked to participate and provide information for the entire household. Adult men were not excluded, but this study concentrated primarily on women as they are more likely to be home during the daytime, their role as caretaker in the household, and their participation in microfinance groups such as Mahasemam (http://www.mahasemam.org/) make them an ideal source of information and a natural target for an educational intervention.

3.4 Data Sources

3.4.1 Tamil Nadu rural household health survey

A 61-item survey instrument (See Appendix 3) was used to collect demographic, socioeconomic position (SEP) and health information (including questions about CHIK knowledge) from participants. The questionnaire took on average 30 minutes to conduct.

3.4.2 Tamil Nadu chikungunya evaluation survey

A 48-item survey instrument (See Appendix 4) was used to collect follow-up data on health related information from participants. The questionnaire took on average 20 minutes to conduct.

3.5 Data Collection and Management

3.5.1 Consent process

1. A study representative, an assistant nurse with MMHRC who is well known in the study area, selected the villages and explained the study to village representatives. The study representative also acted as a guide around the villages, provided introductions at each household, and aided in data collection.
2. At each household in the village, the study team was introduced to the family by the representative. An adult female in the household was asked to participate in the study. On occasion, an adult male would participate instead of an adult female, which was acceptable.
3. The prospective participants were read an explanation of the study goals, which included the collection of family characteristics and health knowledge. The study participants were purposefully blinded to the CHIK aspect of the study to prevent biased answers. A statement of consent was then read to prospective study participants. They were given the opportunity to consent, request time to consult family and discuss participation, or decline participation. If the subject consented, survey administration began immediately. If the subject wished to take time to consider, a return visit was scheduled. Subjects who declined were thanked and their response was noted.

3.5.2 Questionnaire administration

1. Once verbal consent was obtained, the study team began to administer the 30 minute Tamil Nadu rural household health survey. Each question was read to the subject in Tamil. The subject's response was recorded on a hardcopy of the survey. In accordance with MMHRC Ethics committee guidelines, MMHRC employees were responsible for data collection, with the principal investigator (PI) acting as an observer of the data collection process.
2. During the course of the interview, participants were asked to show the PI or data collector their water storage. If they consented, containers were counted and the number of containers negative and positive for larvae were recorded. See section 3.5.5 for a description of larval survey methodology.
3. At the end of the interview, the participant was given the opportunity to ask questions or seek clarifications before the session was terminated.

3.5.3 Intervention and evaluation

1. The PI asked the community for input on the type and scope of the intervention they wanted to see implemented to address the needs of the panchayat.
2. Taking into account the results of the needs assessment and input of the community, an educational intervention (Appendix 5) was developed to address gaps in the knowledge and practices relating to CHIK.
3. The educational intervention was implemented between December 14, 2010 and August, 2011 by MMHRC nursing assistants assigned to the satellite

clinic in Varapur, Tamil Nadu. The intervention consisted of school visits, community meetings, group meetings, and door-to-door visits.

4. Following the implementation of the educational intervention, the Tamil Nadu chikungunya evaluation survey was administered between August 2011 and December 2011 by the study team in the same 12 communities as the Tamil Nadu rural household health survey.
5. Consent for the Tamil Nadu chikungunya evaluation survey was obtained following the procedure established during the Tamil Nadu rural household health survey. During the course of the interview, participants were asked to show the data collector their water storage and containers were counted and the numbers of containers negative and positive for larvae were recorded. See section 3.5.5 for a description of larval survey methodology.
6. At the end of the interview, the participant was given the opportunity to ask questions or seek clarifications before the session was terminated.

3.5.4 Evaluation questionnaire (version 2.0)

1. During data cleanup after the completion of the post-intervention data, it was determined that data collected for the 2011 post-intervention study was not adequate for analysis as the households surveyed were not matched to those in the needs assessment group. A second post-intervention survey was needed to obtain complete demographic and health data. The first version of the evaluation survey contained only CHIK and health variables to assess the change between CHIK knowledge and prevention. The updated version (v. 2) of the survey contained additional demographic and household questions.

The Tamil Nadu chikungunya evaluation survey (v. 2) was administered during April 2012 by the study team on a new random sample of households in the same twelve communities used previously. A new random sample was selected the MMHRC study team deemed it too difficult to locate the original households from either the needs assessment or first evaluation.

2. Consent for the additional data collection was obtained following the procedure established during the previous study rounds.
3. Once all the questions were asked, the subject was allowed to ask questions before the survey was completed.

Participant responses to the all questionnaires were entered onto hard copies of the instrument by the MMHRC data collectors along with household global positioning system (GPS) coordinates (Tamil Nadu rural household health survey and Tamil Nadu chikungunya evaluation survey v.2) and provided with a study ID. Questionnaire data were manually entered into an Access database by the PI. Data integrity checks were built into the Access database to ensure that only valid data were entered. All hardcopies of the surveys were transported from Madurai, India, to the University of Iowa to be stored in locked file cabinets within locked offices. Computer files are password protected and only the PI and project collaborators has access to the data.

Information collected during the community needs assessment, intervention implementation and post-intervention were used to design an intervention protocol that would serve as a template for future intervention replication. A component of the intervention was the training of educators.

MMHRC employs a group of young nursing assistants, called “sisters”, who staff MMHRC clinics to provide onsite aid and triage. We trained a group of these women to deliver a CHIK message about its cause, transmission, and prevention.

3.5.5 Larval survey

At each consenting household, all water containers were inspected for presence or absence of mosquito larvae. The CI, HI, and BI were calculated from this information. The PI received training on proper larval identification and counting techniques from the head of the Centre for Research in Medical Entomology in Madurai, India. Unfortunately, by the time the training was completed, the needs assessment had already started, which resulted in a need to revisit eight villages to complete larval surveying. This delay resulted in some missing data for households that were inaccessible on the date of the return visit.

During the Tamil Nadu rural household health survey, the PI conducted all data collection for the larval survey. The last two villages were used to train the head nurse, Rosemary, and primary data collector, Valli, on proper methods of larval surveying. The data collectors were responsible for the larval survey during the evaluation study. Dr. Anne Wallis monitored one of the data collectors while observing data collection in two villages.

Larval surveys are useful in establishing risk for mosquito borne diseases, but do have limitations, particularly with regards to seasonal and climate factors. Recent rain, temperature, and humidity positively influence mosquito breeding. A limitation of this method is that it depending on attempting to collect data during

similar weather conditions, or control for seasonality during data analysis. There is the possibility that seasonality could influence the larval indices.

3.5.6 GIS

Satellite images provided through Google Earth™ were used to develop detailed village-level data layers of the villages. GPS coordinates of participating households (i.e., location, disease status, and larval status) were collected using a handheld GPS receiver. Pre- and post-intervention maps were compared visually to evaluate the effect of the intervention on numbers and clustering of larval positive households.

3.6 Principal component analysis

Principal component analysis (PCA) was selected for this study in order to assess total area level variance in SEP and water variables in this district of Tamil Nadu. PCA is one method of data reduction which is used when it is hypothesized that the data comprise more than one domain. Another method of data reduction is factor analysis. Step-wise, factor analysis and PCA are similar and occasionally used as synonyms. Conceptually, factor analysis and PCA differ in the assumptions regarding underlying variable structure and the study hypotheses.[29] While PCA does not make assumptions regarding the number of variables or the underlying causal model, factor analysis is used when it is believed that latent factors exist; therefore, it is often considered confirmatory.[29] PCA was selected to create socioeconomic and water indexes for use in statistical models for this study as the underlying causal model is not known. While both procedures were originally developed for use with continuous

variables with normal distributions, there is substantial literature on the use of discrete data in factor analysis and PCA. Since the original development, these methods of data reduction have been used extensively to produce indexes for health care research, most consisting entirely of Likert scale or other categorical data.[30] There exist computationally intensive methods for dealing with discrete variables in PCA such as polychoric correlations. A study by Kolenikov and Angeles showed that using polychoric correlations provides more consistent estimates of the explained variance compared to using ordinal data with no modification, as if it were continuous.[31] They reported that misclassification rates and Spearman correlations were very similar between the use of ordinal data or the polychoric method.[31]

3.6.1 PCA variable selection

3.6.1.1 SEP variable selection

Based on a literature review and previous work by Dr. S. Umashankar, SEP variables were selected across four domains: (1) individual characteristics, (2) employment, (3) household characteristics, and (4) amenities provided by the government. These domains comprise individual demographic characteristics, durable asset ownership, access to utilities and infrastructure, and other attributes that are theorized to contribute to wealth and/or social status, such as education and savings. Household variables were chosen over individual variables as these variables more closely represent the ability of the family as a whole to respond to a health (or other) crisis.[32] Additionally, women often work in

the home and thus their employment or income status may not accurately reflect their SEP.[15b, 33]

A household was defined as a group of individuals living under the same roof. Individual characteristics such as age, gender, and employment are represented by the head of household rather than the individual survey respondent. We assessed housing characteristics and amenities such as roof/floor materials, separate kitchen, cooking fuel, electricity, and other household goods via questions and observations. Variables such as those related to water acquisition and water safety, which may be connected to health-related knowledge and attitudes, were excluded from this index as they were believed to be directly related to the outcome in the main study. Many of these variables are regionally defined and specific to a rural Indian population.

3.6.1.2 Water variable selection

Similarly to the SEP variable selection, water variables were selected based on a literature review and previous work by Dr. S. Umashankar. Water variables included distance from water sources, water location, which family member is responsible for collecting water, water storage, and methods for making water safer to drink.

3.6.2 Coding of variables

3.6.2.1 SEP variable coding

Continuous variables (e.g., age and number of rooms) were transformed into categorical or dichotomous variables based on the distribution of the values in the dataset. The variable crowding was derived from the number of persons in

Table 3. Coding of all PCA variables

	Original variable	New variable	Code
Crowding	Continuous	Dichotomous	0=2.1 and above 1=0-2.0
Toilet	Categorical	Dichotomous	0=no facility/bush 1=flush/within dwelling
Electricity	Yes/No	Dichotomous	0=No 1=Yes
Phone	Yes/No	Dichotomous	0=No 1=Yes
TV	Yes/No	Dichotomous	0=No 1=Yes
Grinder	Yes/No	Dichotomous	0=No 1=Yes
Refrigerator	Yes/No	Dichotomous	0=No 1=Yes
Fuel	Categorical	Dichotomous	0=firewood 1=anything else
Kitchen	Yes/No	Dichotomous	0=No 1=Yes
Rooms	Continuous	Dichotomous	0=1-2 rooms 1=3 or more rooms
Floor	Categorical	Categorical	0=earth or dung 1=cement 2=mosaic or tiles
Roof	Categorical	Categorical	0= no roof, mud, GI sheets, or thatch/palm leaf, 1=tiles, 2=RCC
HHGender	Male/Female	Dichotomous	1=male 2=female
HHMarital	Categorical	Categorical	1=married, 2=single, 3=widowed
HHAge	Continuous	Categorical	0=0-25 1=26-50 2=51 and above
HHEmployment	Categorical	Dichotomous	0=employed 1=unemployed
WaterDrink	Categorical	Categorical	0= unprotected surface or well water, 1=protected well or tanker truck, 2=public tap/tap near yard, 3=piped into house/ bottled water
WaterOther	Categorical	Categorical	0= unprotected surface or well water, 1=protected well or tanker truck, 2=public tap or tap near yard, 3= piped into house or bottled water
WaterLoc	Categorical	Categorical	0= same village or elsewhere 1= same street, 2=in yard, 3= in dwelling
WaterDistance	Continuous	Dichotomous	0=More than 10 minutes, 1= Less than 10 minutes
WaterSafeMethod	Categorical	Categorical	0=nothing, 1=don't know/other, 2=strain through cloth, 3=boil, 4=filter

Table 3. Continued

WaterStorage	Dichotomous	Dichotomous	0=not covered, 1=covered
WaterDipper	Dichotomous	Dichotomous	0=not clean, 1=clean

Abbreviation: GI=galvanized iron, RCC=Reinforced cement concrete.

the household divided by the number of household rooms. For the SEP index, dichotomous variables include: rooms per household (i.e., 1 or 2 rooms; 3 or above), crowding (i.e., 0-2; 2.1 individuals per room and higher), toilet (no facility/bush; flush/within dwelling), and fuel (i.e., firewood; other). Categorical variables were used to represent head of household (HH) marital status (i.e., married, single, widowed), household roof material (i.e., reinforced cement concrete (RCC)), tile, thatch or palm leaves), age (i.e., ≤ 25, 26-50, and >50), and flooring (i.e., earth/dung, cement, mosaic/tile). For descriptions of variable coding, see Table 3.

3.6.2.2 Water variable coding

Water source variables (for both drinking and other use) were reduced to four categories. Dichotomous water variables include: water storage, water dipper cleanliness, and water distance. Categorical water variables include: water location, source of drinking water, source of other use water, and method of making water safe. See Table 3 for coding of water variables.

3.6.3 PCA methods

PCA procedures followed those developed by H. Kaiser in 1958.[34] First, a non-rotated PCA was performed, followed by varimax rotation with Kaiser normalization. The goal of varimax rotation is to simplify the components of the

unrotated matrix. Varimax rotation maximizes the variance of the loadings within factors while simultaneously maximizing the high and low loadings on a particular factor. This makes higher loadings higher and lower loadings lower, essentially compressing the factors. Typical minimum sample size requirements for PCA are greater than 100 subjects or five times the number of variables under study.[29] This would mean a minimum of 150 subjects for this study; the sample size meets this requirement.

3.6.4 Reliability of indexes

The reliability of both the SEP index and the water index were assessed using Crohnbach's alpha, a measure of internal consistency among a group of items, including variance and standard deviation. The reliability was calculated in order to verify that the variables making up a component measure the same underlying concept. Reliability was also evaluated by assessing whether the SEP index discriminated well in this population. Each of the SEP and water factor scores were divided into five equal groups-described as most poor to least poor-based on the distribution of each factor. Next, each household sorted into one of the five poverty categories based on their factor score. Finally, the distribution of each variable within the factor was assessed to observe the relationship between the poverty categories and asset ownership.

3.6.5 Reproducibility

The SEP and water indexes were used to calculate SEP factor scores and water factor scores for both the baseline dataset in which they were developed

and the post-intervention data. The SEP factor scores and water factor scores were used in the multivariate regression models.

3.7 Statistical considerations

3.7.1 Power analysis and sample size

The means method was used to calculate sample size for the pre- and post-intervention studies. This method is used to determine whether a program was associated with a change in behavior between baseline and follow-up, $n=\frac{16\sigma^2}{\Delta^2}+1$. The mean CHIK knowledge score was created using four sections from the survey instrument: CHIK knowledge, transmission, signs and symptoms, and prevention. Each response was assigned a point value, resulting in a total score of 28 points (See Appendix table A3). The range of possible scores were rated as excellent (24-28), Good (19-23), Fair (15-18) and Poor (<14) (See Appendix table A4). This rating was developed based on previous, unpublished research conducted in this area by the PI during a previous trip to Tamil Nadu. It was hypothesized that the intervention would lead to an increase in knowledge and practices; a 7-9 point increase was selected as a meaningful change. A change of 7-9 points was selected to represent respondents increased knowledge of transmission and prevention on the CHIK knowledge score. Using this method, we expect a total sample size of 12 households for the intervention group, or 24 households in each treatment group. Since the sample size requirement to achieve the main aim of this study was small, a larger sample size of 180 (90 in each arm) were sampled to ensure the study is powered to study

additional hypotheses. The sample was distributed across 12 study villages, with a sample size of 15 households in each village.

3.7.2 Statistical analysis

Data were analyzed with SPSS version 19 (SPSS, Inc., 2010, Chicago, IL, www.spss.com) and SAS version 9.2 (SAS Institute. Cary, NC) for Windows and included univariate and multivariate statistics. Data were analyzed by intention-to-treat (ITT) where all subjects in the intervention communities were dealt with as if they were exposed to the educational intervention while control communities were dealt with as if they were not exposed to the educational intervention. Dichotomous and nominal variables were summarized by proportions. Continuous variables were summarized by their mean. Proportions of household, dwelling, water, and health variables in the intervention and control groups were compared using the chi-squared test or analysis of variance (ANOVA) when appropriate. A mixed randomized block model with repetition was used to identify variables that predict CHIK knowledge. Least squares means were calculated to evaluate the interaction between the treatment and pre/post variable for the means of CHIK knowledge scores. The dichotomous larval indicator and CHIK case were used to map geographic patterns of larval habitats and recent experience of CHIK.

Missing post-intervention data for the SEP index variables were imputed. Listwise deletion of these cases would result in a significant drop in the sample size and make analysis difficult. A list of random variable data from each village in the pre-intervention was generated using odd numbered cases to fill in missing

data in the post-intervention. This technique was selected in order to preserve the variability present in the data. This method was preferred over replacing missing data with the mean which would potentially reduce variability and introduce error.

3.8 Potential methodological limitations

First, when implementing educational interventions that rely on behavioral change, it may be possible to see a positive short-term change that is not maintained in the long term. Real, sustainable change takes time, which is difficult to measure in the short time available to the researcher. Second, the villages participating in this trial have prevalent cases of CHIK among their populations which may raise the level of motivation in the study participants to accept the educational message and behavioral change. In areas with less intense transmission and fewer cases of disease, behavioral change may be difficult to promote. Third, measures of knowledge, attitudes and larval indices are surrogate outcomes for the true outcome of reduced incidence of CHIK. Fourth, there are several biases that may affect the evaluation of the intervention program exposure measurement. Two methodological types of selectivity that may affect this study are cuing and response selectivity.[25] Cuing selectivity represents a desire to please the interviewer by providing a particular response. From personal experience, many in Indian society feel it is difficult to say no to a guest. Response bias represents behavioral change, but unrelated to the program under evaluation. Other biases of concern are access (SEP factors), literacy (cognitive decoding) and predisposition (KAP).[25] Many of these factors

were measured during the needs assessment. Cuing and response selectivity were carefully controlled for during the needs assessment and evaluation. Providing an environment in which the participant could feel comfortable answering questions was the key to preventing these two biases.

Table 4. Evaluation Research Design

Research questions	Data sources/data collection	Hypothesis	Analysis
1. Do participants know the cause of CHIK?	Household survey	1. Rural villagers will lack knowledge of the causal agent of CHIK. 2. Post-intervention, individuals in the intervention village will have more knowledge of the causal agent of CHIK.	Analysis of pre- and post-intervention data; Chi-square or ANOVA to compare knowledge between and among groups
2. Do participants know the symptoms of CHIK?	Household survey	1. Rural villagers will lack knowledge of the symptoms of CHIK. 2. Post-intervention, individuals in the intervention village will have more knowledge of the symptoms of CHIK.	Analysis of pre- and post-intervention data; Chi-square or ANOVA to compare knowledge between and among groups
3. Do participants know how to prevent CHIK?	Household survey	1. Rural villagers will lack knowledge of methods of CHIK prevention. 2. Post-intervention, individuals in the intervention village will have more knowledge of CHIK prevention methods.	Analysis of pre- and post-intervention data; Chi-square or ANOVA to compare knowledge between and among groups
4. Does knowledge of CHIK cause translate into knowledge of symptoms or prevention?	Household survey	1. Individuals with knowledge of the CHIK causal agent will be more likely to correctly identify CHIK symptoms. 2. Individuals in the intervention village will be more likely to correctly identify both the causal agent and symptoms of CHIK.	Analysis of pre- and post-intervention data; Chi-square or ANOVA to compare knowledge between and among groups
5. Did the intervention affect knowledge of CHIK? (Cause, symptoms or prevention methods)	Evaluation survey	Individuals in the intervention village will have higher rates of knowledge of CHIK causal agent, symptoms and prevention methods compared to individuals in the control village.	Analysis of treatment and comparison group data; comparison of proportions.
6. Did the intervention affect practices related to CHIK prevention?	Evaluation survey	Individuals in the intervention village will have higher rates of current use of prevention methods compared to individuals in the control village	Analysis of treatment and comparison group data; comparison of proportions

Table 4. Continued

Research questions	Data sources/data collection	Hypothesis	Analysis
7. What are barriers to implementation?	**Evaluation survey**	**Individuals in the intervention village will have valuable feedback for improving future intervention**	**Descriptive analysis of barriers cited in questionnaires; bivariate and multivariate analysis to study associations**
8. GIS study	GIS survey	Pre-intervention, there will be significant patterns of larval indicators and CHIK illness. Post-intervention, there will be no patterns.	Dichotomous larval indicator used to evaluate geographic patterns.
9. Larval Indices	Larval survey	Larval indices in the intervention village will be lower after the intervention compared to the control village	Analysis of pre- and post-intervention data; ANOVA to compare larval indices between and among groups

CHAPTER 4-STUDY AREA DESCRIPTION

In this chapter, characteristics of the study villages are presented to provide a picture of the study area and to help understand some of the many factors that may influence important health variables in this population. Village layouts are described, and important community infrastructure items listed, including: roads, schools, temples, and other buildings of note. Based on observations by the principal investigator (PI), housing located closer to the village centers tends to be more closely spaced, while housing on the village fringes is more spread out. Housing density may influence a household's proximity to uncovered water containers (higher density housing) or to location of bodies of water, irrigated fields, or storage tanks to provide water to animals (lower density housing). Maps (generated using GoogleEarth) and photographs from each village are used to provide context.

4.1 Intervention villages

4.1.1 Varapur

Varapur is a village with a total population 2462 and 549 households. Varapur is the location of the Meenakshi Telemedicine Centre (MTC). The village is at the crossroads of three roads (two lanes, paved). There is a village square in the center of the village, around which are located a primary and secondary school, the ruins of an old building, and a shop in which rice rations are received. Varapur is a compact village, with the immediate area surrounding the village square containing the highest housing density. There is a large pond on the

Figure 5. Varapur map (left) and village photo (right)

southwestern edge of the village and another near a coconut grove on the road heading east out of Varapur.

4.1.2 Kurumbalur

Kurumbalur, a village with a population of 11,126, is located about five kilometers to the east of Varapur. The village is located just where the two lane road out of Varapur turns south, with the majority of the village in the southwest quadrant. A primary school is located north of the road. There is a portion of the

Figure 6. Kurumbalur map (left) and village photo (right)

village extending to the east where the houses are more spread out.

4.1.3 Kattayanpatti

Kattayanpatti is the home village of our village liaison and primary data collector, Valli. The village is a kilometer northeast on the road from Varapur with 2302 people and 555 households. This village is quite spread out compared to other study villages. There is a central portion with a large number of closely spaced houses and a second section with houses located a kilometer out that are more isolated. There is a small temple located on the eastern edge of the village, and a primary school located just outside the central portion of the village. There is a small pond on the southern edge of the village.

Figure 7. Kattayanpatti map (left) and village photo (right)

4.1.4 Ariyandipatti

Ariyandipatti is the second farthest out of the intervention villages and has a population of 503. It is located on either side of a two lane road. There is a

primary and secondary school located in the center of the village and a large pond on the southern edge. There is a small shop located near the southern edge of the village. Beyond the main road that runs through the center of the village, there is a confusing maze of small paths connecting the houses.

Figure 8. Ariyandipatti map (left) and village photo (right)

4.1.5 Keeranipatti

Keeranipatti is the farthest out of intervention villages and has a

Figure 9. Keeranipatti map (left) and village photo (right)

population of 9164. It is located on either side of a two lane road. There are several large multistory concrete houses in the center of the village, with the majority of the remaining houses made up of the more traditional cement walls and red tile roofs. There are several houses on the very edge of the town that are also two-story and made out of concrete.

4.1.6 Sadayanpatti

Sadayanpatti is located about three kilometers to the southwest of Varapur. The village is located primarily on the southern side of the road, with a primary school located on the north side of the road. There is a central meeting area with a temple like building (where women are not allowed to sit) and a large tree where people congregate. The village is visibly poorer than the other villages.

Figure 10. Sadayanpatti map (left) and village photo (right)

4.2 Control villages

4.2.1 Gopalapacheri

Gopalapacheri is an isolated village at the end of small, paved two lane road. The village is built around a large water tower. The village is well laid out with newly built single lane roads. There is a mix of houses constructed from the higher end concrete walls and roofs, and those more traditional with brick walls and tile roofs.

Figure 11. Gopalapacheri map (left) and village photo (right)

4.2.2 Kirungakkottai

Kirungakkottai is a large village, with 920 households (total population of 4155. The village is situated around a large pond at the intersection of two roads. There are several large, two storied houses located to the south of the village pond. There is also an area of new construction houses (concrete walls and roofs) on the southeast edge of the village. The houses to the west and north of the village pond are older, more traditionally built houses with brick walls and tile

roofs. There is a community toilet house with about twenty latrines across from the pond (east).

Figure 12. Kirungakkottai map (left) and village photo (right)

4.2.3 Sirumaruthur

Sirumaruthur is located on the bend of a road, with the majority of the village located just off a two lane road. It is a small village, with a population of 2667 and 580 households. The village has nice roads within the village, with many nice two-storied concrete houses. There is a small temple and a small shop in the center of the village. As a whole, there were better built, concrete houses in this village, making it stand out as village that is better off financially than many of the other villages we visited. This village is prone to flooding during the rainy season.

Figure 13. Sirumaruthur map (top left) and village photo (top right and bottom)

4.2.4 Thennammalpatti

Thennammalpatti is located on a two lane road, with the majority of the village located to the north of the road. A primary school is located on the western edge of the village. The village is small and compact.

Figure 14. Thennammalpatti map (left) and village photo (right)

4.2.5 S.V. Mangalam (Sadurvedamangalam)

S.V. Mangalam is a village located near a larger town, Singampunari, just off the Dindigul-Karaikudi Rd Highway. The total population is 3733, with 877 households. The village is built around a medium-sized temple (dedicated to Ganesh) and temple pond. The houses located closer to the temple are newer and nicer appearing than the houses located farther out.

Figure 15. S.V. Mangalam map (left) and village photo (right)

4.2.6 Anaikaraipatti

Anaikaraipatti is a two part village with a couple kilometers separating the two halves. The first (larger) portion of the village is located to the west of a two lane road and is laid out in a ‘U’ shape. The second half is centered around a small convenience shop and multistory, multifamily housing unit. The second half of the village is visibly poorer than the first half.

Figure 16. Anaikaraipatti map (left) and village photo (right)

CHAPTER 5-RESULTS

5.1 Overview of study population

An experimental community-based intervention with six treatment villages and six control villages was conducted in Tamil Nadu, India, between December 14, 2010, and August, 2011. The study's three aims were to: (1) conduct a needs assessment/baseline survey, (2) use data from the needs assessment to develop and implement an educational intervention, and (3) evaluate the intervention. Study participants were drawn from 12 villages in the Sivaganga district of Tamil Nadu including six intervention villages: Varapur, Kurumbalur, Kattayanpatti, Ariyandipatti, Keeranipatti, Sadayanpatti, and six control villages: Gopalapacheri, Kirungakkottai, Sirumaruthur, Thennammalpatti, S. V. Mangalam, and Anaikaraipatti. Based on the needs assessment, an educational intervention was designed and implemented in the six intervention villages between December 2010 and August 2011. Post-intervention data were collected between April 17, 2012 and April 20, 2012 from the same 12 villages as used for the needs assessment/baseline data collection.

5.2 Specific aim 1

5.2.1 Summary of baseline demographic characteristics of the study population

5.2.1.1 Summary of baseline household characteristics

Characteristics of the study households are shown in Table 5. The majority of individuals interviewed for the study were female (n=162, 88%), although the head of household (HH) was typically male (n=155, 84.2%). The

Table 5. Pre-intervention household characteristics

	Study Population (n=184)	Sivaganga	Tamil Nadu
% Respondents female	88.0	51.2[a]	49.8[a]
Respondent average age (years)	38.8	-	-
% HH male	84.2	-	85.2[b]
HH average age (years)	49.4	-	45.3[b]
HH marital status			
Married	82.1	-	60.2[c]
Widowed	17.4	-	9.7[c]
Single	0.5	-	30.1[c]
Average household size	4.6	4[de]	4.3[b]
Average household income (₹) per month	2376 ($43.01)	-	3398[f] ($61.50)
% Own land	65.8	-	25.1[g]
% Own house	92.9	81.1[e]	74.6[e]
% Households owning any livestock	66.8	-	-
Mean household livestock	3.2	-	-
Cow	42.9	-	18.7 [g]
Poultry	41.8	-	12.8 [g]
Goat	26.1	-	16.6 [g]
Bullock	5.4	-	-
Sheep	2.17	-	4.2 [g]
Buffalo	1.1	-	-
Single vs. mixed livestock			
% Single type of livestock	65.2	-	-
% Mixed livestock	34.8	-	-
% With bank account	38.6	53.5[e]	52.5[e]
% BPL card holder	95.1	21.0[a]	28.9[a]
% Belong to microcredit group	26.6	-	-
% Health insurance	70.1	-	-
% Electricity	94.0	91.9[e]	93.4[e]
% Radio	33.2	27.9[e]	22.8[e]
% Phone	76.1	69.3[e]	67.8[e]
% Television	87.5	83.8[e]	87.0[e]
% Grinder	57.6	-	45.8[g]
% Refrigerator	7.1	-	8.5 [g]
% Vehicle	30.4	29.1[e]	36.7[e]
% Bicycle	53.3	50.5[e]	45.2[e]

[a] For the respondent age category, the Tamil Nadu statistics are for the overall percent of females in the rural population. For BPL, this is the percent in the rural population. [35]

b [36]

Table 5. Pre-intervention household characteristics continued

[c] Marriage rates for total population, not just HH. [37]

[d] 29.5% of Sivagangai populations have 4 family members, representing the median and mode.

[e] [38]

[f] [39]

[g] [40]

average age was 38.8years for the respondents and 49.4 years for the HH. The average household size was 4.6, and the majority of the study population reported owning their home (n=171, 92.9%) and 65.8% of the population owning some land. The average monthly income for families was just under ₹2400 ($43.44). Most households had some form of livestock (n=123, 66.8%), with a mean livestock per household of 3.2 animals. The most common type of livestock was cattle (n=79, 42.9%) and poultry (n=77, 41.8%). Two-thirds of households owned a single type of livestock (n=120, 65.2%). Less than half (n=71, 38.6%) of the population had a bank account, while an overwhelming majority were BPL card holders (n=175, 95.1%). A quarter of the population belonged to a microcredit organization (n=49, 26.6%) and 70.1% of households had at least one family member with health insurance. Information on respondent and family member education was collected, but differences in methods of recording that information by the various data collectors made this variable impossible to analyze.

This study population is similar to Sivaganga and Tamil Nadu with regards to amenities such as electricity, radio, phone, television, vehicles, and bicycle

ownership. Percent of male HHs in the study population was similar to the overall proportion in the state (84.2% male versus 85.2% male), although this population was slightly older and more likely to be married. The number of family members per household was also similar between the study population, Sivaganga, and Tamil Nadu. The study respondents reported owning their own house and land at rates much higher than the state rates while also reporting lower monthly incomes and higher rates of having BPL ration cards. Land ownership in this population was 65.8% versus 25.1% for Tamil Nadu and house ownership was 92.9% versus Sivaganga at 81.1% and Tamil Nadu at 74.6%.

A chi-squared test or ANOVA F statistic was used to determine whether household characteristics in the study area differed among the 12 study villages (Appendix Table A5) or between the control and intervention populations (Table 6) at baseline. Among all the study villages, there were significant differences in land ownership, having a bank account, and having cattle, goats, and/or sheep. When considering intervention versus control populations, there were significant differences in land ownership, family size, family income, microcredit membership, owning any livestock, single versus mixed livestock ownership, owning at least one cow or goat, and having electricity. The remaining 20 household characteristics were similar between control and intervention groups.

5.2.1.2 Summary of baseline dwelling characteristics

Table 7 shows dwelling characteristics of the study sample. The majority of houses had tile or cement roofs (n=143; 77.7%, see Figure 17) and cement floors (n=128; 69.6%). Most houses (n=134; 72.8%) comprised one or two

Table 6. Pre-intervention household characteristics between the intervention and control groups

	Intervention (n=94)	Control (n=90)	p-value
% Respondents female	88.3	87.8	0.913
Respondent age	37.7	39.9	0.321
% HH Male	88.3	80.0	0.123
HH age	51.0	47.7	0.095
HH marital status			0.377
Married	85.1	78.9	
Widowed	14.9	20.0	
Single	0	1.1	
Household income (₹)	1534	3208	0.000*
% Own land	77.7	53.3	0.002*
% Own House	92.6	93.3	0.357
% Households owning livestock	78.7	55.6	0.001*
Average household livestock	3.8	3.0	0.221
Cow	55.3	28.9	0.000*
Poultry	42.6	42.2	0.964
Goat	38.3	13.3	0.000*
Bullock	4.3	7.8	0.314
Sheep	3.2	1.1	0.333
Buffalo	1.1	0	0.327
Single vs. mixed types livestock			0.003*
Single type of livestock	36.2	28.9	
Mixed livestock	42.6	26.7	
% Have a bank account	39.4	37.8	0.825
% BPL card holder	95.7	94.4	0.683
% Belong to microcredit	19.1	34.4	0.029*
% Have health insurance	72.3	67.8	0.793
% Electricity	90.4	97.8	0.035*
% Radio	26.6	40.0	0.054
% Phone	77.7	74.4	0.609
% Television	85.1	90.0	0.316
% Grinder	58.5	56.7	0.800
% Refrigerator	4.4	10.0	0.128
% Vehicle	34.0	26.7	0.277
% Bicycle	55.3	51.1	0.567

*Significant at the 0.05 level

Table 7. Pre-intervention dwelling characteristics

	% Respondents (n=184)	Sivaganga[38]	Tamil Nadu[38]
Roof type			
RCC	35.9	36.4	43.7
Tile	41.8	52.4	29.7
Thatch/palm	22.3	8.2	15.8
Floor type			
Cement	70.7	53.2	62.8
Earth/dung	22.8	15.4	16.5
Mosaic/tile	5.9	18.8	17.2
No toilet-Open Space	83.2	55.8	45.7
# Rooms			
1 or 2	72.8	68.4	68.9
3 or more	27.1	16.5	21.3
Separate kitchen	40.8	80.7	78.5
Cooking fuel			
Firewood	91.8	63.2	43.5
Other fuel	8.1		

Figure 17. Examples of typical house with tile roof (top) and cement roof (bottom)

rooms, with more than half (n=109; 59.2%) having no separate room for cooking.

The primary fuel used for cooking was firewood (n=139; 91.8%). A chi-squared test was used to determine whether dwelling characteristics in the study area differed among the 12 study villages (Appendix Table A8) or between the control and intervention populations (See Table 8) at baseline. Among all the

Table 8. Pre-intervention dwelling characteristics between the intervention and control groups

	Intervention (n=94)	Control (n=90)	p-value
Roof Type			0.025*
RCC	26.6	45.6	
Tile	46.8	36.7	
Thatch/Palm	26.6	17.8	
Missing			
Floor Type			0.250
Cement	69.1	72.2	
Earth/dung	26.6	18.9	
Mosaic/Tile	4.3	8.9	
No Toilet-Open Space	87.2	78.9	0.131
# Rooms			0.629
1 or 2	71.3	74.4	
3 or more	28.7	25.6	
Missing			
Separate Kitchen	39.4	42.2	0.693
Cooking Fuel			0.002*
Firewood	97.9	85.6	
Other fuel	2.1	14.4	

*Significant at the 0.05 level

study villages, there were significant differences in material of roofs and floors, and type of cooking fuel. There were no differences among villages in number of rooms or having a separate kitchen for cooking. When considering intervention versus control populations, there were significant differences in roof material and cooking fuel.

This study population has more houses with thatched or palm roofs and earth floors compared to the district and Tamil Nadu. A much larger proportion of this population uses open spaces for a toilet, compared to the rates in Sivaganga and Tamil Nadu. There are fewer separate kitchens than the district and state. A

larger proportion of this population relies on firewood for cooking fuel than the district or state.

5.2.1.2 Summary of baseline water characteristics

As shown in Table 9, the majority of the population utilized public taps (Figure 18) for both their drinking water (n=147, 79.9%) and other household water (n=134, 72.8). For most households, the water source was located on the same ‘street’ (n=157, 85.3%). Time to collect water was less than 10 minutes (n=141, 76.6%) and most often collected by an adult female in the household (n=159, 86.4%). While most households did not do anything to make their drinking water safer to drink (n=108, 58.7%), those who did used boiling (n=53, 28.8%) or filtering through cloth (n=20, 10.9%). Most households kept their drinking water covered (n=167, 90.2%) and their water dipper clean (n=130, 70.7%).

A chi-squared test was used to determine whether water characteristics in the study area differed among the 12 study villages (Appendix Table A11) or

Figure 18. Photographs showing examples of public water taps

Table 9. Pre-intervention water characteristics

	% Respondents (n=184)	Sivaganga[38]	Tamil Nadu[38]
Drinking water			
Unprotected surface or well water	3.3	8.2	0.9
Protected well or tanker truck	13.0	17.9	13.2
Public tap or tap near yard	81.5	59.5	36.8
Piped into house or bottled water	2.2	34.7	34.8
Other use water			
Unprotected surface or well water	5.9	-	-
Protected well or tanker truck	14.7	-	-
Public tap or tap near yard	73.9	-	-
Piped into house or bottled water	4.9	-	-
Water location			
In own dwelling	4.3	-	34.9
In own yard	2.2	-	-
Same street	85.3	-	-
Same village	8.2	-	-
Time to fetch water			
Less than 10 minutes	76.6	-	-
More than 10 minutes	23.4	-	-
Who fetches the water?			
Female	86.9	-	-
Male	8.1	-	-
Do you do anything to make your water safe?			
Nothing	58.7	-	-
Don't know	1.1	-	-
Strain through cloth	10.9	-	-
Boil	28.8	-	-
Water filter	0.5	-	-
Drinking water covered	90.2	-	-
Water dipper clean	70.7	-	-

between the control and intervention populations (See Table 10). Among all the study villages, there were significant differences in source of drinking water, source of other use water, water location, and method of making water safe to drink. There were no differences among villages in distance to water, who collects the water, covered water storage, or clean water dippers. When considering intervention versus control populations, there were significant differences in source of drinking water, source of other use water, method of making water safe to drink, and person who fetches the water.

Table 10.Pre-intervention water characteristics between the intervention and control groups

	Intervention (n=94)	Control (n=90)	p-value
Drinking Water			0.001*
Unprotected surface or well water	6.4	0	
Protected well or tanker truck	5.3	21.1	
Public tap or tap near yard	85.1	77.8	
Piped into house or bottled water	3.2	1.1	
Other use Water			0.010*
Unprotected surface or well water	4.3	7.8	
Protected well or tanker truck	8.5	21.1	
Public tap or tap near yard	77.7	70.0	
Piped into house or bottled water	8.5	1.1	
Missing	1.1	0	
Water location			0.575
In own dwelling	6.4	2.2	
In own yard	2.1	2.2	
Same street	83.0	87.8	
Same village	8.5	7.8	
Time to fetch water			0.291
Less than 10 minutes	73.4	80.0	
More than 10 minutes	26.6	20.0	
Who fetches the water?			0.046*
Female	80.0	93.3	
Male	13.9	2.2	
Other person	5.3	4.4	
Do you do anything to make your water safe?			0.021*
Nothing	63.8	53.3	
Don't know	2.1	0	
Strain through cloth	13.8	7.8	
Boil	19.1	38.9	
Water filter	1.1	0	
Drinking water covered	93.6	86.7	0.111
Water dipper clean	71.3	73.3	0.493

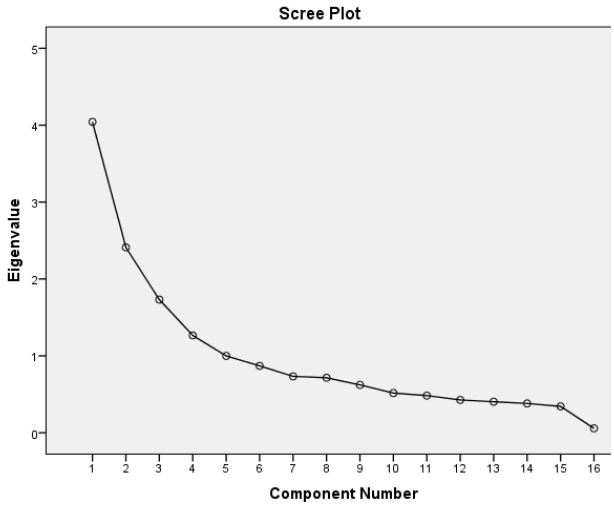
***Significant at the 0.05 level**

5.2.2 PCA

5.2.2.1 SEP Index

PCA was used to identify variables that, taken together, comprise the domain of SEP. From the original 31 variables, 16 variables were extracted based on a combination of eigenvalues >1.0 and observation of the scree plot.[41] The scree plot provides a visual indicator of the important factors (above the outcomes were avoided as they may interact with better health knowledge and outcomes in this study.[43] In particular, water variables may influence risk of mosquito borne diseases. Water storage within and around the house and “elbow”) followed by the less salient scree or rubble (the straight line).[41-42] Figure 19 displays the scree plot of eigenvalues. Variables related to better health location of water sources may provide opportunities for mosquito larvae to breed, while appropriate prevention methods (e.g., covering water containers) may prevention mosquito larvae breeding. As a result, water variables were excluded.

Figure 19. Scree Plot for SEP PCA



As recommended in the literature, we performed a non-rotated PCA, followed by varimax rotation with Kaiser normalization to maximize the variance of loadings within factors and maximizing the high and low loading within a factor.[34] The rotated PCA extracted four components with eigenvalues above 1.0.[44] These components are comprised of 16 variables, representing 59% of the total variability for this measure. Table 11 shows the unrotated components and Table 12 shows rotated components. The values shown in Table 11 and 12 are the loading factors. Factor loadings above 0.40 are considered to be high and show the component to which the variable belongs. Comparing the unrotated components to the rotated components, the variables are scattered in Table 11,

Table 11. Unrotated SEP PCA results

	Component			
	1	2	3	4
HH gender	0.293	0.834	0.25	0.17
HH age	0.255	0.366	0.008	-0.164
HH marital	0.286	0.825	0.292	0.164
HH employment	0.291	0.704	0.057	-0.148
Crowding	0.437	0.006	-0.272	0.604
Toilet	0.628	0.06	-0.138	-0.341
Electricity	0.284	-0.276	0.609	0.025
Phone	0.388	-0.264	0.486	-0.168
Television	0.419	-0.267	0.665	0.059
Grinder	0.545	-0.346	0.359	0.074
Refrigerator	0.64	-0.054	-0.283	-0.411
Fuel	0.645	0.002	-0.234	-0.48
Kitchen	0.659	-0.139	-0.186	0.334
Rooms	0.623	-0.163	-0.337	0.353
Floor	0.666	-0.089	-0.104	0.083
Roof	0.588	-0.088	-0.122	0.015

while the components sort out into clearly defined and understandable factors in Table 12. The first component, HH characteristics, represented 15.5% of the total data variability with variables related to the HH, including: HH gender, age, marital status, and employment. The second component, luxury amenities, accounted for an additional 15% of total data variability and represented goods such as flush toilet, refrigerator, and cooking fuel other than firewood. The third component, dwelling characteristics, accounted for 14.7% of total data variability. Dwelling characteristics include: roofing material, floor material, separate kitchen for cooking, number of rooms in the house, and a measure of crowding. The fourth component included household goods, such as electricity, phone, television, and grinder, and represented 13.9% of the variability.

Table 12. Rotated SEP PCA results

	Component			
	HH	Luxury amenities	Dwelling characteristics	Household goods
HH gender	0.926	-0.053	0.104	0.024
HH age	0.399	0.257	-0.011	-0.021
HH marital status	0.928	-0.067	0.082	0.059
HH employment	0.734	0.239	-0.037	-0.089
Toilet	0.168	0.676	0.179	0.125
Refrigerator	0.024	0.786	0.201	0.052
Fuel	0.085	0.819	0.131	0.074
Kitchen	0.023	0.244	0.715	0.167
Rooms	-0.048	0.259	0.763	0.034
Floor	0.078	0.396	0.507	0.221
Roof	0.048	0.401	0.418	0.174
Crowding	0.023	0.244	0.785	0.167
Electricity	-0.011	-0.033	0.01	0.726
Phone	-0.017	0.209	-0.022	0.663
Television	0.051	0.009	0.096	0.825
Grinder	-0.068	0.183	0.299	0.651

A reliability analysis using Cronbach's alpha (α) was utilized to determine the reliability (internal consistency) of each of the four components identified in the PCA, as shown in Table 13 below. The α values describe how well the items that comprise each component "fit" together. High consistency (i.e., ≥0.60) suggests that the items are strongly correlated. All four components were acceptable (1 α =0.72, 2 α =0.74, 3 α =0.73, 4 α =0.68).

Table 13. Reliability statistics for the SEP PCA

Component	Cronbach's α	Variance	Standard deviation
HH	0.72	2.51	1.59
Luxury amenities	0.74	0.56	0.75
Dwelling characteristics	0.73	3.64	1.91
Household goods	0.68	1.22	1.11

The scoring factors were transformed from continuous variables, into categorical variables in order to see how well the factors discriminated between the lowest scoring respondents (labeled most poor) and the highest scoring respondents (labeled least poor) with regards to the items used for the PCA in this population (Table 14). Very few of the most poor households owned an asset or were represented by the higher SEP item compared to the least poor households. For the HH factor, the highest scores were for older, unemployed (retired), widowed female HH. For the luxury factor, none of respondents in the most poor category had an indoor toilet, refrigerator, or used something other than firewood for cooking.

Table 14. Scoring factors and percentage of households owning an asset: comparison of most poor to least poor

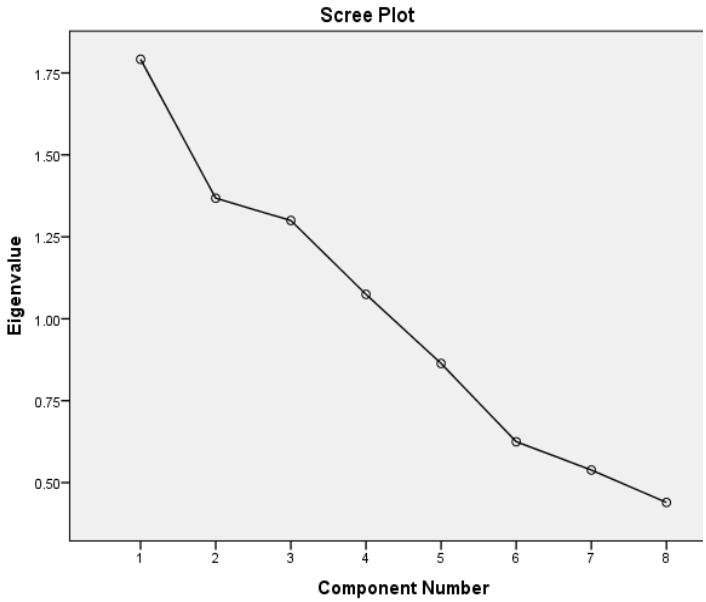
Index item	Scoring factor	% of distribution in the sample	Most poor (%)	Least poor (%)
Factor 1-HH				
HH gender (female)	0.926	15.8	0	15.8
HH age (50+)	0.399	48.4	1.6	15.2
HH marital status (widowed)	0.928	17.4	0	17.4
HH employment (unemployed)	0.734	19.0	0	13.6
Factor 2-Luxury amenities				
Toilet (flush)	0.676	16.8	0	13.6
Refrigerator (yes)	0.786	7.1	0	7.1
Fuel (kerosene/gas)	0.819	8.2	0	8.2
Factor 3-Dwelling characteristics				
Crowding (0-2.0)	0.785	50.0	0	20.1
Separate kitchen	0.715	40.8	0	19.6
Rooms (3+)	0.763	27.2	0	19.0
Floor (Mosaic/Tile)	0.507	6.5	0.5	4.3
Roof (RCC)	0.418	35.9	1.6	13.0
Factor 4-Household goods				
Electricity (yes)	0.726	94.0	14.1	19.6
Phone (yes)	0.663	76.1	4.9	19.6
Television (yes)	0.825	87.5	7.6	19.6
Grinder (yes)	0.651	57.6	0	19.6

Floor, roof, HH marital, and HH age are categorical. All other variables are dichotomous. The scoring factor is the weight assigned to each variable.

5.2.2.2 Water Index

PCA was used to identify variables that, taken together, comprise the domain of water. From the original eight variables, eight variables were extracted based on eigenvalues >1.0. Based on the scree plot, only three factors (comprised of seven variables) were extracted.[41] Figure 20 displays the scree plot of eigenvalues. The three factors identified by the scree plot were selected for further analysis.

Figure 20. Scree Plot for water PCA



As with the SEP PCA, we performed a non-rotated PCA, followed by varimax rotation with Kaiser normalization to maximize the variance of loadings within factors and to maximize the high and low loadings within a factor.[34] The rotated PCA extracted three components with eigenvalues above 1.0.[44] These components are comprised of seven variables, representing 62.8% of the total variability for this measure. Table 15 shows the unrotated components and Table 16 shows rotated components. The first component, household water use, accounted for 22.3% of total data variability and represented drinking water and other use water. The second component, water storage, represented 21.3% of the total data variability with variables related to how the household water is stored and accessed, including: water storage and water dipper. The third component, water source, accounted for 19.2% of the

Table 15. Unrotated water PCA results

	Component		
	1	2	3
Drinking water	0.616	-0.416	0.262
Other use water	0.714	-0.254	0.417
Water location	0.347	0.455	0.513
Distance from water	-0.304	0.408	0.611
Method of making water safe	-0.202	0.599	0.191
Water storage	0.503	0.471	-0.442
Water dipper	0.565	0.511	-0.339

Table 16. Rotated water PCA results

	Component		
	Household water use	Water storage	Water source
Drinking water	**0.772**	-0.001	-0.16
Other use water	**0.86**	0.078	0.055
Water storage	-0.008	**0.818**	-0.029
Water dipper	0.074	**0.828**	0.067
Water location	0.341	0.224	**0.651**
Distance from water	-0.101	-0.257	**0.745**
Method of making water safe	-0.301	0.135	**0.572**

total data variability. Water source included variables describing the location of the water source, distance to the water source, and methods to make water from that location safe to drink.

A reliability analysis using α was utilized to determine the reliability of each of the three components identified in the PCA, as shown in Table 17 below. Component one (household water use) and component two (water storage) were acceptable (1 α =0.60, 2 α =0.55). Component three (water source) was very low (3 α =0.24) which may indicate that the factor items are more different than similar. The reliability of the water index is discussed further in section 6.5.

Table 17. Reliability statistics for the water PCA

Component	Cronbach's α	Variance	Standard deviation
Household water use	0.60	0.92	0.96
Water storage	0.55	0.40	0.63
Water source	0.24	2.81	1.68

As with the SEP index, the scoring factors for the water index were transformed from continuous variables into categorical variables in order to see how well the factors discriminated between the lowest scoring respondents (labeled most poor) and the highest scoring respondents (labeled least poor) with regards to the items used for the PCA in this population (Table 18). Very few of the most poor households owned an asset or were represented by the higher value item compared to the least poor households. Having piped water inside the house was rare in this population and all those households with in-house piped water were classified into the least poor category. While covering water containers and keeping the water dipper were more prevalent practices, the index still distinguishes well between the most poor and least poor. Having the water source located inside the home, less than 10 minutes away, and the ability to use a water filter to make water safer to drink were all found almost exclusively in the least poor category.

5.2.3 Summary of health statistics of the study population

At baseline, 73.4% (n=135) of the respondents had heard of CHIK, but only 36.2% (n=67) knew that a mosquito transmits CHIK (Table 19). At least one symptom of CHIK was correctly identified by 60.3% of respondents, but 75.5% had no knowledge of how to prevent CHIK.

Table 18. Scoring factors and percentage of households owning an asset for water index: comparison of most poor to least poor

Index item	Scoring factor	% of distribution in the sample	Most poor (%)	Least poor (%)
Factor 1-Household water use				
Drinking water (Piped in house or bottled water)	0.772	2.2	0	2.2
Other use water (Piped in house or bottled water)	0.86	5.9	0	5.9
Factor 2-Water storage				
Water covered	0.818	90.7	11.5	23.0
Water dipper clean	0.828	70.5	1.6	29.5
Factor 3-Water source				
Type of water source (In dwelling)	0.651	4.4	0	4.4
Distance to water (<10 minutes)	0.745	76.4	1.4	18.7
Method of making water safe (Filter)	0.572	0.5	0	0.5

Drinking water, other use water, type of water source, and method of making water safe are categorical. All other variables are dichotomous. The scoring factor is the weight assigned to each variable.

Table 19. Pre-intervention CHIK knowledge

Have you heard of CHIK?	n=184
Yes	73.4%
No	26.6%
What transmits CHIK?	
Mosquito	36.2%
Don't know	63.8%
What are the symptoms of CHIK?	
Don't know	39.7%
Fever	4.3%
Joint pain	25.0%
Fever and joint pain	31.0%
How do you prevent CHIK?	
Don't know	75.5%
Prevent stagnant water	13.0%
Prevent mosquito	11.4%

There were no differences between the intervention and control villages with regard to knowledge of CHIK (p=0.322), transmission (p=0.707), symptoms

(p=0.064) as shown in Table 20. There was a statistically significant difference between the groups with regards to knowledge of prevention (p=0.019).

Table 20. Pre-intervention group differences for knowledge of CHIK

Variable	Intervention	Control	p-value
Have heard of CHIK (yes)	70.2	76.7	0.322
Knowledge of mosquito transmission (yes)	35.1	37.8	0.707
Knowledge of CHIK symptoms			0.064
None	47.9	31.1	
One	24.5	34.4	
Two	27.7	34.4	
Knowledge of CHIK prevention (yes)	17.2	5.6	0.019*

*Significant at the 0.05 level

As would be expected, there was a significant association between knowledge of CHIK and knowledge of CHIK transmission (p<0.0001), symptoms (p <0.0001), and prevention (p<0.0001), as shown in Table 21.

Table 21. Pre-intervention associations with knowledge of CHIK

Variable	p-value
Knowledge of mosquito transmission	0.0001*
Knowledge of CHIK symptoms	0.0001*
Knowledge of CHIK prevention	0.0001*

*Significant at the 0.05 level

ANOVA was used to identify whether source of CHIK knowledge (e.g., friend, relative, community meeting, health worker, etc.) was associated with knowledge of symptoms, transmission, and prevention. ANOVA showed that there are significant differences between the source of CHIK knowledge and knowledge of CHIK symptoms (Table 22). The Levene statistic test of

homogeneity of variances was significant (p=0.0001); the post-hoc test Games-Howell was therefore selected since there is no assumption of equal variances. For CHIK symptoms, the only differences in the source of CHIK knowledge were between those with no knowledge of CHIK and those who had heard of CHIK(from any source). This shows that there this not a source of CHIK knowledge in the community that particularly influences whether a person knows the symptoms of CHIK. There were no differences between the other sources of knowledge of CHIK and knowledge of CHIK symptoms.

Table 22. Pre-intervention Analysis of Variance for Source of CHIK knowledge and knowledge of symptoms

Source of variation	df	Sums of squares	Mean square	F	p-value
Between groups	7	52.371	7.482	16.760	0.0001*
Within groups	176	78.564	.446		
Total	183	130.935			

ANOVA suggested that there are significant differences between the sources of knowledge and knowledge of CHIK transmission (Table 23). The Levene statistic test of homogeneity of variances was again significant (p=0.0001) and the post-hoc test Games-Howell was selected to test for differences with the sources of CHIK knowledge. For CHIK transmission the only differences in the source of CHIK knowledge were again between those with no knowledge of CHIK and those who had heard of CHIK (from any source). This shows that there this not a source of CHIK knowledge in the community that particularly influences a person's knowledge of CHIK transmission. There were

no differences between the other sources of knowledge of CHIK and knowledge of CHIK transmission.

Table 23. Pre-intervention Analysis of Variance for Source of CHIK knowledge and knowledge of transmission

Source of variation	df	Sums of squares	Mean square	F	p-value
Between groups	7	18.273	2.610	8.552	0.0001*
Within groups	176	53.722	.305		
Total	183	71.995			

ANOVA was not significant for the source of CHIK knowledge and knowledge of CHIK prevention (Table 24), showing that there were no significant differences between the sources of knowledge and knowledge of CHIK prevention. This shows that source of CHIK knowledge in the community that does not influence a person's knowledge of CHIK transmission.

Table 24. Pre-intervention Analysis of Variance for Source of CHIK knowledge and knowledge of prevention

Source of variation	df	Sums of squares	Mean square	F	p-value
Between groups	7	424.880	60.697	1.132	0.345
Within groups	176	9433.201	53.598		
Total	183	9858.082			

Source of CHIK knowledge is not significant for having heard of CHIK, symptoms of CHIK, transmission of CHIK, or prevention of CHIK. As a result of the above analysis, source of CHIK knowledge will not be further analyzed in this study.

A total of 172 households and 1293 containers were surveyed for the presence or absence of mosquito larvae, with 15 households per village, for an average of 7.5 containers surveyed per household. Baseline larval studies (Table 25) indicated that the HI was 35.3% (n=61 households) and the CI was 9.2% (n=119 containers). BI could not be reported as there were fewer than 100 households surveyed per village.

Table 25. Pre-intervention larval statistics

Index	Overall (%)	Intervention (%)	Control (%)
Larval positive households (HI)	35.3	44.7	21.1
Larval positive containers (CI)	9.2	13.9	4.7

5.3 Specific aim 2

The educational intervention was developed with collaboration from colleagues at MMHRC. The final product was a 16-page flip book, with pictures on the side facing the audience and, on the reverse, speaking cues (text) for the educator. The page facing the audience was primarily composed of pictures with minimal text to allow easy use in communities with low literacy rates. From December 13 to December 17, 2010, the flip book was tested on 300 subjects, in the six intervention villages. The flip book was also utilized during door-to-door health education campaigns, at local schools, at local women's groups meetings, and during general community meetings in 2011 (See Figure 21). The educational flip book is included in Appendix 3.

Figure 21. Photographs of intervention at a local school (left) and community meeting (right)

5.4 Specific aim 3

5.4.1 Summary of household characteristics

5.4.1.1 Post-intervention summary of household characteristics

Village characteristics, including household, dwelling, and water characteristics were assessed for post-intervention differences among all 12 villages. A chi-squared test or ANOVA F statistic, as appropriate to the data, was used to determine whether household characteristics in the study area differed across all 12 study villages (Appendix Table A6) and between the intervention and control populations (Appendix Table A7) post-intervention. Across all the study villages, there were significant differences in land ownership, income, and ownership of at least one goat or poultry. There were also significant differences in income, and goat or poultry ownership between the control and intervention villages. All other household characteristics were similar between the control and intervention groups.

5.4.1.2 Pre- and post-intervention comparison of household characteristics

A chi-squared test or ANOVA F statistic was used to determine whether household characteristics in the study area differed between the pre- and post-intervention study populations. Table 26 shows that there were no differences in the pre- and post-intervention study populations with regard to the percentage of respondents' age and gender, HH characteristics, household size, house ownership, average numbers of livestock per household, and ownership of at least one buffalo, bullock, or goat. Table 26 does show that the sampled populations were more variable than expected. The pre- and post-intervention study populations differed on the average household income ($p=0.001$), land ownership ($p=0.026$), owning any livestock ($p=0.004$), owning cows ($p=0.0001$), single versus mixed types of livestock ($p=0.017$), and household amenities such as electricity ($p=0.018$), telephone ($p=0.044$), and grinder ($p=0.038$). While these may have statistical significance, it may be possible that practically, there is less difference between the pre- and post-intervention populations due to increased variability based on the small sample size. Possible explanations for some of these differences are discussed in Section 6.4

5.4.2 Summary of dwelling characteristics

5.4.2.1 Post-intervention summary of dwelling characteristics

Dwelling characteristics were assessed by a chi-squared test for differences among the post-intervention study villages (Appendix Table A9) and between control and intervention groups (Appendix Table A10) in the post-intervention. Across all the study villages, there were significant differences in

Table 26. Household characteristics comparison pre- and post-intervention

	Pre		Post		
	Intervention	Control	Intervention	Control	p-value
% Respondents female	88.3	87.8	80.0	85.6	0.511
Respondent age (average)	37.7	39.9	37.6	38.5	0.338
% HH male	88.3	80.0	95.6	92.2	0.086
HH age (average)	51.0	47.7	49.0	48.1	0.150
HH marital status					0.174
Married	85.1	78.9	92.2	87.8	
Widowed	14.9	20.0	7.8	11.1	
Single	0	1.1	0	1.1	
Household income (₹)	₹1534 ($27.46)	₹3208 ($57.42)	₹3147 ($56.33)	₹3872 ($69.31)	0.001*
% Own land	77.7	53.3	53.3	51.1	0.026*
% Own house	92.6	93.3	83.3	82.2	0.214
% Households owning livestock	78.7	55.6	50.0	43.3	0.004*
Average household livestock	3.81	3.02	1.47	2.17	0.877
Cow	55.3	28.9	33.3	20.0	0.0001*
Poultry	42.6	42.2	1.1	18.9	0.059
Goat	38.3	13.3	32.2	10.0	0.000*
Bullock	4.3	7.8	3.3	5.6	0.206
Sheep	3.2	1.1	7.8	13.3	0.458
Buffalo	1.1	0	0	1.1	0.978
Single vs. mixed type of livestock					0.017*
Single type of livestock	36.2	28.9	26.7	34.4	
Mixed livestock	42.6	26.7	23.3	18.4	
% Have a bank account	39.4	37.8	66.7	61.1	0.928
% Electricity	90.4	97.8	88.9	94.4	0.018*
% Radio	26.6	40.0	14.4	17.8	0.064
% Phone	77.7	74.4	54.4	75.6	0.044*
% Television	85.1	90.0	83.3	84.4	0.429
% Grinder	58.5	56.7	38.9	63.3	0.038*
% Refrigerator	4.4	10.0	7.8	10.0	0.152
% Vehicle	34.0	26.7	38.9	35.6	0.210
% Bicycle	55.3	51.1	33.3	48.9	0.276

*Significant at the 0.05 level

roof material, floor material, having a separate kitchen, and cooking fuel used. Only the number of rooms in each house was similar among villages. There were significant differences in all dwelling characteristics (i.e., roof material, floor material, having a separate kitchen, number of rooms, and cooking fuel used) between the control and intervention villages.

5.4.2.2 Pre and post-intervention comparison of dwelling characteristics

A chi-squared test was used to determine whether dwelling characteristics in the study area differed between the pre- and post-study study populations with regards to number of rooms in the house or having a separate kitchen (Table 27). The pre- and post-study populations differed on the materials used for the roof and floor, and the type of cooking fuel used by the household.

5.4.3 Summary of water characteristics

5.4.3.1 Post-intervention summary of water characteristics

Household water characteristics were analyzed separately as water variables are likely associated with risk of CHIK. Household water characteristics were assessed by a chi-squared test for differences across the post-intervention study villages (Appendix Table A12) and between control and intervention groups (Appendix Table A13). Across all the villages, there were significant differences in the source of drinking water, the source of other use water, water location, covered water storage, and clean water dipper. There were significant differences in all household water characteristics between the control and intervention villages, including: source of other use water, water location, water distance, covered water storage, and clean water dipper.

Table 27. Dwelling characteristics comparison pre- and post-intervention

	Pre		Post		
	Intervention (n=94)	Control (n=90)	Intervention (n=90)	Control (n=90)	p-value
Roof type					0.001*
RCC	26.6	45.6	36.7	66.7	
Tile	46.8	36.7	48.9	27.8	
Thatch/palm	26.6	17.8	13.3	5.5	
Missing	0	0	1.1	0	
Floor type					0.000*
Cement	69.1	72.2	92.2	72.2	
Earth/dung	26.6	18.9	2.2	12.2	
Mosaic/tile	4.3	8.9	3.3	15.6	
Missing	0	0	2.2	0	
No toilet-open space	87.2	78.9	93.3	73.3	
# Rooms					0.894
1 or 2	71.3	74.4	51.1	46.7	
3 or more	28.7	25.6	6.7	31.0	
Missing	0	0	42.2	56.7	
Separate kitchen	39.4	42.2	24.7	56.7	0.997
Cooking fuel					0.005*
Firewood	97.9	85.6	94.3	69.7	
Other fuel	2.1	14.4	5.7	30.3	

*Significant at the 0.05 level

5.4.3.2 Pre- and post-intervention comparison of water characteristics

A chi-squared test was used to determine whether household water characteristics in the study area differed between the pre- and post-intervention study populations. Table 28 shows the pre- and post-intervention study populations differed on all water characteristics. There was much greater variability in the responses to all of the water-related questions than expected; this is discussed further in Section 6.7.5.

Table 28. Description of water variables comparison pre- and post-intervention

	Pre		Post		
	Intervention (n=94)	Control (n=90)	Intervention (n=90)	Control (n=90)	p-value
Drinking water					0.001*
Unprotected surface or well water	6.4	0	0	1.1	
Protected well or tanker truck	5.3	21.1	4.4	2.2	
Public tap or tap near yard	85.1	77.8	91.1	90.0	
Piped into house or bottled water	3.2	1.1	4.4	6.7	
Other use water					0.0001*
Unprotected surface or well water	4.3	7.8	1.1	0	
Protected well or tanker truck	8.5	21.1	7.8	3.3	
Public tap or tap near yard	77.7	70.0	86.7	92.2	
Piped into house or bottled water	8.5	1.1	4.4	4.4	
Water location					0.002*
In own dwelling	6.4	2.2	3.3	5.6	
In own yard	2.1	2.2	0	12.2	
Same street	83.0	87.8	96.7	78.9	
Same village	8.5	7.8	0	1.1	
Elsewhere	0	0	0	2.2	
Time to fetch water					0.013*
Less than 10 minutes	73.4	80.0	81.1	92.2	
More than 10 minutes	26.6	20.0	18.9	7.8	
Who fetches the water?					0.005*
Female	80.0	93.3	93.3	97.8	
Male	13.9	2.2	5.6	1.1	
Other person	5.3	4.4	0	1.1	
Do you do anything to make your water safe?					0.0001*
Nothing	63.8	53.3	41.1	53.3	
Don't know/Other	2.1	0	8.9	2.2	
Strain through cloth	13.8	7.8	0	0	
Boil	19.1	38.9	17.8	17.8	
Water filter	1.1	0	31.1	23.3	
Missing	0	0	1.1	3.3	
Drinking water covered	93.6	86.7	66.7	58.8	0.000*
Water dipper clean	71.3	73.3	62.2	46.7	0.001

* Significant at the 0.05 level

5.4.4 Health models

Table 29 shows the differences in the CHIK variables between the pre- and post-intervention for the intervention and control groups. There were no

differences between the intervention and control groups (controlling for pre- and post-intervention) for having heard of CHIK, knowing the symptoms of CHIK, or knowing how to prevent CHIK. There was a significant difference for knowing that a mosquito transmits CHIK (p=0.001) between the intervention and control groups, while controlling for the time (pre/post). Knowledge and use of methods of mosquito prevention did differ between the intervention and control groups at pre- and post-intervention (p=0.001), most likely due to the low value post-intervention in the intervention group. These CHIK variables were used to calculate the CHIK knowledge scores that is the dependent variable used in the final health model. The CHIK knowledge score was calculated for each

Table 29. Baseline CHIK knowledge Comparison Pre- and Post-Intervention

	Pre		Post		
	Intervention (n=94)	Control (n=90)	Intervention (n=90)	Control (n=90)	p-value
Have you heard of CHIK?					0.815
Yes	70.2	76.7	76.7	72.2	
No	29.8	23.3	23.3	27.8	
What transmits CHIK?					0.001*
Mosquito	35.1	37.8	62.2	44.4	
Don't know	64.9	62.2	37.8	55.6	
What are the symptoms of CHIK?					0.755
Don't know	47.9	31.1	34.4	36.7	
Fever	5.3	3.3	4.4	5.6	
Joint Pain	18.1	31.1	35.6	22.2	
Fever and Joint Pain	28.7	34.4	25.6	35.6	
How do you prevent CHIK?					0.214
Don't know	72.3	78.9	85.6	67.8	
Prevent stagnant water	10.6	15.6	8.9	24.4	
Prevent mosquito	17.0	5.6	5.6	7.8	
Mosquito prevention methods					
Knowledge and use	2.4 Range (0.0-5.0)	2.5 Range (0.0-5.3)	1.6 Range (0.0-3.5)	2.5 Range (0.0-6.5)	0.001*

* Significant at the 0.05 level

household in the study. The CHIK knowledge score consists of five items: (1) CHIK knowledge, (2) CHIK transmission, (3) CHIK symptoms, (4) CHIK prevention, and (5) mosquito prevention (See Appendix Table A3). Categories ranging from poor to excellent knowledge levels were calculated (See Appendix Table A4). Prior to the study, it was believed that most participants would generate CHIK knowledge scores in the range of 9-11 (i.e., Have heard of CHIK, transmission unknown, symptoms known, CHIK prevention water related, and may know of/use a few methods of prevention). Following the intervention, it was proposed that CHIK knowledge scores would increase to ≥19 (i.e., have heard of CHIK, transmission known, symptoms known, mosquito prevention for CHIK prevention, and may know of/use a more than a few methods of prevention). The values of CHIK knowledge score (average, median, and range) are shown in Table 30. The pre-intervention averages for the intervention villages range from 4.6 to 10.2. Post-intervention, the intervention village average scores ranged from 10.9 to 13.3. The pre-intervention averages for the control villages range from 6.0 to 10.0. The post-intervention averages for the control villages range from 6.8 to 11.2. The ranges for intervention and control villages, both pre- and post-intervention, are very wide, representing a large variation in CHIK knowledge scores at the village level.

Several independent variables were used to determine the best model to predict the CHIK knowledge score variable. The normality assumptions for the model were met (Figure 22 for the stem leaf plot, box plot, and normality probability plot). The solution for the random effects of villages nested

Table 30. CHIK knowledge scores for study villages pre- and post-intervention

	Pre			Post		
Village	**Average**	**Median**	**Range**	**Average**	**Median**	**Range**
Varapur	10.2	11.1	1.8-16.0	8.7	9.5	1.0-16.8
Kurumbalur	4.6	3.8	0.0-14.0	7.9	9.5	1.0-14.3
Katayanpatti	7.3	6.8	0.3-16.5	8.8	9.3	1.0-16.8
Ariyandipatti	8.7	7.0	1.8-18.3	7.0	9.3	1.0-13.3
Keeranipatti	7.1	7.3	1.0-15.5	6.3	5.5	0.0-15.5
Sadayanpatti	5.7	4.0	1.0-17.8	7.4	9.0	1.3-11.3
Intervention	**7.3**	**6.1**	**0-18.3**	**7.7**	**9.3**	**0.0-16.8**
Gopalapacheri	6.1	7.0	1.5-11.5	7.0	6.5	0.0-19.0
Kirungakkottai	7.1	6.5	0.0-14.5	10.4	11.5	1.3-19.0
Sirmaruthur	8.0	7.5	1.0-16.8	6.5	5.5	0.0-16.3
Thennammalpatti	8.7	10.0	0.0-17.0	5.4	3.5	1.0-15.3
S.V. Mangalam	6.6	6.0	1.0-14.3	10.3	11.8	1.0-19.0
Anaikaraipatti	8.7	9.5	1.0-14.3	9.9	11.5	1.25-16.8
Control	**7.5**	**7.1**	**0.0-17.0**	**8.2**	**6.5**	**0.0-19.0**

within treatment group for pre- and post-intervention showed no significance (Table 31).

Using a random block design with repetition, the four SEP scores, the three water scores, livestock amounts, larval HI, larval CI, household CHIK experience, respondent age, and respondent gender were entered into the model (Table 32). Variables representing respondent age ($p=0.002$), household CHIK experience ($p=0.004$), luxury amenities ($p=<0.0001$), and water source (0.041) were significant in this model. Household goods ($p=0.060$) was marginally significant. Of significance, the pre/post, and treatment group variables were not significant. A process variable, recent education regarding CHIK, was considered but not added to the model as information was only collected during the evaluation, and not during the needs assessment.

Figure 22. Stem leaf plot, boxplot, and normal probability plot of residuals for normality assumption test

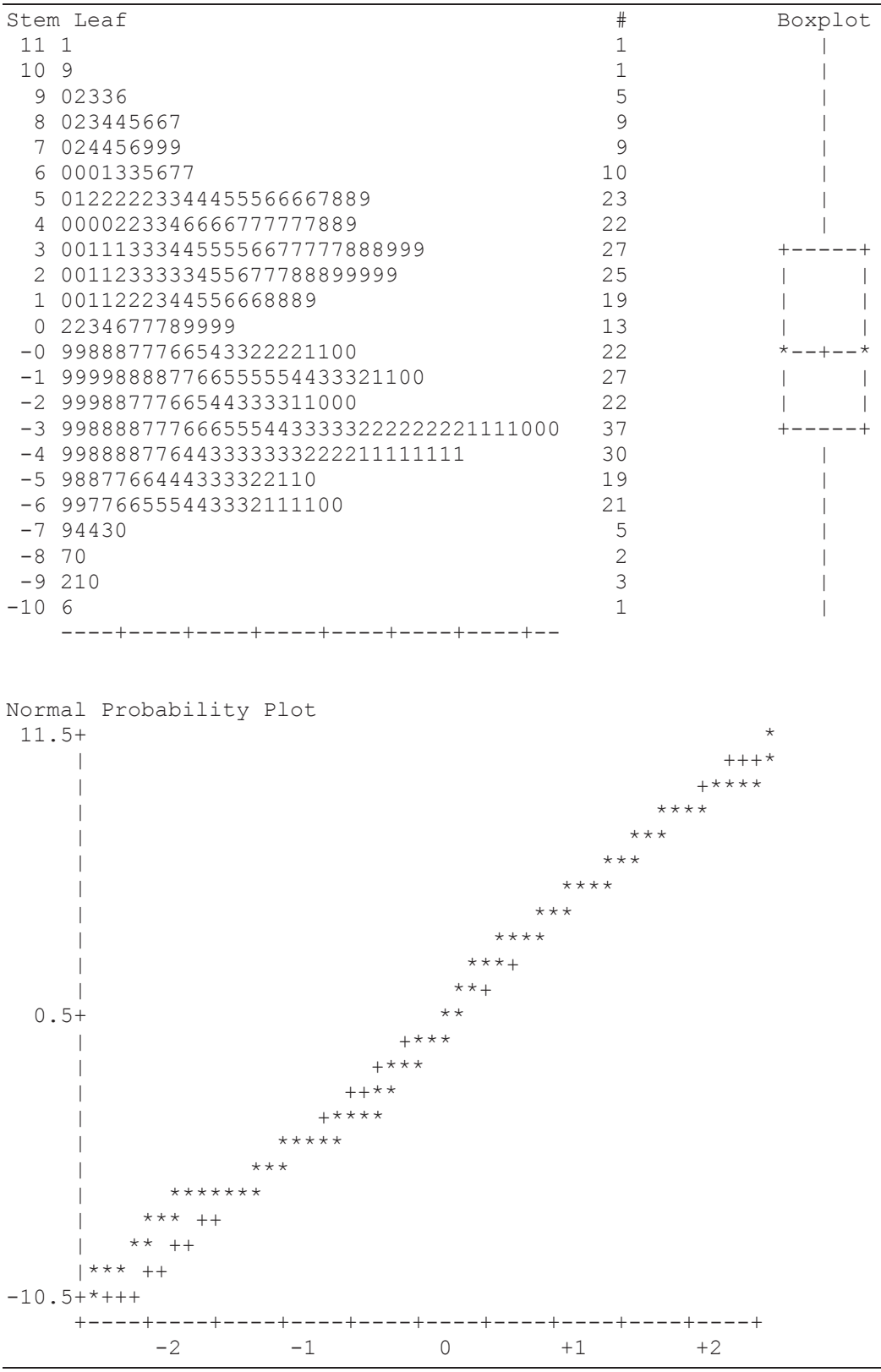


Table 31. Solution for random effects of villages nested within treatment group by pre- and post-intervention status

Village	Treatment group	Pre/post	Estimate	Standard error	DF	P
1	Intervention	Pre	0.245	0.4886	1	0.704
1	Intervention	Post	0.185	0.4896	1	0.770
2	Intervention	Pre	-0.274	0.4896	1	0.675
2	Intervention	Post	0.063	0.4926	1	0.919
3	Intervention	Pre	0.057	0.4889	1	0.927
3	Intervention	Post	0.075	0.4902	1	0.904
4	Intervention	Pre	0.206	0.4905	1	0.747
4	Intervention	Post	-0.064	0.4897	1	0.917
5	Intervention	Pre	-0.057	0.4867	1	0.926
5	Intervention	Post	-0.278	0.4889	1	0.671
6	Intervention	Pre	-0.176	0.4890	1	0.780
6	Intervention	Post	0.020	0.4890	1	0.975
7	Control	Pre	-0.121	0.4892	1	0.846
7	Control	Post	-0.101	0.4912	1	0.871
8	Control	Pre	-0.221	0.4917	1	0.731
8	Control	Post	0.104	0.4911	1	0.867
9	Control	Pre	0.225	0.4914	1	0.726
9	Control	Post	-0.126	0.4894	1	0.840
10	Control	Pre	0.138	0.4891	1	0.825
10	Control	Post	-0.293	0.4905	1	0.657
11	Control	Pre	-0.098	0.4892	1	0.875
11	Control	Post	0.237	0.4896	1	0.713
12	Control	Pre	0.076	0.4891	1	0.902
12	Control	Post	0.179	0.4907	1	0.778

Table 32. Test of fixed effects for model of CHIK knowledge score

Effect	df	Den df	F	p
Treatment group	1	11.7	0.35	0.564
PrePost	1	11.2	0.90	0.362
Respondent gender	1	331	1.79	0.182
Respondent age	1	336	9.41	0.002*
Average livestock per household	1	333	0.01	0.928
Larval household index	1	325	0.02	0.898
Larval container index	1	332	1.07	0.301
Household experience with CHIK	1	334	8.88	0.003*
Water storage factor	1	326	0.05	0.818
Household water use water factor	1	330	0.11	0.743
Water source water factor	1	330	4.23	0.041*
HH SEP water factor	1	336	0.63	0.429
Luxury amenities SEP factor	1	286	19.0	<.0001*
Dwelling characteristics SEP factor	1	336	1.69	0.195
Household goods SEP factor	1	333	3.55	0.060
Treatment group*PrePost	1	10.3	0.08	0.784

***** Significant at the 0.05 level

To further assess the effects of treatment group and the pre/post variable, the F test was calculated for treatment group*pre/post using the least squares means test. In Table 33, the mean CHIK knowledge score for the intervention group increased from 9.00 in the pre-intervention, to 9.40 in the post-intervention, this difference of 0.39 was not significant (p=0.646). The mean CHIK knowledge score for the control group increased from 8.46 in the pre-intervention, to 9.16 in the post-intervention, this difference of 0.70 was not significant (p=0.393). This shows that there were similar increases in CHIK education among the intervention and control treatment groups, with the increase in the intervention group being much lower than expectations prior to the start of this study.

Table 33. Least squares means of CHIK knowledge scores simple differences among treatment groups for pre- and post-intervention

	Pre-intervention		Post-intervention			
	Mean CHIK score	Std. error	Mean CHIK score	Std. error	Difference	p-value
Intervention	9.00	0.741	9.40	0.812	0.39	0.646
Control	8.46	0.737	9.16	0.821	0.70	0.393

A total of 145 households and 623 containers were surveyed for the presence or absence of mosquito larvae, with 15 households per village, resulting in an average of 3.5 containers surveyed per household. Pre- and post-intervention comparison of larval statistics using chi-squared or F statistic are shown in Table 34. The larval indices, both HI and CI, decreased dramatically in the intervention group in the post-intervention, while the indices increased in the

Table 34. Larval statistics Comparison Pre- and Post-Intervention

	Pre		Post		
	Intervention (n=94)	Control (n=90)	Intervention (n=90)	Control (n=90)	p-value
Larval positive households (HI)	35.3	7.2	3.3	11.1	0.000*
Larval positive containers (CI)	9.2	3.5	2.9	4.7	0.147

control group. There was a significant difference in the HI between pre- and post-intervention among the treatment groups (p=0.000). There was no significant difference in the CI between pre- and post-intervention (p=0.147). The number of containers decreased from 1293 containers in the pre-intervention, to 623 in the post-intervention, indicating that most households have fewer containers with water in or around the home during the hot season. See Section 6.7.5 for more discussion about the potential effects of seasonality on these results.

HI and CI were highly correlated with each other (R=0.656). Neither HI or CI were correlated with the CHIK knowledge score (R=-0.070 and R=-0.093 respectively).

Table 35. Larval statistics correlations

	CHIK score	Other index
Larval positive households (HI)	-0.070	-0.656**
Larval positive containers (CI)	-0.093	-0.656**

** Significant at the 0.01 level

5.4.5 GIS

For households the following GIS-related data were used: (1) GPS location of the house, (2) information about recent experience with CHIK, and (3) whether any water containers were positive for mosquito larvae. Maps comparing the pre- and post-intervention data are shown in this section.

5.4.5.1 Varapur

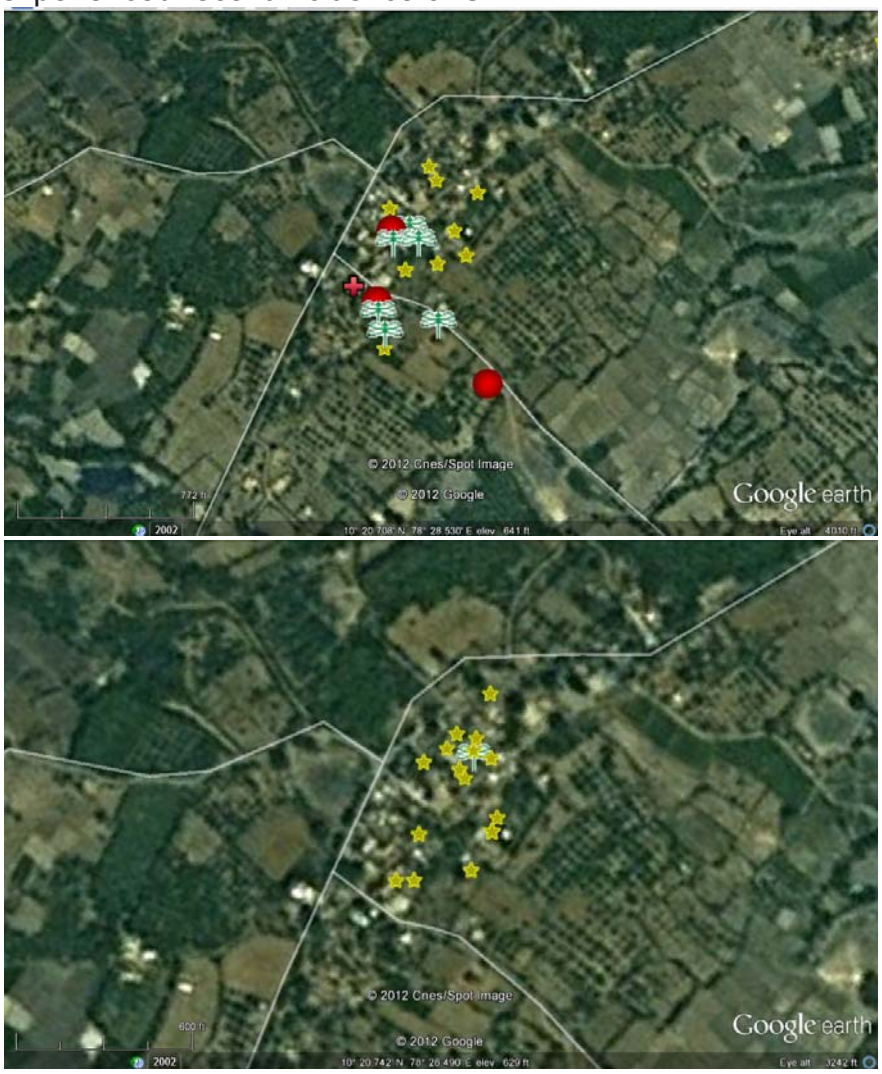
Figure 23 (top), shows the baseline map for Varapur, showing the distribution of the study households, the larval positive households, and indicators for recent experience with CHIK. Six households were found to be larval positive and three households had recent experience with CHIK. Two of the households were positive for both CHIK and mosquito larvae. There was one household with missing larval data. The mosquito larval positive households show some clustering around the households with recent experience with mosquito larvae.

Post-intervention (Figure 23, bottom), there is a sharp decrease in both incidence of CHIK and larval positive households compared to the baseline map in Figure23, top. There were no cases of recent CHIK in the study population and a single larval positive household. The distribution of the post-intervention sample is slightly less spread out than the baseline survey. Larval household data were missing for five households (33% of the post-intervention sample).

5.4.5.2 Kurumbalur

The baseline map of the Kurumbalur study population shows a large clustering of larval positive households in the village center, Figure 24 (top).

Figure 23. Varapur map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK



Study household Larval positive household Recent CHIK cases Varapur MTC

There were two recent experiences with CHIK, one in the central village area, and another in the more rural fringes of the village. One household (CHIK negative) was missing larval information.

Comparing the pre- and post-intervention maps (Figure 24, top and bottom), we see that the post-intervention sample was more concentrated in the

central village area, with no households from the more rural village fringes. There were no larval positive households identified in the post-intervention sample (Figure 24, bottom), and a single case of CHIK. Larval household data was missing for two households from the post-intervention sample.

Figure 24. Kurumbalur map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK

5.4.5.3 Katayanpatti

Figure 25, top, shows the baseline map for the study population in Katayanpatti. There were seven larval positive households identified in the baseline sample, with one case of recent CHIK. The case of CHIK was located in a household found to be positive for mosquito larvae and near another household

Figure 25. Katayanpatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK

also positive for larvae. Two households (both negative for CHIK) were missing larval household data.

Comparing the pre- and the post-intervention samples (Figure 25, top and bottom, respectively), we see that the post-intervention sample is much more clustered compared to the pre-intervention sample. There were no recent cases of CHIK in the post-intervention sample (Figure 25, bottom), and two larval positive households. In the baseline sample, there was a wider distribution of the study households including households from the village center and the farther out rural areas. In comparison, the post-intervention sample was taken only from the village center. The majority of the larval positive households in the pre-intervention were located in the more rural areas of the village, which may explain (in part) the lower incidence of larval positive households in the post-intervention sample which lacked the more rural households. Larval household data was missing for six households in the post-intervention study sample. GPS data was missing for one household in Katayanpatti. The household with missing GPS coordinates was a household that had experienced CHIK recently.

5.4.5.4 Ariyandipatti

The baseline map for Ariyandipatti (Figure 26, top) shows a wide distribution of larval positive houses and a single case of CHIK. There were seven larval positive households. One household was missing information on larval status.

Figure 26. Ariyandipatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK

The post-intervention map for Ariyandipatti (Figure 26, bottom) shows a similar distribution of study sample households to the baseline study sample. No households were positive for mosquito larvae or had recent experience with CHIK. Four households were missing information on larval status. None of those households missing larval information had had recent experience with CHIK.

5.4.5.5 Keeranipatti

Figure 27, top, displays the baseline household, larval, and CHIK information for the village of Keeranipatti. Nine households were found to be positive for mosquito larvae, while four households were positive for recent experience with CHIK. Three of the four households positive for CHIK were also positive for mosquito larvae. Three households were missing larval information, one of those households had recent experience with CHIK.

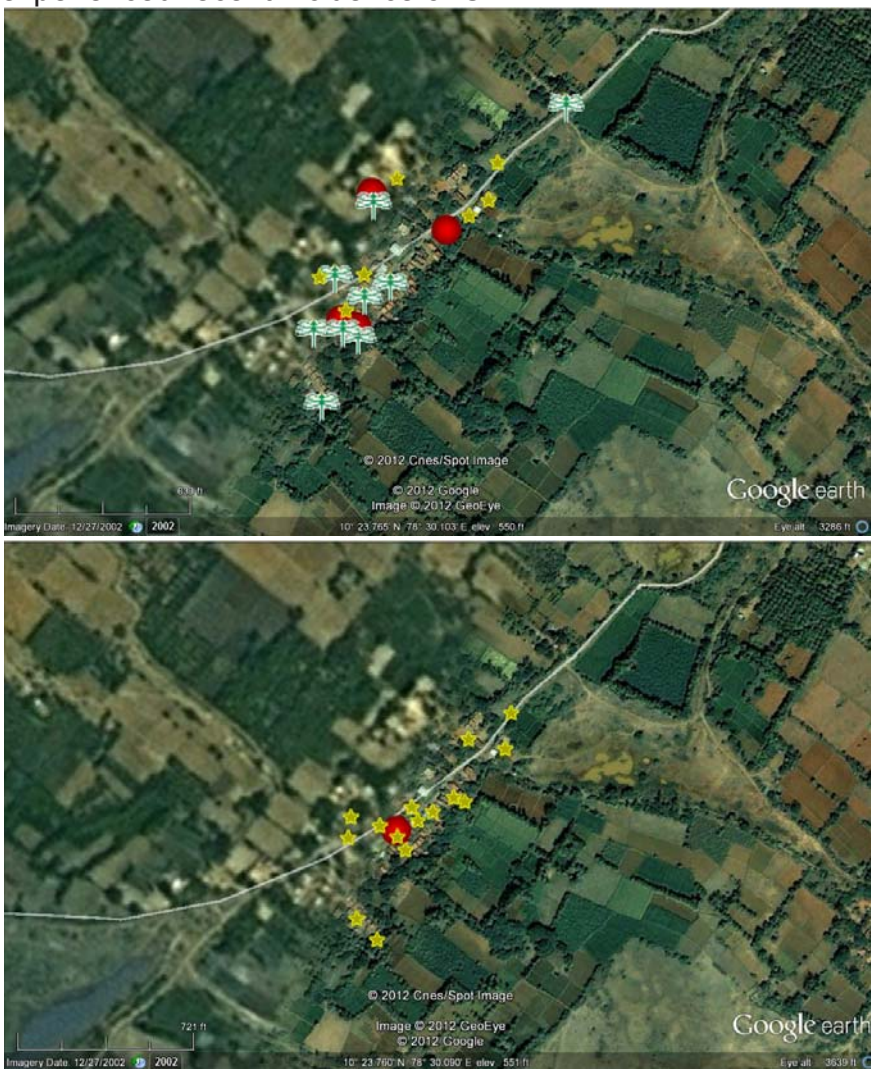
The post-intervention map, Figure 27 bottom, shows that there were no larval positive households, but one household with recent experience with CHIK. The distributions of the pre- and post-intervention study samples were similar. Two households were missing larval information, neither of those households had recent experience with CHIK.

5.4.5.6 Sadayanpatti

The baseline map of household locations, larval positive indicators, and CHIK indicators (Figure 28, top) for Sadayanpatti shows that there were four larval positive households and one CHIK positive household located that was located near the center of the village. There was no missing CHIK or larval information for Sadayanpatti.

The post-intervention map of Sadayanpatti (Figure 28, bottom) shows that there were no larval positive households or households with recent experience of CHIK. Sadayanpatti is a relatively closely spaced village and the distribution of the pre- and post-intervention study samples were similar. Four households were missing information on household larval status. None of the four households had

Figure 27. Keeranipatti map showing baseline (top) and post-intervention (bottom) household locations, larval positive households, and houses that have experienced recent incidence of CHIK

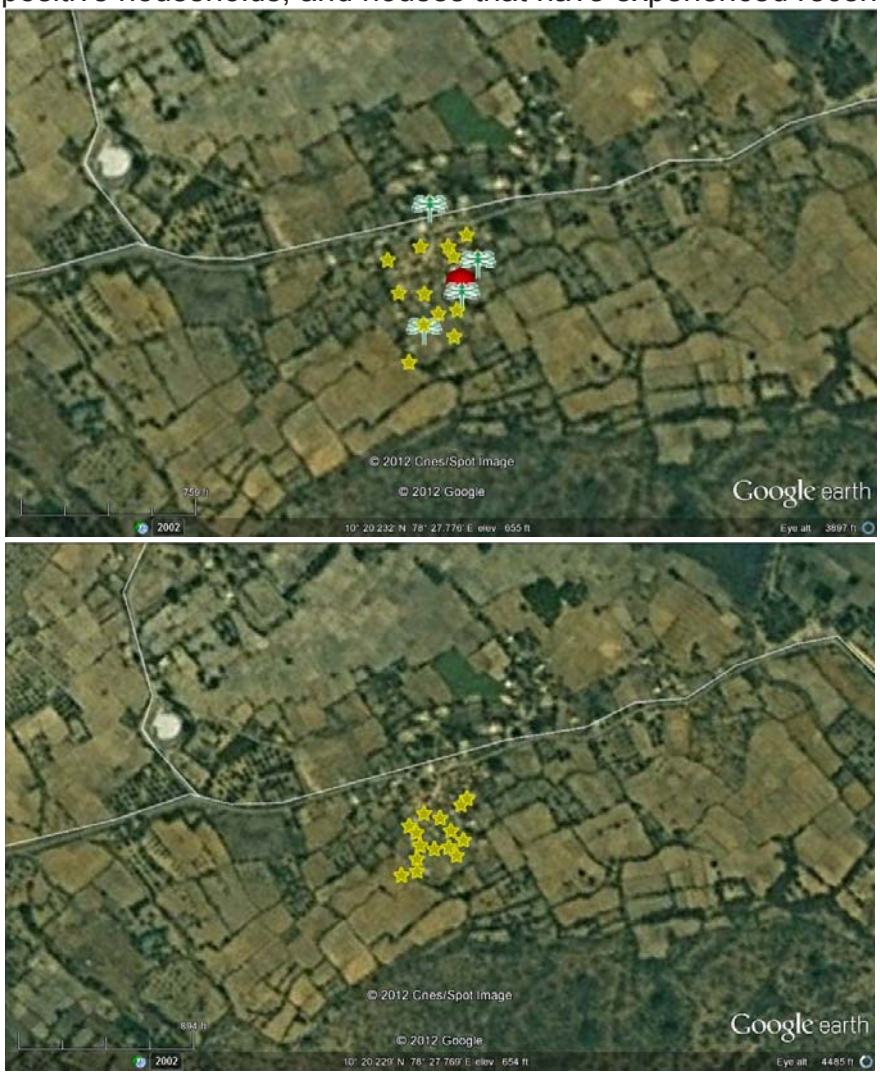


recent experience with CHIK.

5.4.5.7 Gopalapacheri

In Gopalapacheri, the baseline household locations, larval indicators, and CHIK indicators (Figure 29, top) showed that five households were positive for

Figure 28. Sadayanpatti map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK



mosquito larvae, while four households had recent experience with CHIK. One household, which was negative for recent experience with CHIK, was missing larval information.

The post-intervention map for Gopalapacheri (Figure 29, bottom) showed there were two clustered households that were larval positive and one household

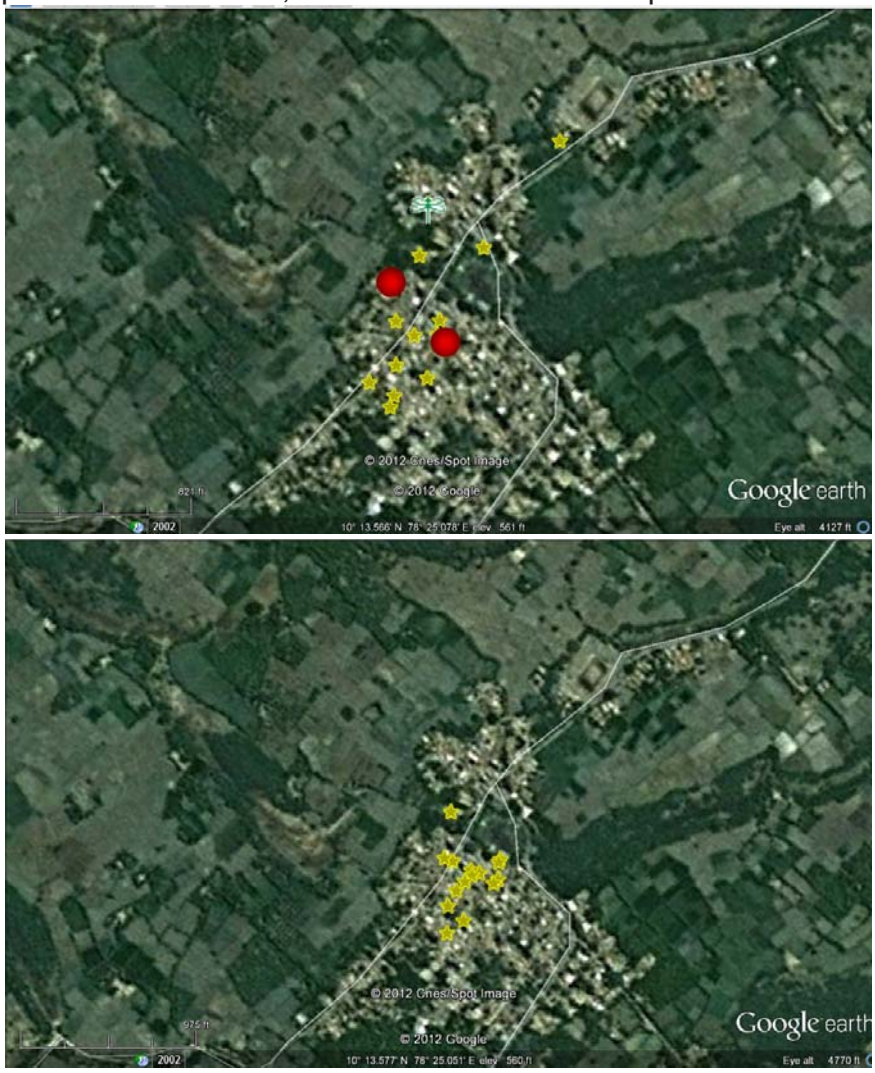
that had recent experience with CHIK. Six of the households in Gopalapacheri were missing information on larval status. None of those villages were positive for recent experience with CHIK.

5.4.5.8 Kirungakkottai

Figure 30 (top) shows the baseline household locations, larval positive

Figure 29. Gopalapacheri map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK

Figure 30. Kirungakkottai map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK



households, and recent experience with CHIK. One household was positive for mosquito larvae, and two households had recent experience with CHIK. Three households, none with recent CHIK experience, were missing information on mosquito larvae status.

The post-intervention map for Kirungakkottai (Figure 30, bottom), shows that were no larval positive households or households with recent experience with CHIK. The distribution of households in the pre- and post-intervention study samples was similar. There was no information missing with regards to larval or CHIK experience in the post-intervention study sample.

5.4.5.9 Sirumaruthur

The baseline map for Sirumaruthur (Figure 31, top) shows the study household locations, larval positive households and households with recent experience of CHIK. The map shows that there were four households found to be positive for mosquito larvae and one household with a recent experience of CHIK. There does appear to be clustering of the mosquito positive households around the single case of CHIK, but this village is also rather small and closely spaced.

The post-intervention map for Sirumaruthur (Figure 31, bottom) shows a single household with recent experience with CHIK and five households that were found to be larval positive. The household that had experience with CHIK was also larval positive. One household was missing information on its larval status.

5.4.5.10 Thennammalpatti

The baseline map shows the study household locations, larval positive households and households with recent experience of CHIK for the village of Thennammalpatti (Figure 32, top). There were five households with recent

Figure 31. Sirumaruthur map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK

experience with CHIK in the pre-intervention population, and four households that were positive for mosquito larvae. One of the households positive for CHIK, was also positive for mosquito larvae. In general, there appears to be clustering of those households with CHIK experience and mosquito larvae in this village. There were no households with missing CHIK or larval information.

In the post-intervention study sample for Thennammalpatti (Figure 32, bottom), there were no cases of recent experience with CHIK, and two households found to be positive for mosquito larvae. Three households were missing information on their larval status.

Figure 32. Thennammalpatti map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK

5.4.5.11 S.V. Mangalam (Sadurvedamangalam)

In Figure 33, top, the baseline household locations, larval positive households, and households with recent experience with CHIK are shown for the village of S.V. Mangalam. In the pre-intervention, there were three households with recent experience with CHIK and two households that were positive for mosquito larvae. One of the CHIK households was also positive for mosquito larvae. The layout of S.V. Mangalam is not suited to clustering as the village is long and less crowded than other villages, yet the cases of CHIK do seem to be located near households found to be positive for mosquito larvae. There were no households with missing larval or CHIK information.

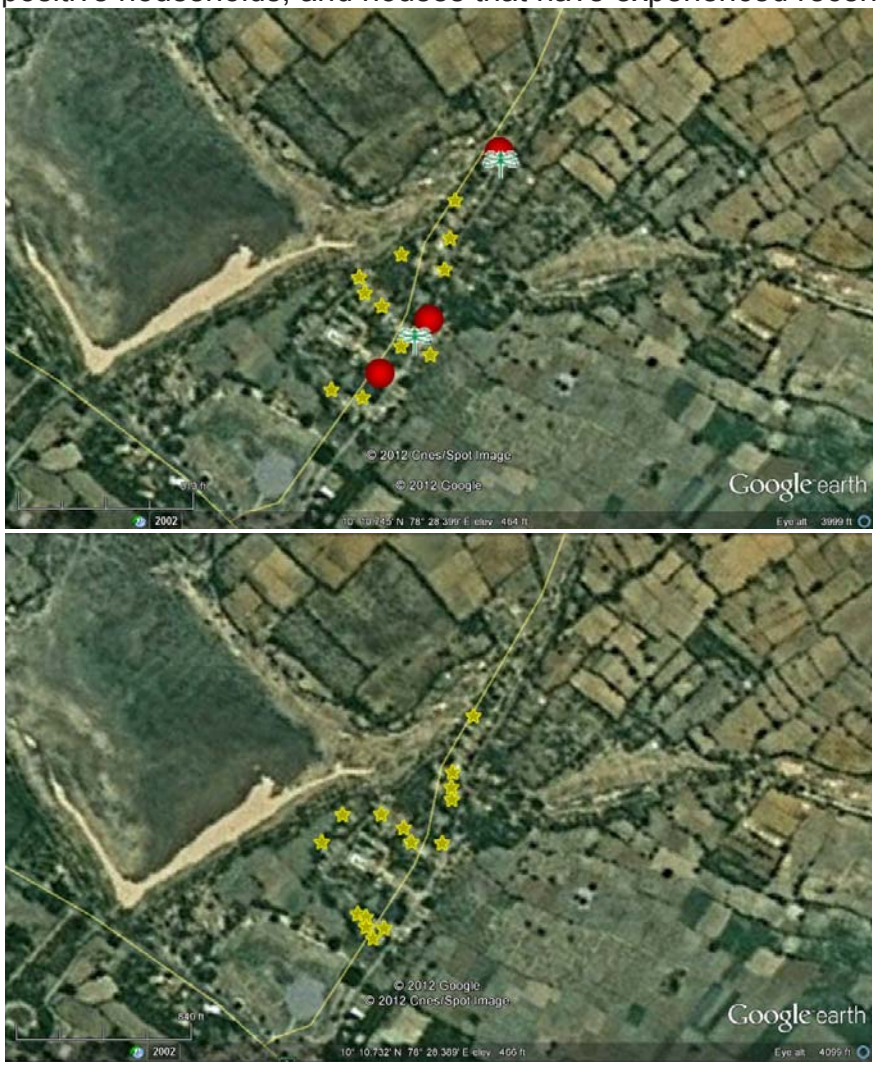
The post-intervention map for S.V. Mangalam (Figure 33, bottom), shows no households that were positive for either recent experience with CHIK or mosquito larvae. Two households were missing larval information.

5.4.5.12 Anaikaraipatti

The baseline map for Anaikaraipatti (Figure 34, top) shows the study household locations, larval positive households and households with recent experience of CHIK. The map shows that there were three households found to be positive for mosquito larvae and three household with a recent experience of CHIK. There does appear to clustering of the mosquito positive households with the cases of CHIK.

The post-intervention map for Anaikaraipatti (Figure 34, bottom) shows three households with recent experience with CHIK and one household that was found to be larval positive. One household was missing GPS information.

Figure 33. S.V. Mangalam map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK



Study household Larval positive household Recent CHIK cases

That household was negative for both mosquito larvae and recent experience with CHIK. One household (negative for mosquito larvae) was missing information on recent experience with CHIK.

Figure 34. Anaikaraipatti map showing baseline household locations, larval positive households, and houses that have experienced recent incidence of CHIK

Study household Larval positive household Recent CHIK cases

5.5 Conclusions

Table 35 provides a summary of the research questions tested during this study and the results. This is adapted from Table 4 which laid out the research questions at the end of Chapter 3.

Table 35. Research results

Research questions	Hypothesis	Results
1. Do participants know the cause of CHIK?	1. Rural villagers will lack knowledge of the causal agent of CHIK. 2. Post-intervention, individuals in the intervention village will have more knowledge of the causal agent of CHIK.	1. 36.2% lack knowledge of transmission. 2. Post-intervention, control group has less transmission knowledge (Control=55.6%, Int.=37.8%, p=0.0001)
2. Do participants know the symptoms of CHIK?	1. Rural villagers will lack knowledge of the symptoms of CHIK. 2. Post-intervention, individuals in the intervention village will have more knowledge of the symptoms of CHIK.	1. 39.7% lack knowledge of symptoms. 2. Post-intervention, control and intervention groups have similar symptom knowledge (Control=36.7%, Int.=34.4%, p=0.755)
3. Do participants know how to prevent CHIK?	1. Rural villagers will lack knowledge of methods of CHIK prevention. 2. Post-intervention, individuals in the intervention village will have more knowledge of CHIK prevention methods.	1. 75.5% lack knowledge of prevention. 2. Post-intervention, control and intervention groups have similar symptom knowledge (Control=67.8%, Int.=85.6%, p=0.214)
4. Does knowledge of CHIK cause translate into knowledge of symptoms or prevention?	1. Individuals with knowledge of the CHIK causal agent will be more likely to correctly identify CHIK symptoms. 2. Individuals in the intervention village will be more likely to correctly identify both the causal agent and symptoms of CHIK.	As shown in Table 21, knowledge of CHIK translated to significant knowledge of CHIK transmission, symptoms, and prevention (p=0.0001)
5. Did the intervention affect knowledge of CHIK? (Cause, symptoms or prevention methods)	Individuals in the intervention village will have higher rates of knowledge of CHIK causal agent, symptoms and prevention methods compared to individuals in the control village.	The intervention resulted in a 0.4 increase in CHIK knowledge scores for the intervention group compared to a 0.7 increase in the control group. This was not a significant increase.
6. Did the intervention affect practices related to CHIK prevention?	Individuals in the intervention village will have higher rates of current use of prevention methods compared to individuals in the control village	There was a difference between pre- and post-intervention knowledge and use of mosquito prevention methods (0.001) as shown in Table 29.
7. What are barriers to implementation?	Individuals in the intervention village will have valuable feedback for improving future intervention	This was not analyzed due to inconsistency in data collection.

Table 35. Continued

8. GIS study	Pre-intervention, there will be significant patterns of larval indicators and CHIK illness. Post-intervention, there will be no patterns.	GIS showed more clustering of larval positive households pre-intervention compared to post-intervention.
9. Larval Indices	Larval indices in the intervention village will be lower after the intervention compared to the control village	The HI decreased from 35.3% to 3.3% in the intervention group, but increased from 7.2% to 11.1% for the control group. This was a significant difference (p=0.000). The CI decreased from 9.2 to 2.9 in the intervention group and increased from 3.5 to 4.7 in the control group. This was not significant.

CHAPTER 6-DISCUSSION

6.1 Introduction

This chapter provides a summary of the results presented in the previous chapter and describes the conclusions drawn from this study. Future studies on the knowledge, attitudes, and behaviors related to chikungunya in rural populations may benefit from the lessons learned through the process of this study. This study hypothesized that (1) CHIK knowledge and prevention practices would increase in the intervention village compared to the control village (Specific Aim 3, hypothesis 3a), (2) that larval indices would decrease in the intervention villages compared to the control villages (Specific Aim 3, hypothesis 3b), and (3) GIS would be able to identify locations within a village that increase risk for CHIK infection (Specific Aim 3, hypothesis 3c). This study is the first of its kind to explore the knowledge of CHIK transmission, symptoms, and preventive methods. Further studies will be needed to further explore the methods of increasing rural knowledge of CHIK.

We conducted a baseline needs assessment, then developed, implemented, and evaluated an experimental community-based educational intervention in rural Tamil Nadu, India. A total of 184 households participated in the needs assessment. The experimental community-based educational intervention was implemented between December 2010 and August 2011, in six intervention villages. A total of 180 households participated in the post-intervention evaluation. The study was purposefully designed to interview more females than males and the study was successful in this goal. It was believed

that females in this population have greater responsibility for caring for sick family members and thus woman were an ideal population to target for education. This also was due in part to the timing of the survey administration which took place during the daytime when women were more likely to be home than men.

A model including respondent variables gender and age, livestock amounts, larval HI and CI, household CHIK experience, SEP variables, and water variables were utilized to predict CHIK knowledge scores in rural Tamil Nadu. Respondent age, recent experience with CHIK, the luxury amenity factor, and the water source factor were significant in this model. There was no difference in CHIK knowledge scores between the intervention and control groups at pre- and post-intervention in this study.

This study compared well to previous studies by Raude and colleagues, showing that SEP and cognitive variables were important factors in CHIK prevention, despite different methodology and variable definitions.

6.2 Specific aim 1

Prior to developing the educational intervention, a baseline needs assessment was conducted to establish the pre-intervention characteristics of the study villages and identify the gaps in CHIK knowledge. In addition to using this baseline information to develop the educational intervention, these data were used to identify differences among the villages and treatment groups (i.e., intervention and control). Among all the study villages, there were differences in land ownership, having a bank account, and some livestock variables. Differences between the intervention and control groups were identified in family

characteristics, several livestock variables, and some amenities. Could these differences be indictors of real differences between villages and groups at baseline, or are they due to the small sample with only 15 households per village? It is possible that livestock differences could be due to differences in livestock practices in different villages or areas, but it is more difficult to explain the differences in amenities or family characteristics. In observing the 12 villages, there were one or two of the control villages that appeared to be more prosperous, and one intervention village that appeared ‘poorer’; but overall, the villages did not seem as different as the data representing household, dwelling, and water characteristics seem to show. We must consider the practical significance versus statistical significance when dealing with these potential confounders.

6.3 Specific aim 2

The process of developing the educational intervention was an interesting experience for the PI. It was originally difficult to receive feedback on what changes were needed on the various flip book pages from colleagues and staff at MMHRC. Eventually, the PI found that providing two different versions of the same page prompted discussion on the benefits of each option. The intervention was well received in the instances witnessed by the PI of the study. The assistant nurse, Valli, was very clear and on message while presenting the intervention. The PI was present during one educational event in each of the intervention villages. The majority of these events took place at the local primary or secondary school within the intervention village, which provided a convenient

sample for the short time available to the PI. While children were not the main target for the educational intervention, their education is of benefit for the community. Just under 300 persons (mostly children) were educated during the first week of educational intervention. After that, exact numbers of educated persons are unknown, but it is believed that there was a period of extensive use during the final two weeks of 2010 and well into 2011. It is also clear that the intervention was no longer used after the close of the first post-intervention in December 2011. This is based on the numbers of respondents reporting recent education about CHIK in the second post-intervention. For any educational intervention to be successful, it must be regularly utilized, and recommendations for integration of this educational intervention will be discussed at the close of this chapter.

6.4 Specific aim 3

Prior to conducting the multivariate analysis, differences were assessed between the intervention and control groups within the post-study. Noted differences between the two treatment groups during the post-intervention included: differences in reported income and in the rates of livestock ownership, in particular, ownership of poultry, and goats. Whether this is due to different villages having different types of livestock or different animal slaughtering patterns may be difficult to tease out with the data available.

Differences were observed in many of the household, dwelling, and water variables between the pre- and post-intervention samples. It would be surprising if characteristics such as those relating to HH, household dwelling, or amenities

differed significantly as we utilized the same population for the pre- and the post-intervention. As a result, the differences observed in income, land ownership, several livestock variables, electricity, grinder and phone ownership, type of roof and floor, type of fuel utilized for cooking, and all the water variables were unexpected. The small sample sizes may increase the variability among these variables. Differences in livestock from pre- to post-study samples may be due to the small sample size, but could also be due to seasonal changes (discussed further in 6.7.5). Differences in animal butchering, breeding, or programs such as Pass the Goat[2], are all potential explanations for the observed differences in livestock from pre- to post-intervention, although more research would be required to illuminate whether these differences are real or artificial. It is possible that the question of land ownership was not subtle enough to truly represent significant difference in land or home ownership and is discussed further in section 6.6.3. The change in seasons may also have affected the type of person at home during the day and available for study participation. During the post-intervention, it did seem that more families were absent (out working in the fields) compared to the pre-intervention.

The study was powered for a change in CHIK knowledge scores of seven points. As we discovered, this change was overly ambitious and the study was not significant. It is possible that choosing another outcome measure, such as increase in transmission knowledge, would have provided a better indication of acquisition of prevention knowledge compared to a composite index. Yet, using a

[2] Pass the Goat is a charitable program in this region of Tamil Nadu developed by MMHRC and Mahasemam Trust to provide rural villagers access to livestock. Each recipient of a goat is expected pass a goat from the next litter to another family in need.

single variable compared to a composite may not reflect the full knowledge needed to prevent CHIK. So while there was not the level of change needed to show significant changes in CHIK knowledge, an index score is more sensitive to increases in transmission, symptoms, and prevention, rather than just one aspect of CHIK knowledge.

6.5 SEP and Water index

As part of this study, the PI described development and validation of an SEP and water index for southern India. We are aware of two other publications that describe SEP measures in India; however, they are recommended for use in other Indian regions and states.[23, 32] Analysis and measurement of SEP is an important aspect of epidemiologic studies, not only to help adjust for confounding, but also to understand the underlying structure of the community being studied. Assets can be important indicators of a person's economic status, their wealth, and their ability to respond to economic crisis in their life. Yet important assets may differ from location to location so it is important to explore the locally important assets to properly assess a families SEP. It is also true that some items or components in an asset index will be more important than other items. This is why it is important to use a method such as PCA to determine how the items fit together into components and the weight of each component in the asset index.

Some differences between our SEP measure and the other two Indian measures are that they included water-related items, and other items less relevant for this rural region of Tamil Nadu. For the purposes of this study, we felt

it would be best to separate the water variables into their own scale. CHIK is a mosquito borne disease, thus water variables may be connected to the outcome variables in this study setting. The multi-domain composite index for SEP is more versatile than the traditional use of just one or two variables (e.g., income, caste) and is more resistant to the effects of short-term change than a variable like income. Occasionally, SEP scales include variables that are more often thought of as community-level rather than household-level variables. Electricity is the only item on our scale that qualifies as community infrastructure, which may make our scale more applicable for household-level surveys.

Internal consistency of the four components on the SEP scale was very good, while not as high as might be preferred for the components of the water scale. This result may be explained due to measurement error and/or culturally grounded interpretations of the questions. The questionnaire was developed and written in English, while in this region of India, the primary language is Tamil, and thus all the interviews were conducted in Tamil. Responses were translated into English and recorded on the hard-copy questionnaire, which may have introduced some measurement error. The water index had lower α's than the SEP index. The low α (0.24) of the third water component suggests that these items are not homogenous. In this case, component three may be a "catch all" factor where the variables should be different as the component is not meant to be redundant. The component variables do not need to be consistent in order to describe the construct. Reliability has become a measure automatically reported without much thought as to the underlying meaning behind the measurement. So

while some of the components in this measurement do fit together well, other components are meant to include variables that more broadly describe the underlying construct, thus reliability may not be the ideal measurement for this instrument.[45] By definition, alpha is lower when there are fewer items in a factor. Considering the ability of each component to accurately discriminate between the most and least poor in this population, the lower alpha values may not reflect the accurate reliability of the instrument.

There are very few articles in the peer-reviewed literature regarding development of SEP scales, especially for locations outside the US and the UK. While this scale does not have widespread geographic generalizability, it is very appropriate for this study population and other similar populations in southern India, which do not fit well with the currently available set of standardized SEP scales. The area in which this study took place has many unique social and economic features that would be difficult to incorporate into an analysis without an index like the one developed as part of this study.

6.6 Culture and epidemiology

Epidemiology is the “study of the distribution and determinants of health-related states or events in human populations”, with the understanding that disease is not randomly distributed in populations.[46] Variables representing person, place, and time moderate an individual’s risk for disease. These factors may be considered risk factors or confounding variables for the associated increased risk of disease. These same variables may also provide insight into cultural differences in disease risk. Culture is the lens by which we view other

societies. Rarely is one's own culture considered when undertaking a study of other societies, yet this is the basis from which differences in culture are determined. Global health, the study of health with a global context, is increasing of interest when studying the distributions of diseases and risk factors. By its very definition, global health must take into consideration the concept of culture and its potential effects on study approaches, data collection, and interpretations.

As a project conceived by a PI from Iowa, developed in concert with colleagues from Madurai, India, and implemented in a rural district in southern India, culture and the issues of differing cultures were certainly present. There were concerns of offending respondents by asking about income or caste on the side of the PI, which turned out to be inconsequential, while education seemed to be a more sensitive subject judging from the higher rates of non-response. Privacy, primarily the need to enter a respondent's home to inspect water containers, was a concern of the PI's. This did not seem to be a problem for the local Tamil Nadu study population. The study population, on the other hand, worried about why this data were being collected, and how the data would be used. The concept of using culture in epidemiologic studies is still developing, but the first step is an awareness of culture and its potential effects on epidemiology studies.

Culture affects both knowledge, attitudes, and practices regarding disease transmission, prevention, and treatment. Local concepts of disease are important to designing and implementing intervention programs. This study did use a mixed methods approach to collect both quantitative and qualitative data to inform the

intervention design. Addition of a trained medical anthropologist to this study would have built upon the qualitative data collected and helped to increase understanding of local beliefs about CHIK.

6.7 Data issues

Several issues may be related to data quality. This includes issues with missing variables, translation, and the meaning of various variables.

6.7.1 Missing data

There was very little missing information in the pre-intervention, with the exception of: caste, education, and waste. While caste-based discrimination was outlawed in Part 3 of India's Constitution in 1950, the PI (and other informants) believes that caste remains salient throughout India.[47] It is difficult to gain a full understanding of the issue of caste, especially when it is often not discussed and castes are classified as disadvantaged independently by each state, which may result in differences in a particular caste's classification. In addition to the caste issue, there was some reluctance associated with providing education levels. It is difficult to know that kind of effect this may have on the data analysis, but education is a variable that may be both a confounder and/or an effect modifier. Without complete data on this variable, it is difficult to estimate which (if any) direction the results may be biased. Due to an error in photocopying the needs assessment survey by MMHRC staff, one question (waste variable) was missing in 19% of surveys.

Missing data were more prevalent in the post-intervention compared to the pre-intervention. Data on respondent age and education, HH age and education,

religion, caste, and number of household rooms were missing, mostly in surveys conducted by one data collector. Missing post-intervention data imputed for items used to calculate the SEP index was used in the multivariate regression models. For the most part, the missing data were in the variable household rooms (32% missing). This variable was also used to calculate crowding, where household rooms was the denominator. There were a few cases with other missing data on HH age (2), HH employment (1), toilet (2), cooking fuel (2), kitchen (1), roof material (1), and floor material (2). Most of these missing data were from a single case in which a page of the survey was lost. Data were replaced on a village by village basis, rather than using the overall mean. This was meant to preserve the variability present at the village level. The household room variable was dichotomized to one or two rooms and three or more rooms. The overall mean (2.0) would have resulted in a bias toward smaller numbers of rooms.

6.7.2 Translation

Open-ended questions generated mixed responses in both English and Tamil which needed to be translated prior to data entry and eventually coded. For the baseline data, the staff at MMHRC translated the questionnaires before turning them over to the PI. For the post-intervention data, Soman Puzhankara at the University of Iowa translated all the Tamil responses to open-ended questions. While the word for mosquito, கொசு, is easily recognized and translated, differences in translation of longer answers may be present in the data. Some questions, such as CHIK prevention, generated longer responses

that may provide opportunities for differences in word and sentence structure between translators. This most likely did not affect data coding.

6.7.3 Variable meaning

The meaning of several variables may be open to interpretation in this study. Ownership may mean different things to different people. While land laws in India are based on British land laws, there are interesting side notes that make it difficult to interpret the data on land ownership collected for this study. We are unsure whether there was any distinction between land ownership and land leasing during questionnaire administration. In addition, it may be that the amount of land is not enough information and some indicator of quality may be needed. Future studies should consider collecting data on the amounts of irrigated compared to non-irrigated land, arability of the land owned, or whether land is rented out, to further investigate the importance of land as a possible SEP variable to explain differences in status. Land amounts ranged from 0-10 acres, with the mean at 0.73 acres. There was one instance during the pilot testing phase, where the interviewer asked the PI to distinguish between ownership of land, and ownership of the house. The family in question did not own the land they lived on, but they had built the house with their own resources and had lived there more than 20 years. This may explain the large difference in home ownership in this study population (92.9%) compared to that of the district (81.1%), and the state (74.6%). Focus groups, or in-depth interviews would be useful in revealing the meaning of ownership in this population. As the data stands, it is difficult to interpret.

In observing study interviews, it was noticed that the question of age occasionally generated discussion before answers were recorded. There were also situations when the age of the woman was in disagreement with the age of the listed children (for example, in one case, the female respondent's age was recorded as 40 and the oldest son's age was recorded as 30). When the age discrepancy was noted, there was discussion and then the age was revised.

Income was somewhat suspicious in this study sample. Partners at MMHRC suggest that study participants may have been reluctant to provide accurate income information, due to their fear that the number would be reported to the authorities and they might lose their status as BPL. In general, income is considered to be a less than reliable indicator of SEP in developing countries.[32] As a result, income was not considered a reliable variable for use in modeling or construction of the SEP index.

6.8 Limitations

6.8.1 Study village selection

Limitations of this study include that villages included in this study were not randomly selected, but chosen for their accessibility. In general, the villages appeared to be similar in most respects, except for a few observational differences made by the PI that a few villages 'felt' nicer, or an intervention village 'felt' less well off. These observations were substantiated by analysis of the household, dwelling, and water variables. In general the control villages were better off than the intervention villages.

6.8.2 Data collectors

Another potential limitation of this study can be related to data collection and data quality. As requested by the MMHRC Ethics committee, the study utilized hospital staff: young, female nursing assistants as data collectors. A total of 10 women worked on the project over the 18-month project period. These data collectors had varying levels of education and training in data collection. Training specific to this study consisted of an overview of each item on the questionnaire, with the question translated into Tamil and the intent of the question explained. This training was done with five of the ten data collectors. The other nursing assistants were substituted in as needed, without consultation of the PI and were trained in the field by the 'seasoned' data collectors. It was discovered after data entry was complete for the needs assessment that the education variable was not consistently recorded among the ten data collectors. We believe this variable would contain relevant information for a SEP index and should be considered for inclusion in any future analysis.

6.8.3 Sampling bias

There were three instances where the data sampling differed between the pre- and post-samples. For two intervention villages, the sampling of the villages was more complete during the pre-intervention than the post-intervention. Parts of the village that were located further from the village centers were not sampled, due to time constraints on the data collection (the PI only had five days to collect data on 12 villages) and the extreme heat during which the data was being collected. The heat limited the range of the data collectors, as walking long

distances in the heat was not possible. One control village consisted of two communities separated by about one kilometer. The eastern half of the community was sampled during the baseline, while the western half of the community was sampled during the post-intervention. The potential effects of these sampling errors on the data are unknown, but it is possible that the areas not sampled in the post-intervention may differ on household, dwelling, and water variables, any of which may be confounders and effect modifiers for this study.

6.8.4 Study delays

There were several delays during collection of data that had potential effects on the overall study. During the needs assessment, there were several delays due to institutional/logistical issues and weather. While these delays were frustrating to the PI, there was not a significant impact on the quality of the data. During the initial post-intervention phase of the study, the PI was not on site due to resource and time limitations. Without the presence of the PI to ensure the priority of the data collection, there was a four-month delay in starting post-intervention data collection. Some of these delays were due to hospital staffing issues and weather. This delay was not ideal for the completion of a timely study, but in the end, was beneficial in matching seasonality of the pre- and post-interventions. Unfortunately, with the error in household matching between the pre- and post-interventions, the post-intervention had to be repeated. This resulted in a further three month-delay and a lack of matching seasonality between the pre- and post-interventions. As a result of the repeat evaluation, the evaluation survey was retooled to add questions pertaining to SEP status. Other

variables were left out to try and keep the survey short and to the point for this second implementation. Testing effects and diffusion bias are of concern with the repeated post-intervention data collection and the additional three months of study time.

The needs assessment and the first post-intervention data collection took place during the rainy season in southern India between October and December. The second post-intervention data collection took place during the hottest months of the year (April and May). Average rainfall during the rainy season is 240 mm while the month of April averages only 25 mm. This difference in both temperature and rain between the administration of the pre- and the post-intervention did result in a difference in the likelihood of the presence of mosquito breeding in the study area.[48] A study by Pham and colleagues in Vietnam found that HI, CI, and BI were all significantly correlated with increased cases of dengue, but also increased temperature, rainfall, and humidity also increased risk for disease.[48] Climate factors affect not only the vector lifecycle, breeding and biting habits, but also the prevalence of breeding containers present for adult female mosquitoes to lay eggs. While the number of containers in and around the house did not change, the number of containers holding water were drastically lower during the post-intervention, as compared to pre-intervention. This resulted in a natural reduction of the larval indices for the entire study population, rather than just the intervention population as we had hypothesized (Specific Aim 3, hypothesis 3b). It is hard to tease out what, if any, role the intervention played in this reduction compared to the season and temporal water collection practices. It

is entirely possible that the seasonal effect overwhelmed any effect of the intervention. Seasonal changes may also explain the differences in all the water variables collected. Differences in source of drinking water and other use water differed between the two data collection periods. Other differences were noted in the location of the water source, the person who collected the water, and the method of making water safe to drink. Future studies should absolutely match data collections for season to avoid this type of bias.

6.8.5 Resources

Resources and time were limited with this study. It is possible that extra funding may have provided the opportunity to conduct this study with more advanced methodology, including adding seroprevalence data and more in-depth anthropological focus to the study. Instead, this study used surrogate outcomes (i.e., knowledge, prevention, larval counts). This was not just due to a lack of resources, but also the time required for completion of an anthropological and seroprevalence study. Yet, the goal of this study was to produce a low-cost intervention which would be easily reproducible. Eventually, we hope that the educational intervention will result in a decrease of incidence, but for the amount of time available to the study, seeing an increase in knowledge and practices is very appropriate.

6.8.6 Disease prevalence

This study was conducted during a period of relatively low CHIK incidence in southern India. As a result, there were not many prevalent cases of disease in the study area. Recent experience with CHIK would likely lead to increased

knowledge of CHIK and mosquito prevention practices. So, while there were not many cases of CHIK, this makes this study a primary education intervention compared to a secondary education intervention.

As with any vector-borne disease spread by *Ae. aegypti* mosquitoes, there is always concern that competing education or prevention programs for another *Ae. aegypti* spread disease. During the administration of the baseline needs assessment, the Commonwealth Games[3] were taking place in New Delhi, India. During the lead up to the Games, several different vector-borne diseases were very prevalent in New Delhi, including: malaria, dengue, and CHIK. Media coverage (including both television and newsprint) was intense during the months of September and October due to some controversy surrounding the building of the athletes village and several cases of disease in the construction workers prior to the arrival of the athletes. The National Vector Borne Disease Control Programme did produce educational commercials with mosquito prevention information during October 2010.

Despite limitations, this study was successful in providing a method to develop and implement an educational intervention. While the intervention itself did not result in a significant change in CHIK knowledge, the study overall (baseline needs assessment, intervention development and implementation, and evaluation) was a positive learning experience for everyone involved. The development of the SEP and water indices are positive contributions that can be used in future studies in this region. We now know what needs to be done to

[3] The Commonwealth Games is an international, multi-sport event, held every four years for the members of the Commonwealth of Nations. It is the third largest multi-sport event in the world behind the Olympics and the Asian Games.

improve future education for CHIK and have a template that can be used to develop other interventions.

6.9 Barriers

Communication, language, and cultural barriers played a significant role in the design, implementation, and analysis of this project. In developing the research proposal, cultural and logistical advice was sought from colleagues at MMHRC. Communication was conducted via email and Skype. The PI was not fluent in the Tamil language spoken by the majority of the study area and relied on MMHRC staff for data collection and translation of the pre-intervention data when needed. The use of MMHRC staff as data collectors, in place of the PI with the assistance of a translator, sped up the process of data collection. In other areas, the use of MMHRC staff in the place of the PI (aided by a translator) was less helpful. When planning the intervention, the PI asked if a focus group could be arranged to discuss chikungunya knowledge and what the community felt necessary for education. A list of topic questions was prepared by the PI to generate discussion among a group of local woman. Without a trained translator, the PI relied upon MMHRC staff to conduct the focus group. The staff had no experience with how to conduct a focus group, and in the end, this activity was not useful in the development of the educational intervention.

6.10 Generalizability

This study is generalizable to the region in which the study was conducted. There is potential for additional generalizability to the rest of Tamil Nadu and potentially southern India as the educational intervention is simple to

implement and contains general advice on the prevention of CHIK and proper water storage. The SEP Index in particular was able to distinguish well between SEP groups.

6.11 Recommendations

This project was an important learning experience for both the PI and the staff at MMHRC. The PI learned how to conduct field work and the difference between developing a set of methods on paper and implementing those methods in the field. The staff at MMHRC increased their experience with rigorous study design and implementation of field studies.

Recommendations to MMHRC include, adding the CHIK educational intervention to their weekly routine, instead of limiting the intervention to the study period only. Also, there is the potential to expand this intervention to other regions (MMHRC has several telemedicine centers) and to consider utilizing medical students doing their social medicine rotations for delivery of the CHIK message. It is also recommended that MMHRC utilize questionnaires written in Tamil with an English version available. The majority of the questions are multiple-choice and there would be no difficulty in doing data entry in English for most questions without translation. This would help reduce any potential misunderstandings by the data collectors, whose English is limited. I would also recommend more in-depth education for the data collectors than I was able to accomplish during a few sessions and in the field. MMHRC has the potential to collect large amounts of data, but there is work to be done to improve the quality of data collection.

6.12 Future studies

Further studies in the knowledge and prevention of CHIK are required to establish how large a gap exists, in India and beyond. We suspect that more people are lacking in knowledge of this disease than would be expected in a country that has experienced more than one epidemic in the last decade, so more education is needed to help rural and urban populations recognize and prevent CHIK. Future studies should consider including more detailed questions regarding the quality of land owned rather than just quantity, and the typical locations of livestock in and around the home rather than just livestock quantity and types.

With availability of appropriate funding, addition of a seroprevalence study should be considered. Seroprevalence data would add precision to the question regarding a person's previous experience of CHIK and would allow for calculation of prevalence of previous infection and incidence of CHIK during the study period. Testing study participant blood samples for CHIK virus (RT-PCR for current infection) and antibodies (Immunoglobulin (Ig) M and IgG) will provide estimates of recent infection (IgM antibodies peak 3-5 weeks after infection and persist up to 12 months[49]) or a more distant infection (IgG antibodies). Molecular epidemiology would increase the accuracy to estimating exposure to CHIK and would allow for measurement of a final outcome of less CHIK in the population which is the ultimate outcome of this study, measured by proxy of increased education.

In the future, additional variables measuring time and process would be helpful to interpreting some of the delays and data issues described earlier. The evaluation survey did have a question are recent CHIK education, but this variable was only part of the post-intervention evaluation and not the pre-intervention needs assessment, thus it lacks usefulness as a process measure. There was also a question addressing potential barriers to mosquito prevention, but the question was not consistently collected and thus could not be included in the analysis.

More advanced methods in larval studies would prove useful in more clearly estimating a household's risk for CHIK. In addition to container and household indexes, it would be useful to categorize the numbers of artificial versus natural containers around a household. This would provide an estimate of excess risk as households with more artificial containers represent households with excess breeding capacity. Natural and artificial barriers should also be recorded, as environmental fragmentation does affect *Aedes* mosquitoes migration patterns.[50] We would also use oviposition traps to assess the numbers of mosquito eggs present near the household, providing estimates on the fecundity of the population. Collection of adult mosquitoes using aspirators would provide information on the relative abundance of the prominent mosquito species around the household, and the structure of the population with respect to age, gender, gravid females, and parous females.

Sustainability of any intervention over time is another area in which more research is required. Finding ways to help health workers integrate new

education into their routines is a natural follow-up for this project. Long-term change is hard to come by, especially when interventions are only used in the short term.

Other, non-educational, interventions should also be explored in this rural population if funding were available to support a more costly intervention. Larvicides, mosquito nets, and adult mosquito traps may result in reductions of the CHIK prevalence if used appropriately. It would also be interesting to implement similar educational intervention studies in other areas of India, or even other areas such as southeastern Asia and Africa with experience with CHIK.

6.13 Conclusions

There are many lessons to be learned from this study. Although this low cost intervention, utilized in a resource poor area of Tamil Nadu, India did not result in an increase of CHIK knowledge, the process of developing the educational intervention may provide a template for other interventions. It appears that the intervention was utilized solely for the purposes of the study intervention. Thus, when the study period was extended unexpectedly for a further five months; there was not a continuation of use of the intervention. Thus, a drop off in knowledge regarding CHIK and mosquito prevention was noted. It is possible that if the educational intervention had been utilized on a regular basis, the evaluation would have shown an increase in CHIK knowledge. The decrease in larval indices is most likely due to the change in season, and not to the educational intervention. It would be ideal to see this educational intervention

used for an extended period of time and on a more regular schedule before deciding fully its benefit in the rural communities of Tamil Nadu and beyond.

APPENDIX

A.1 University of Iowa Institutional Review Board Approval

THE UNIVERSITY OF IOWA

Human Subjects Office/
Institutional Review Board (IRB)
105 Hardin Library for the Health Sciences
600 Newton Road
Iowa City, Iowa 52242-1098
319-335-6564 *Fax* 319-335-7310
irb@uiowa.edu
http://research.uiowa.edu/hso

IRB ID #: 201008722

To: Erin Reynolds

From: IRB-01 DHHS Registration # IRB00000099,
Univ of Iowa, DHHS Federalwide Assurance # FWA00003007

Re: Exploring chikungunya fever in Southern India: A needs assessment, educational intervention and evaluation

Protocol Number:
Protocol Version:
Protocol Date:
Amendment Number/Date(s):

Approval Date: 10/20/10

Next IRB Approval Due Before: 09/27/11

Type of Application:	**Type of Application Review:**	**Approved for Populations:**
☒ New Project	☒ Full Board:	☐ Children
☐ Continuing Review	Meeting Date: 09/27/10	☐ Prisoners
☐ Modification	☐ Expedited	☐ Pregnant Women, Fetuses, Neonates
	☐ Exempt	

Source of Support:

Investigational New Drug/Biologic Name:
Investigational New Drug/Biologic Number:
Name of Sponsor who holds IND:

Investigational Device Name:
Investigational Device Number:
Sponsor who holds IDE:

This approval has been electronically signed by IRB Chair:
Herbert Berger, MD, MD
10/20/10 1058

A.2 Meenakshi Mission Hospital and Research Centre Ethics Approval

MEENAKSHI MISSION HOSPITAL AND RESEARCH CENTRE
(Run by S.R. Trust)
Lake Area, Melur Road, Madurai - 625 107. Tamil Nadu, India

Founder Chairman
Dr. N. SETHURAMAN
M.S., M.Ch. (Uro), MNAMS. (Uro), FICS.,

Executive Director
Dr. RAJAM SETHURAMAN
M.B.B.S.,

Medical Director
Dr. V.N. RAJASEKARAN
Ph.D., M.D., DTM&H.,

Vice Chairman
Dr. S. GURUSHANKAR
M.B.B.S.,

Phone : (91 - 452) 2588741 (10 Lines) & 4263000 (6 Lines) Fax : (91 - 452) 2586353 E.mail : mmhrc@sancharnet.in web : www.meenakshimission.org

18th October 2010

Dear Erin Reynolds,

Application title: ***Exploring chikungunya fever in Southern India: A needs assessment, educational intervention and evaluation***

Thank you for submitting your application which was considered on the 14th October 2010. The following documents were reviewed:

- Application form
- Consent form
- Methodology
- Questionnaire

On behalf of the Committee, I am pleased to approve this study from an ethical point of view based on the application form and supporting documents. You must inform the committee if there are any changes or additions to the study. The approval is given for the period of 6 weeks for observation and data collection in association with the Meenakshi Mission Hospital and Research Centre staff, provided that you comply with the conditions set out in the guidelines.

With the Committee's best wishes for the success of this study

With regards

Authorized Signatory

Ethics Committee

Meenakshi Mission Hospital and Research Centre

A.3 Tamil Nadu Rural Household Health Survey

INTRODUCTION AND CONSENT

We invite you to participate in a research study being conducted by investigators from Meenakshi Mission Hospital and Research Center and The University of Iowa. The purpose of the study is to collect information about your household and the health of your family.

If you agree to participate, we would like you to answer some questions about your home and family. You are free to skip any questions that you prefer not to answer. It will take approximately 30 minutes. Any information we collect about your family will not be shared without first removing your name. It will not be possible to link you to your responses on the survey. Taking part in this research study is completely voluntary. If you do not wish to participate in this study, you may decline now.

If you have questions about the rights of research subjects, please contact Meenakshi Mission Hospital and Research Center at (91-452-2588741)

Thank you very much for your consideration of this research study.

மீனாட்சி மருத்துவ மனையும் ஐயோவா பல்கலைக்கழகமும் ஒன்றுசேர்ந்து நடத்தும் ஆராயச்சியில் பங்கேர்க்க உங்களை பணிவுடன் அழைக்கிறோம். இந்த ஆராயச்சியின் குறிக்கோள் உங்கள் குடும்பத்தையும் குடும்பத்தின் ஆரோக்கியத்தையும் பற்றி தெரிந்துகொள்வதாகும்.

எங்கள் ஆராய்ச்சியில் பங்கேர்க்க நீங்கள் ஒப்புக்கொண்டால் உங்கள் இல்லத்தையும் குடும்பத்தையும் பற்றி சில கேள்விகள் கேட்ப்போம். கேட்ட கேள்விகளில் ஏதாவது கேள்விக்கு பதிலளிக்க உங்களுக்கு விருப்பமில்லையென்றால் பதிலளிக்காமலே நீங்கள் அடுத்த கேள்விக்குச் செல்லலாம். ஆரம்பம் முதல் முடிவு வரை கேள்வி பதில்கள் ஏறக்குறைய அரை மணி நேரம் எடுக்கும். நீங்கள் அளிக்கும் பதில்களிருந்து உங்கள் பெயரை அகற்றியபிறகுதான் அவற்றை வேறு யாவரிடமும் பகிருவோம். உங்களை உங்கள் பதில்களோடு யாராலும் இணைக்க முடியாது. இந்த ஆராயச்சியில் பங்கேர்ப்பதற்கு கட்டாயம் எதுவும் கிடையாது. உங்களுக்கு பங்குபெற விருப்பம் இல்லையென்றால் இப்பொழுதே மறுத்துவிடலாம்.

ஆராயச்சிகளில் பங்கேர்ப்பவர்களின் உரிமைகளைப்பற்றி உங்களுக்கு ஏதாவது சந்தேகமிருந்தால் மீனாட்சி மருத்துவ மனையுடன் இந்த தொலைபேசி எண்மூலம் பேசலாம்: (91-452-2588741)

உங்கள் கவனிப்பிற்கு எங்களது மனப்பூர்வமான நன்றியை தெரிவித்துக்கொள்கிறோம்.

Respondent agrees to be interviewed ....01 | Respondent disagrees to be interview 02

May we begin the interview now? Thank and Terminate

IDENTIFICATION		
Name of Respondent: 1.....	2.....	3.....
Cluster No.....	House Hold Number.....	Street Name.....
Village.....	Taluk.....	District.....
Size of House Hold.....	Name of House hold head.....	
Religion/ Caste of the household.....		

INTERVIEWER VISIT				
	1	**2**	3	**GPS COORDINATES**
Date	.....	.....	.....	
Interviewer Name -	.....	.....	.....	☐☐.☐☐ °S ☐☐.☐☐ °E
Result* -	.....	.....	.....	

RESULT CODE*					
01	Completed	02	No household member at home	03	No competent respondent
04	Refused	05	Partly completed	06	Dwelling Vacant
07	Dwelling not found	08	Postponed	09	Other specify

LANGUAGE OF INTERVIEW							
01	Tamil	02	English	03	Hindi	04	Others.....

Section 1: Household schedule

Family member	Usual Residents Please give me the names of the persons who usually live in your household.	Relationship What is the relationship of (name) to the head of the household? **See code below	Sex Is (name) male or female? 1=Male 2=Female	Residence Does (name) usually stay here? 1=Yes 2=No	Age How old is (name)? In years	Marital status What is (name) current marital status? 1=Married 2=Single 3=Widowed 4=Separated 99=Don't know	Education What is (name) current educational status? Level	Occupation What is (name) current occupational status? 01=Farmer 02=Teacher 03=Housewife 04=Daily wage 05=Office 06=Nil 07=Others 99=Don't know	Income What is the monthly income of the (name)?
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									
TICK HERE, IF CONTINUATION SHEET IS USED : _____									

Codes for Relationship to head of house hold01=Head

02=Wife or Husband
03=Son
04=Daughter
05=Daughter-in-law
06=Son-in-law
07=Father
08=Mother
09=Brother
10=Sister
11=Grand Mother
12=Grand Father
13=Uncle
14=Aunt
15=Niece
16=Nephew
17=others specify
99=don't know

Section 2: Livelihood related

Q 1	Does anyone in your household own land?	Yes	No	Don't know	Numbers
		1	2	99	
Q2	If Yes, Specify the area in cent/acre? **(Record Verbatim)**				
Q3	Do you own the house you live in?	1	2	99	
Q4	Do you own the following? If yes, how many?				
	Cow	1	2	99	
	Bullock	1	2	99	
	Buffaloes	1	2	99	
	Goats	1	2	99	
	Sheep	1	2	99	
	Poultry	1	2	99	
	Others Specify				
Q5	Does anyone in the household own a bank account?	1	2	99	
Q6	Are you a below poverty line (BPL) card holder?	1	2	99	
Q7	Does anyone in your house hold belong to any micro-credit schemes/ youth clubs/ women's group?	1	2	99	
Q8	If yes, which group?				
Q9	Since when?				
Q10	Does any member of your household have health insurance / Kalaignar Kapitu Thittam	1	2	99	
	If yes, who in the family has insurance and how long have they had insurance?				

Section 3: Household characteristics/ civic amenities

What is the main source of drinking water for members of your house hold?

01	Piped water-into dwelling	06	Dug well-Unprotected	11	Cart with small truck
02	Piped water- into yard/plot	07	Rain water	12	Surface water/ river water/ lake/ponds/irrigation canal
03	Piped water-Public taps/ stand pipe	08	Water from spring-Protected	13	Bottled water
04	Tube well or bore hole	09	Water from spring-Unprotected	14	Others specify
05	Dug well-Protected	10	Tanker /truck	99	Don't know

What is main source of water used by your household for other purposes?

01	Piped water-into dwelling	06	Dug well-Unprotected	11	Cart with small truck
02	Piped water- into yard/plot	07	Rain water	12	Surface water/ river water/ lake/ponds/irrigation canal
03	Piped water-Public taps/ stand pipe	08	Water from spring-Protected	13	Bottled water
04	Tube well or bore hole	09	Water from spring-Unprotected	14	Others specify
05	Dug well-Protected	10	Tanker /truck	99	Don't know

Where is the water source located?

01	In own dwelling	03	Same Street	05	Elsewhere
02	In own yard/plot	04	Same village		

How long does it take to go there and get water and come back?

	Minutes	99	Don't Know

Who usually goes to this source to fetch the water for your household?

01	Adult woman	03	Adult man	05	Others
02	Female child (under 15 years)	04	Male child (under 15 years)	99	Don't know

Do you do anything to the water to make it safer to drink?

1	Yes	2	No	99	Don't Know

What do you usually do to make the water safer to drink? (Record all mentioned)

01	Boil	04	Solar disinfection	07	Others specify
02	Add Bleaching powder/chlorine	05	Use water filter (ceramic/sand/composite/etc)	99	Don't know
03	Strain through a cloth	06	Let it stand and settle		

May we look at your water storage?

	Yes	No	N A
[OBSERVATION]Water Storage: If a drinking storage water container is used, is it kept covered?	1	2	999
[OBSERVATION]Dipping container: If a dipping container is used, is it kept clean?	1	2	999

May we collect a sample of your water?

1	Yes	2	No

Do you have toilet facility?

1	Yes	2	No

What kind of toilet facility do members of your household usually use?

01	No facility	06	Flush to septic tank	11	Pit latrine with slab
02	Within dwelling	07	Flush to pit latrine	12	Composting toilet
03	Open space/Bush/Field	08	Flush to somewhere else	13	Others specify.....
04	Community toilet	09	Flush. Don't know where	14	Don't want to answer
05	Flush to piped sewer	10	Pit latrine without slab/open pit	99	Don't know

Do you share this toilet facility with other households?

1	Yes	2	No	99	Don't Know

Where do you dispose your household waste?

01	Government dustbin	03	Throw outside of the house	05	Burn
02	Home-back yard	04	Bury them in the soil	06	Other.....

Does your household have any of the following?

	Yes	No
Electricity	1	2
Radio	1	2
Mobile telephone/phone	1	2
Television	1	2
Cycle	1	2
Two wheeler/ four wheeler	1	2
Grinder	1	2
Refrigerator	1	2

What type of fuel do you mainly use for cooking?

01	Fire wood	05	Cow dung	09	Others specify
02	Biogas	06	Natural gas	99	Don't know
03	Kerosene	07	Coal/lignite/charcoal		
04	LPG	08	Electricity		

Do you have a separate room for the kitchen?

1	Yes	2	No	999	NA

Does your house have a chimney or a hood?

01	Chimney	02	Hood	03	None

How many rooms are there in your house? ☐

[OBSERVATION] What is the main material of the floor?

01	Earth/sand/Mud	05	Dung	09	Wooden
02	Brick	06	Stone	10	Others specify
03	Red oxide	07	Cement		
04	Mosaic	08	Ceramic tiles		

[OBSERVATION] What is the main material of the roof?

01	No roof	05	Thatch/palm leaf	09	Wood
02	Mud	06	Polythene sheets	10	Others specify.....
03	GI sheets	07	Tiles		
04	RCC	08	Metal sheet		

Section 4. Health

Since Pongal, have there been any incidents of illness in your family?

1	Yes	2	No	999	NA

If yes, what is the name of the family member, the illness suffered, duration, treatment, outcome and expense for each ill individual?

SlNo	Name	Illness	Duration	Treatment taken	Outcome	Approximate expenditure

When you are sick, where do you go?

01	PHC	06	Medical shop	11	Nursing homes
02	Govt. Hospital	07	Village elder	12	Ayurvedic
03	Govt. mobile clinic	08	Local vaidya	13	Others specify.....
04	Private Clinic	09	Local healer		
05	Community health worker	10	MTC		

What are the health facilities in the village and their distance?

	Distance
PHC	
Govt. Hospital	
Govt. mobile clinic	
Private Clinic	
Community health worker	
Medical shop	
Village elder	
Local vaidya	
Local healer	
MTC	
Nursing homes	
Ayurvedic	
Other: specify	

What are some common ailments in your village? How often do these ailments occur? What season do these ailments occur?

Ailments	Frequency	Season

Have you heard of chikungunya?

1	Yes	2	No

If yes, where did you hear about chikungunya? (Open ended)

01	Friend	06	TV	11	Health Aid
02	Family member	07	School	12	Other (Specify).....
03	Posters/pamphlets	08	Religious meeting	99	Not Applicable
04	Newspapers	09	Community meetings		
05	Radio	10	Health facility		

Since Pongal, have there been any incidents of chikungunya in your family?

[1] Yes [2] No

If yes, what is the name of the family member, the illness suffered, duration, treatment, outcome and expense for each ill individual?

SlNo	Name	Duration	Treatment taken	Outcome	Approximate expenditure

What transmits chikungunya? [ ]

What do you think are the most common signs and symptoms in chikungunya infection? (Open ended, check the responses listed.)

[01]	High temperature/fever	[04]	Headache	[07]	Nausea	[98]	Don't know
[02]	Joint pain	[05]	Fatigue	[08]	Muscle pain	[99]	Not applicable
[03]	Rash	[06]	Vomiting	[09]	Other (Specify)		

How would you prevent chikungunya? [ ]

Are you familiar with other methods of mosquito control? (Allow respondents to list known methods without prompting. Once all known methods are listed, ask about methods not mentioned).

	Methods Known							
	Spontaneously		With Assistance		Used Before		Currently Using	
	Yes	No	Yes	No				
Prevent stagnant water (specify how)	1	0	1	0	1	0	1	0
Indoor residual spraying	1	0	1	0	1	0	1	0
Insecticide treated bednet	1	0	1	0	1	0	1	0
Untreated bednet	1	0	1	0	1	0	1	0
Mosquito Coils	1	0	1	0	1	0	1	0
Smoke	1	0	1	0	1	0	1	0
Fans	1	0	1	0	1	0	1	0
Screened windows	1	0	1	0	1	0	1	0
Clean water (specify how)	1	0	1	0	1	0	1	0
Mosquito liquid (plug in)	1	0	1	0	1	0	1	0
Mosquito repellents (applied to self)	1	0	1	0	1	0	1	0
Mosquito bat	1	0	1	0	1	0	1	0

We have concluded our interview. Thank you very much for your hospitality and your valuable contribution. Do you have any questions for me?

_____

_____

Observations and comments about the interview

Kindly describe the mood of the respondent(s) during the interview

_____

_____

_____

Did the other ones present during the interview participate in it? 1 Yes 2 No

Any other observations? Any comment from debriefing?

_____

A.4 Tamil Nadu Chikungunya Evaluation Survey

INTRODUCTION AND CONSENT

We invite you to participate in a research study being conducted by investigators from Meenakshi Mission Hospital and Research Center and The University of Iowa. The purpose of the study is to collect information about your household and the health of your family.

If you agree to participate, we would like you to answer some questions about your home and family. You are free to skip any questions that you prefer not to answer. It will take approximately 30 minutes. Any information we collect about your family will not be shared without first removing your name. It will not be possible to link you to your responses on the survey. Taking part in this research study is completely voluntary. If you do not wish to participate in this study, you may decline now.

If you have questions about the rights of research subjects, please contact Meenakshi Mission Hospital and Research Center at (91-452-2588741) Thank you very much for your consideration of this research study.

மீனாட்சி மருத்துவ மனையும் ஐயோவா பல்களைக்கழகமும் ஒன்றுசேர்ந்து நடத்தும் ஆராயச்சியில் பங்கேர்க்க உங்களை பணிவுடன் அழைக்கிறோம். இந்த ஆராயச்சியின் குறிக்கோள் உங்கள் குடும்பத்தையும் குடும்பத்தின் ஆரோக்கியத்தையும் பற்றி தெரிந்துகொள்வதாகும்.

எங்கள் ஆராய்ச்சியில் பங்கேர்க்க நீங்கள் ஒப்புக்கொண்டால் உங்கள் இல்லத்தையும் குடும்பத்தையும் பற்றி சில கேள்விகள் கேட்ப்போம். கேட்ட கேள்விகளில் ஏதாவது கேள்விக்கு பதிலளிக்க உங்களுக்கு விருப்பமில்லையென்றால் பதிலளிக்காமலே நீங்கள் அடுத்த கேள்விக்குச் செல்லலாம். ஆரம்பம் முதல் முடிவு வரை கேள்வி பதில்கள் ஏறக்குறைய அரை மணி நேரம் எடுக்கும். நீங்கள் அளிக்கும் பதில்களிருந்து உங்கள் பெயரை அகற்றியபிறகுதான் அவற்றை வேறு யாவரிடமும் பகிருவோம். உங்களை உங்கள் பதில்களோடு யாராலும் இணைக்க முடியாது. இந்த ஆராயச்சியில் பங்கேர்ப்பதற்கு கட்டாயம் எதுவும் கிடையாது. உங்களுக்கு பங்குபெற விருப்பம் இல்லையென்றால் இப்பொழுதே மறுத்துவிடலாம்.

ஆராயச்சிகளில் பங்கேர்ப்பவர்களின் உரிமைகளைப்பற்றி உங்களுக்கு ஏதாவது சந்தேகமிருந்தால் மீனாட்சி மருத்துவ மனையுடன் இந்த தொலைபேசி எண்மூலம் பேசலாம்: (91-452-2588741)
உங்கள் கவனிப்பிற்கு எங்களது மனப்பூர்வமான நன்றியை தெரிவித்துக்கொள்கிறோம்.

Respondent agrees to be interviewed ....01 Respondent disagrees to be interview 02

May we begin the interview now? Thank and Terminate

IDENTIFICATION			
Name of Respondent: 1.....	2.....	3.....	
Cluster No.....	Household Number.....	Street Name.....	
Village.....	Taluk.....	District.....	
Size of Household.....	Name of Household head.....		
Religion/ Caste of the household.....			

INTERVIEWER VISIT				
	1	**2**	**3**	**GPS COORDINATES**
Date	.....	.....	.....	
Interviewer Name -	.....	.....	.....	10 . . . . . °S 78 . . . . . °E
Result* -	.....	.....	.....	

RESULT CODE*					
01	Completed	02	No household member at home	03	No competent respondent
04	Refused	05	Partly completed	06	Dwelling Vacant
07	Dwelling not found	08	Postponed	09	Other specify

LANGUAGE OF INTERVIEW							
01	Tamil	02	English	03	Hindi	04	Others.....

Section 1: Household schedule

Family member	Usual Residents Please give me the names of the persons who usually live in your household.	Relationship What is the relationship of (name) to the head of the household? **See code below	Sex Is (name) male or female? 1=Male 2=Female	Residence Does (name) usually stay here? 1=Yes 2=No	Age How old is (name)? In years	Marital status What is (name) current marital status? 1=Married 2=Single 3=Widowed 4=Separated 99=Don't know	Education What is (name) current educational status? Level	Occupation What is (name) current occupational status? 01=Farmer 02=Teacher 03=Housewife 04=Daily wage 05=Office 06=Nil 07=Others 99=Don't know	Income What is the monthly income of the (name)?
01									
02									
03									
04									
05									
06									
07									
08									
09									
10									

Codes for Relationship to head of house hold

01=Head
02=Wife or Husband
03=Son
04=Daughter
05=Daughter-in-law
06=Son-in-law
07=Father
08=Mother
09=Brother
10=Sister
11=Grand Mother
12=Grand Father
13=Uncle
14=Aunt
15=Niece
16=Nephew
17=others specify
99=don't know

Section 2: Household Characteristics

Does anyone in your household own land?	Yes	No	Don't know	Numbers
	1	2	99	
If Yes, Specify the area in cent/acre? **(Record Verbatim)**				
Do you own the house you live in?	1	2	99	
Do you own the following? If yes, how many?				
Cow	1	2	99	
Bullock	1	2	99	
Buffaloes	1	2	99	
Goats	1	2	99	
Sheep	1	2	99	
Poultry	1	2	99	
Others Specify				
Does anyone in the household own a bank account?	1	2	99	

What is the main source of drinking water for members of your house hold?

01	Piped water-into dwelling	06	Dug well-Unprotected	11	Cart with small truck
02	Piped water- into yard/plot	07	Rain water	12	Surface water/ river water/ lake/ponds/irrigation canal
03	Piped water-Public taps/ stand pipe	08	Water from spring-Protected	13	Bottled water
04	Tube well or bore hole	09	Water from spring-Unprotected	14	Others specify
05	Dug well-Protected	10	Tanker /truck	99	Don't know

What is main source of water used by your household for other purposes?

01	Piped water-into dwelling	06	Dug well-Unprotected	11	Cart with small truck
02	Piped water- into yard/plot	07	Rain water	12	Surface water/ river water/ lake/ponds/irrigation canal
03	Piped water-Public taps/ stand pipe	08	Water from spring-Protected	13	Bottled water
04	Tube well or bore hole	09	Water from spring-Unprotected	14	Others specify
05	Dug well-Protected	10	Tanker /truck	99	Don't know

Where is the water source located?

01	In own dwelling	03	Same Street	05	Elsewhere
02	In own yard/plot	04	Same village		

How long does it take to go there and get water and come back?

	Minutes	99	Don't Know

Who usually goes to this source to fetch the water for your household?

01	Adult woman	03	Adult man	05	Others
02	Female child (under 15 years)	04	Male child (under 15 years)	99	Don't know

Do you have toilet facility? 1 Yes 2 No

What kind of toilet facility do members of your household usually use?

01	No facility	06	Flush to septic tank	11	Pit latrine with slab
02	Within dwelling	07	Flush to pit latrine	12	Composting toilet
03	Open space/Bush/Field	08	Flush to somewhere else	13	Others specify.....
04	Community toilet	09	Flush. Don't know where	14	Don't want to answer
05	Flush to piped sewer	10	Pit latrine without slab/open pit	99	Don't know

Do you have a separate room for the kitchen?

1	Yes	2	No	999	NA

What type of fuel do you mainly use for cooking?

01	Fire wood	03	Kerosene	05	Cow dung	07	Coal/lignite/charcoal	09	Others specify
02	Biogas	04	LPG	06	Natural gas	08	Electricity	99	Don't know

Does your household have any of the following?

	Yes	No
Electricity	1	2
Radio	1	2
Mobile telephone/phone	1	2
Television	1	2

	Yes	No
Cycle	1	2
Two wheeler/ four wheeler	1	2
Grinder	1	2
Refrigerator	1	2

How many rooms are there in your house? _____

[OBSERVATION] What is the main material of the floor?

01	Earth/sand/Mud	03	Red oxide	05	Dung	07	Cement	09	Wooden
02	Brick	04	Mosaic	06	Stone	08	Ceramic tiles	10	Others specify

[OBSERVATION] What is the main material of the roof?

01	No roof	03	GI sheets	05	Thatch/palm leaf	07	Tiles	09	Wood
02	Mud	04	RCC	06	Polythene sheets	08	Metal sheet	10	Others specify.....

Section 3: Health

In the last three months have you been educated about health?

1 Yes 2 No 99 Don't Know

If yes, Could you please tell me what you were told about?

_____

_____

Do you do anything to the water to make it safer to drink?

1 Yes 2 No 99 Don't Know

What do you usually do to make the water safer to drink? (Record all mentioned)

01	Boil	04	Solar disinfection	07	Others specify
02	Add Bleaching powder/Chlorine	05	Use water filter (ceramic/sand/composite/etc)	99	Don't know
03	Strain through a cloth	06	Let it stand and settle		

May we look at your water storage?

	Yes	No	N A
[OBSERVATION]Water Storage: If a drinking storage water container is used, is it kept covered?	1	2	999
[OBSERVATION]Dipping container: If a dipping container is used, is it kept clean?	1	2	999

May we collect a sample of your water?

1 Yes 2 No

Since Pongal, have there been any incidents of illness in your family?

1 Yes 2 No 999 NA

If yes, what is the name of the family member, the illness suffered, duration, treatment, outcome and expense for each ill individual?

SlNo	Name	Illness	Duration	Treatment taken	Outcome	Approximate expenditure

Have you heard of chikungunya? 1 Yes 2 No

In the last three months have you been educated about chikungunya?

1 Yes 2 No

If yes, please describe the educational message?-

_____
_____
_____

If yes, where did you hear about chikungunya? (Open ended)

01	Friend	04	Newspapers	07	School	10	Health facility
02	Family member	05	Radio	08	Religious meeting	11	Health Aid
03	Posters/pamphlets	06	TV	09	Community meetings	12	Other (Specify).....
						99	Not Applicable

Since Pongal, have there been any incidents of chikungunya in your family?

1 Yes 2 No

If yes, what is the name of the family member, the illness suffered, duration, treatment, outcome and expense for each ill individual?

SlNo	Name	Duration	Treatment taken	Outcome	Approximate expenditure

What transmits chikungunya? ☐

What do you think are the most common signs and symptoms in chikungunya infection? (Open ended, check the responses listed.)

01	High temperature/fever	04	Headache	07	Nausea	98	Don't know
02	Joint pain	05	Fatigue	08	Muscle pain	99	Not applicable
03	Rash	06	Vomiting	09	Other (Specify)		

How would you prevent chikungunya?

Are you familiar with other methods of mosquito control? (Allow respondents to list known methods without prompting. Once all known methods are listed, ask about methods not mentioned).

	Methods Known							
	Spontaneously		With Assistance					
	Yes	No	Yes	No	Used Before		Currently Using	
Prevent stagnant water (specify how)	1	0	1	0	1	0	1	0
Indoor residual spraying	1	0	1	0	1	0	1	0
Insecticide treated bednet	1	0	1	0	1	0	1	0
Untreated bednet	1	0	1	0	1	0	1	0
Mosquito Coils	1	0	1	0	1	0	1	0
Smoke	1	0	1	0	1	0	1	0
Fans	1	0	1	0	1	0	1	0
Screened windows	1	0	1	0	1	0	1	0
Clean water (specify how)	1	0	1	0	1	0	1	0
Mosquito liquid (plug in)	1	0	1	0	1	0	1	0
Mosquito repellents (applied to self)	1	0	1	0	1	0	1	0
Mosquito bat	1	0	1	0	1	0	1	0

What mosquito prevention methods would you like to use in the future?

_____

What has kept you from using the above method of prevention?

_____

We have concluded our interview. Thank you very much for your hospitality and your valuable contribution. Do you have any questions for me?

_____

Observations and comments about the interview
Kindly describe the mood of the respondent(s) during the interview

_____

Did the other ones present during the interview participate in it? [1] Yes [2] No

Any other observations? Any comment from debriefing?

_____

A.5 Educational Intervention

Chikungunya Fever

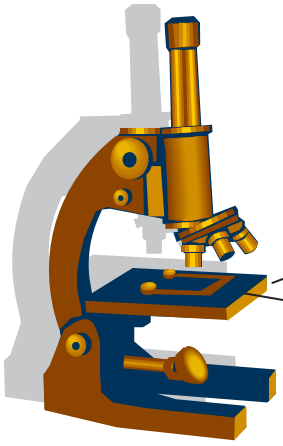
An educational manual to increase knowledge of chikungunya signs and symptoms, transmission, and prevention methods.

Images : Mosquito: http://extermicon.com/fumigation.htm.

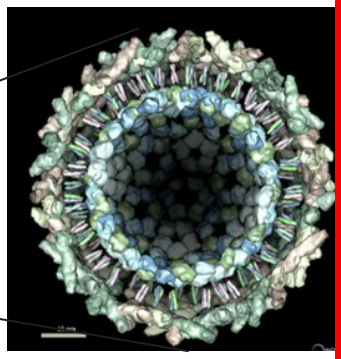
English:

Introduce yourself and your organization. Today we will be discussing Chikungunya fever using this educational manual. We hope at the end of this talk that we will have increased your knowledge of chikungunya signs and symptoms, transmission, and prevention methods.

What is Chikungunya?



A Virus!



Signs and Symptoms

Acute, rapid fever

Joint Pain

Rash

Symptoms usually last 3-5 days

Joint pain may linger several months

Images : Chikungunya virus: http://ranjitwarrier.blogspot.com/2006/02/chikungunya-picture.html, Thermometer: http://www.wonderdoctor.com/static_content.php?cat=allergy&c_link=mold_allergy, joint pain: http://www.tnhealth.org/dphfacts/chikungunya.htm and rash: http://drdevendrapatel.blogspot.com/2010/03/chikungunya.html

English:

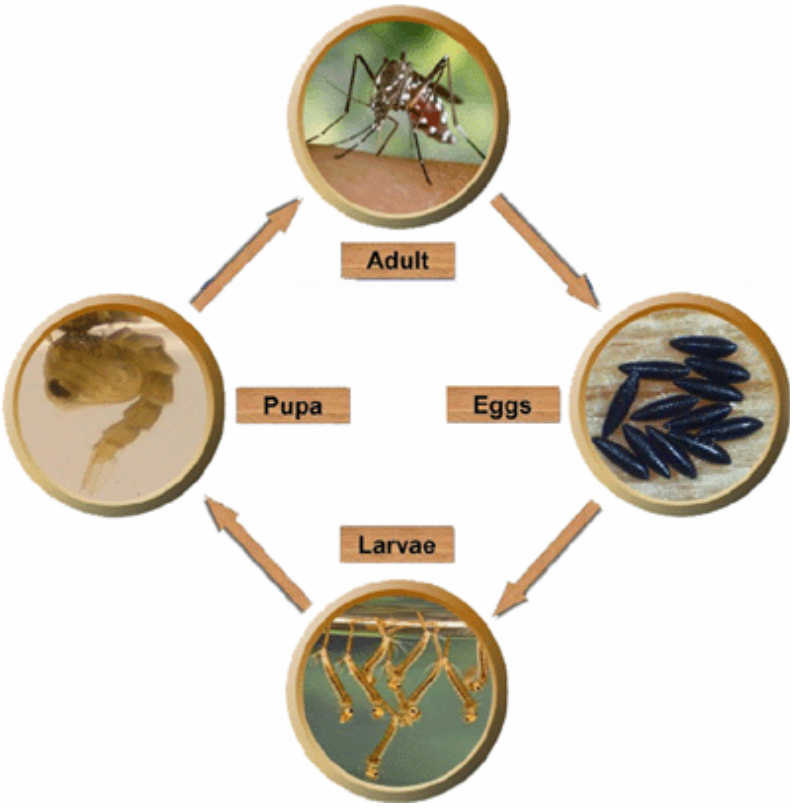
What is chikungunya? Chikungunya is a virus that causes an acute, rapid fever, severe joint pain and rash. These are the three most common symptoms, but there are other symptoms that occasionally have been attributed to chikungunya. The fever and rash usually last between 3-5 days, but the joint pain can continue for months.

Transmission

Aedes aegypti mosquito

A **DAY** biting mosquito that prefers to lay eggs in

The Mosquito life cycle



Images : Mosquito: http://extermicon.com/fumigation.htm, Mosquito life cycle: http://sigmabiotech.com/mosquitoes.html

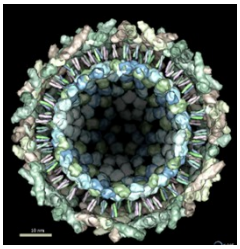
English:

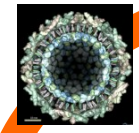
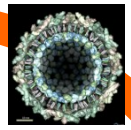
Chikungunya virus is transmitted to humans by the Aedes aegypti mosquito. This is the same mosquito that carries Yellow fever and Dengue. This mosquito is most active during the daytime and prefers biting humans.

The mosquito life cycle starts when a mosquito lays eggs in water. The eggs develop into larvae, then pupae before the adult mosquito emerges.

Transmission

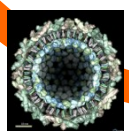
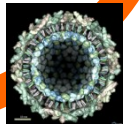






And the cycle

continues!



Images : Mosquito: http://extermicon.com/fumigation.htm, environment: http://www.tnhealth.org/dphfacts/chikungunya.htm Chikungunya virus: http://ranjitwarrier.blogspot.com/2006/02/chikungunya-picture.html, Thermometer: http://www.wonderdoctor.com/static_content.php?cat=allergy&c_link=mold_allergy, joint pain: http://www.tnhealth.org/dphfacts/chikungunya.htm and rash: http://drdevendrapatel.blogspot.com/2010/03/chikungunya.html, Woman with baby and Boy: Personal collection Erin Reynolds.

English:

When you have the right environment, the mosquito and chikungunya virus, people will develop chikungunya virus. When a mosquito bites someone experiencing the symptoms of chikungunya, the process starts over again. You do not get chikungunya from interacting with other people or from stagnant water. You only get chikungunya when a mosquito bites you after biting an infected person.

Mosquito Breeding Sites

Images : Personal collection of Erin Reynolds

English:

There are many sites where mosquitoes breed. Here we see old tires, rain water containers, discarded coconut shells, porticos, plastic bags, unused grinders, discarded bottles, open water tanks, and pools of stagnant water.

Mosquitoes like both stagnant AND clean water...so prevent stagnant water build up, properly dispose of containers that may collect water, and cover all containers!

Mosquitoes Travel!

Mosquitoes have a flight range of

between 200 and 500 meters

Images : Mosquito: http://extermicon.com/fumigation.htm, Chesapeake, Virginia Mosquito control Commission http://www.chesapeake.va.us/services/depart/mosquito/citizen-participation.shtml

English:

Even if your house doesn't have any mosquito breeding sites, you are still at risk if your neighbor's house does contain breeding sites. Mosquitoes can travel up to 500 meters (1/2 km) in order to feed. Mosquito prevention is a village concern, not an individual concern so educate your neighbors. So everybody in the village should take care.

Prevention

Prevent mosquito breeding and protect yourself from mosquito bites!

Images : Mosquito coil: http://www.footprintsglasgow.co.uk/index.php?main_page=index&cPath=3_30, mosquito bat http://www.made-in-china.com/showroom/taizi07/product-detailAaYmcpxDoEKI/China-Mosquito-Bat-HYD-42-.html, Bednet: http://www.dfid.gov.uk/Where-we-work/Africa-Eastern--Southern/Kenya1,/IRS: http://blogs.millenniumpromise.org/index.php/2010/01/28/tanzania-government-draws-lessons-from-mbola-for-the-fight-against-malaria/, Fogging: http://www.pharmachem.gr/details.aspx?P=23&L=2, Window screen:http://cgi.ebay.ie/ws/eBayISAPI.dll?VISuperSize&item=400028822941, Neem: http://www.aos.org/AM/Template.cfm?Section=Pests_and_Diseases&CONTENTID=5664&TEMPLATE=/CM/ContentDisplay.cfm, Personal collection of Erin Reynolds

English:

- Cover all water containers, not just drinking water. Turn any unused containers upside down to prevent water collection.
- Do not store water uncovered for more than 2 days.
- Screen household windows
- Drain roofs and porticos to prevent water build up.
- Drain all areas of stagnant water
- Burn natural products such as neem leaves to ward off mosquitoes
- Conduct anti-mosquito fogging in public locations to get rid of large mosquito habitats
- Protect yourself while inside with indoor insecticide repellents such as IRS, mosquito liquid, or coils.
- Use fans when indoors.
- Use personal insecticide repellent sprays or ointments
- Pregnant women and children should sleep under a bednet, even during the daytime
- Wear long-sleeved clothing

Any Questions?

If you think you or a family member have Chikungunya, please contact your nearest health care provider.

If your village needs help removing mosquitoes from your public areas, contact your village president and ask for help from your local Tamil Nadu government.

English:

If you or a family member are experiencing the symptoms of chikungunya (fever, joint pain and rash), please contact your nearest health care provider.

If your village needs help removing mosquitoes from your public areas, contact your village president and ask for help from your local Tamil Nadu government.

Table A1. Data dictionary for the needs assessment survey

Needs Assessment Variables	Coding
ID	First two numbers represent cluster, second two numbers village number
Cluster	1-12 (1-6 Intervention, 7-12 Control)
Group	1=Intervention, 0=Control
HHAge	Continuous
HHAgeCat	0=0-25, 1=25.1-49.1, and 2=>50 years)
HH Sex	1=Male, 2=Female
HHEduc	0=0, 1=1-5, 2=6-10, 3=11-12, 4=Degree, 5=Post Grad
HHEmploy	1=Farmer, 2=Teacher, 3=Housewife, 4=Daily wage, 5=Office, 6=None, 7=Other
HHEmployDi	0=Not employed, 1=Employed
RespondentAge	0=0-25, 1=25-50, and 2=50+ years
RespondentAgeCat	0=0-25, 1=25-50, and 2=50+ years
Respondent Sex	1=Male, 2=Female
Respondent1Educ	Years education
Respondent1EducCat	0=0, 1=1-5, 2=6-10, 3=11-12, 4=Degree, 5=Post Grad
Religion	0=Not listed, 1=Hindu, 2=Muslim, 3=Christian
FamilyIncome	Continuous
Income	0=0-500, 1=501-2500, 2=2501+
Family Size	Integers
Rooms	Integers
RoomsDi	Dichotomous (0=1-2 and 1=3+)
Crowding	Number of household members/room
CrowdingDi	0=0-2, 1=2.1 and up
OwnLand	0=No, 1=Yes
LandAmt	Continuous

Table A1. Continued

LandAmtDi	0=0-0.36, 1=0.37 and greater
OwnHouse	0=No, 1=Yes
OwnLivestock	0=No, 1=Yes
LivestockAmt	Integers
LivestockCat	0=0, 1=1-3, 2=4 or more
LivestockMix	0=No livestock, 1=Single type livestock, 2=Mixed types livestock
Bank Account	0=No, 1=Yes
BPL	0=No, 1=Yes
Microcredit	0=No, 1=Yes
HealthInsurance	0=No, 1=Yes
Water Distance	0=+10, 1=0-10
WaterDrink	0=Unprotected surface water or well, 1=protected well or tanker truck, 2=public tap or tap near house, 3=piped into house or bottled water
WaterOther	0=Unprotected surface water or well, 1=protected well or tanker truck, 2=public tap or tap near house, 3=piped into house or bottled water
WaterLoc	0=Same village, 1=Same street, 2=In own yard, 3=In own dwelling,
WaterFetch	0=male, 1=female
WaterSafe	0=No, 1=Yes
WaterSafeMethod	0=Nothing, 1=don't know or other, 2=strain through cloth, 3=boil, 4=filter
WaterStorage	0=No, 1=Yes
WaterDipper	0=No, 1=Yes
ToiletYN	0=No, 1=Yes
ToiletUseDi	0=No facility or Open space, 1=Within dwelling or Flush to septic tank
Waste	1=Gov dustbin, 2=Home-back yard, 3=Throw outside house, 4=Bury them in soil, 5=Burn, 6=Other
Electricity	0=No, 1=Yes
Radio	0=No, 1=Yes
Phone	0=No, 1=Yes

Table A1. Continued

TV	0=No, 1=Yes
Cycle	0=No, 1=Yes
Wheels	0=No, 1=Yes
Grinder	0=No, 1=Yes
Fridge	0=No, 1=Yes
Fuel	1=Fire wood, 3=Kerosene, 4=LPG, 6=Natural gas
FuelDi	0=Fire wood, 1=Kerosene, LPG, or Natural gas
Kitchen	0=No, 1=Yes
Chimney	0=Chimney or Hood, 1=Neither
Floor	1=Earth, 3=Red Oxide, 4=Mosaic, 5=Dung, 7=Cement, 8=Tile, 10=Other
FloorCat	0=Earth or Dung,1=Cement, 2=Mosaic, Tiles or Other
Roof	1=None, 2=Mud, 3=GI sheets, 5=Thatch/palm leaf, 4=RCC, 7=Tile
RoofCat	0=No roof or Mud or GI sheets or Thatch/palm leaf, 1=Tiles, 2=RCC
Knowledge	0=No, 1=Yes
TransmissionCoded	0=Don't know, 1=Mosquito, 2=Anything else
SignsCoded	0=No symptoms known, 1=1 symptom listed, 2=2 symptoms listed, 3=3 symptoms listed
Prevention1Coded	0=Don't know, 1=Cleaning, 2=Anything water related, 3=Mosquito, 4=Anything else
Prevention 2Coded	0.50 for each spontaneously listed prevention method, 0.25 for assisted prevention method, and 0.5 for each method used
Knowledge Scored	0=Don't know, 1=Have heard of CHIK
TransmissionScored	0=Don't know or anything not mosquito, 5=Mosquito
Signs Scored	0=No signs, 2=1 sign, 4=2 signs, 6=3 signs
Prevention1 Scored	0=Don't know or anything else, 2=Anything water related, 4=Mosquito
Prevention2 Scored	0.50 for each spontaneously listed prevention method or 0.25 for any assisted prevention method, and 0.5 for each method used
Score	Variable consisting of KnowledgeScored, TransmissionScored, SignsScored, and PreventionScored variables

Table A2. Data dictionary for the evaluation survey

Evaluation Variables	Coding
ID	E=Evaluation, first two numbers represent cluster, second two numbers village number
Cluster	1-12 (1-6 Intervention, 7-12 Control)
Group	1=Intervention, 0=Control
PrePost	0=Pre-intervention, 1=Post-intervention
HHAge	Continuous
HHAgeCat	0=0-25, 1=25.1-49.1, and 2=>50 years)
HHSex	1=Male, 2=Female
HHEduc	Years education
HHEducCat	0=0, 1=1-5, 2=6-10, 3=11-12, 4=Degree, 5=Post Grad
HHEmploy	1=Farmer, 2=Teacher, 3=Housewife, 4=Daily wage, 5=Office, 6=None, 7=Other
HHEmployDi	0=Not employed, 1=Employed
RespondentAge	0=0-25, 1=25-50, and 2=50+ years
RespondentAgeCat	0=0-25, 1=25-50, and 2=50+ years
RespondentSex	1=Male, 2=Female
Respondent1Educ	Years education
Respondent1EducCat	0=0, 1=1-5, 2=6-10, 3=11-12, 4=Degree, 5=Post Grad
Caste	*See Caste Sheet
CasteReduced	*See Caste Sheet
CasteTri	*See Caste Sheet
Religion	0=Not listed, 1=Hindu, 2=Muslim, 3=Christian
FamilyIncome	Continuous
Income	0=0-500, 1=501-2500, 2=2501+
FamilySize	Integers
Rooms	Integers
RoomsDi	Dichotomous (0=1-2 and 1=3+)

Table A2. Continued

Crowding	Number of household members/room
CrowdingDi	0=0-2, 1=2.1 and up
OwnLand	0=No, 1=Yes
LandAmt	Continuous
LandAmtDi	0=0-0.36, 1=0.37 and grester
OwnHouse	0=No, 1=Yes
OwnLivestock	0=No, 1=Yes
LivestockAmt	Integers
LivestockCat	0=0, 1=1-3, 2=4 or more
LivestockMix	0=No livestock, 1=Single type livestock, 2=Mixed types livestock
Bank Account	0=No, 1=Yes
Water Distance	0=+10, 1=0-10
WaterDrink	0=Unprotected surface water or well, 1=protected well or tanker truck, 2=public tap or tap near house, 3=piped into house or bottled water
WaterOther	0=Unprotected surface water or well, 1=protected well or tanker truck, 2=public tap or tap near house, 3=piped into house or bottled water
WaterLoc	0=Same village, 1=Same street, 2=In own yard, 3=In own dwelling,
WaterFetch	0=male, 1=female
WaterSafe	0=No, 1=Yes
WaterSafeMethod	0=Nothing, 1=don't know or other, 2=strain through cloth, 3=boil, 4=filter
WaterStorage	0=No, 1=Yes
WaterDipper	0=No, 1=Yes
ToiletYN	0=No, 1=Yes
ToiletUseDi	0=No facility or Open space, 1=Within dwelling or Flush to septic tank
Waste	1=Gov dustbin, 2=Home-back yard, 3=Throw outside house, 4=Bury them in soil, 5=Burn, 6=Other
Electricity	0=No, 1=Yes
Radio	0=No, 1=Yes

Table A2. Continued

Phone	0=No, 1=Yes
TV	0=No, 1=Yes
Cycle	0=No, 1=Yes
Grinder	0=No, 1=Yes
Fridge	0=No, 1=Yes
Fuel	1=Fire wood, 3=Kerosene, 4=LPG, 6=Natural gas
FuelDi	0=Fire wood, 1=Kerosene, LPG, or Natural gas
Kitchen	0=No, 1=Yes
Floor	1=Earth, 3=Red Oxide, 4=Mosaic, 5=Dung, 7=Cement, 8=Tile, 10=Other
FloorCat	0=Earth or Dung,1=Cement, 2==Mosaic, Tiles or Other
Roof	1=None, 2=Mud, 3=GI sheets, 5=Thatch/palm leaf, 4=RCC, 7=Tile
RoofCat	0=No roof or Mud or GI sheets or Thatch/palm leaf, 1=Tiles, 2=RCC
Knowledge	0=No, 1=Yes
TransmissionCoded	0=Don't know, 1=Mosquito, 2=Anything else
SignsCoded	0=No symptoms known, 1=1 symptom listed, 2=2 symptoms listed, 3=3 symptoms listed
Prevention1Coded	0=Don't know, 1=Cleaning, 2=Anything water related, 3=Mosquito, 4=Anything else
Prevention 2Coded	0.50 for each spontaneously listed prevention method, 0.25 for assisted prevention method, and 0.5 for each method used
Knowledge Scored	0=Don't know, 1=Have heard of CHIK
Transmission Scored	0=Don't know or anything not mosquito, 5=Mosquito
Signs Scored	0=No signs, 2=1 sign, 4=2 signs, 6=3 signs
Prevention1 Scored	0=Don't know or anything else, 2=Anything water related, 4=Mosquito
Prevention2 Scored	0.50 for each spontaneously listed prevention method or 0.25 for any assisted prevention method, and 0.5 for each method used
Score	Variable consisting of KnowledgeScored, TransmissionScored, SignsScored, and PreventionScored variables

Table A3. Method of scoring CHIK knowledge score variable

Question	Possible answers	Points	
General Knowledge section			
Have you heard of chikungunya?	Yes	1	
	No	0	
		Section total=1	
Transmission section			
What transmits chikungunya? Open ended.	Mosquito	5	
	Anything else	0	
		Section total=5	
Signs and Symptoms section			
What are the most common signs and symptoms in chikungunya infection? Open ended.	Fever	2	
	Joint pain	2	
	Rash	2	
	Anything else	0	
		Section total=6	
Prevention section			
How would you prevent chikungunya? Open ended.	Anything mosquito related	4	
	Anything stagnant water related	2	
	Anything else	0	
Are you familiar with other methods of mosquito control? 0.5 for knowledge of prevention, 1.0 if know and use method.	Prevent stagnant water	0.5	1
	IRS	0.5	1
	ITN	0.5	1
	Bednet	0.5	1
	Mosquito coil	0.5	1
	Smoke	0.5	1
	Fans	0.5	1
	Screens	0.5	1
	Clean water	0.5	1
	Mosquito liquid	0.5	1
	Mosquito repellent	0.5	1
	Mosquito bat	0.5	1
	No methods known	0	0
		Section total=16	
		Total Possible=28	

Table A4. CHIK knowledge score categories

Category	Score
Excellent Knowledge	24-28
Good	19-23
Fair	15-18
Poor	<14

Table A5. Pre-intervention household characteristics among the 12 study villages

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
% Respondents female	87.5	86.7	87.5	100	88.2	80.0	100	86.7	80.0	93.3	86.7	80.0	0.772
Respondent age	36.0	40.5	36.4	30.7	42.4	39.9	39.8	43.5	35.9	40.9	38.7	40.6	0.590
% HH male	87.5	86.7	93.8	86.7	82.3	93.3	86.7	73.3	98.7	66.7	93.3	73.3	0.569
HH age	51.9	52.1	48.8	49.4	54.8	48.7	45.7	54.3	41.5	47.9	46.5	50.1	0.298
HH marital status													0.559
Married	87.5	86.7	87.5	73.3	82.4	93.3	86.7	66.7	86.7	66.7	93.3	73.3	
Widowed	12.5	13.3	12.5	26.7	17.6	6.7	13.3	26.7	13.3	33.3	6.7	26.7	
Single	0	0	0	0	0	0	0	6.7	0	0	0	0	
Household income (₹)	1277	1293	1581	1421	1719	1917	2346	2447	3307	4300	4653	1980	0.001*
% Own land	93.8	66.7	66.8	93.3	82.3	60.0	74.7	40.0	66.7	80.0	13.3	73.3	0.001*
% Own house	87.5	100	93.8	86.7	94.1	93.3	86.7	86.7	100	93.3	100	93.3	0.611
% Households owning livestock	62.5	73.3	93.8	80.0	88.2	73.3	46.7	40.0	80.0	53.3	53.3	60.0	0.022*
Average household livestock	3.5	3.1	4.5	3.3	5.1	3.3	2.3	1.7	4.1	4.3	1.9	3.7	0.577
Cow	43.8	53.3	37.5	73.3	70.6	53.5	26.7	6.7	53.3	26.7	20.0	40.0	0.003*
Poultry	56.3	40.0	56.3	33.3	35.3	33.3	20.0	33.3	60.0	40.0	46.7	53.3	0.505
Goat	25.0	20.0	68.8	26.7	47.1	40.0	6.7	0	33.3	26.7	0	13.3	0.000*
Bullock	6.3	6.7	0	6.7	0	6.7	6.7	6.7	6.7	6.7	0	20.0	0.678
Sheep	0	0	0	0	17.6	0	6.7	0	0	0	0	0	0.013*
Buffalo	0	0	0	0	6.3	0	0	0	0	0	0	0	0.541
Single vs. mixed types livestock													0.068
Single type of livestock	18.8	40.0	43.8	46.7	29.4	40.0	26.7	33.3	40.0	20.0	40.0	13.3	
Mixed livestock	43.8	33.3	50.0	33.3	58.8	33.3	20.0	6.7	40.0	33.3	13.3	46.7	
% Have a bank account	43.8	20.0	37.5	46.7	52.9	33.3	6.7	60.0	33.3	66.7	13.3	46.7	0.015*
% BPL card holder	93.8	93.3	93.8	93.3	100	100	100	93.3	86.7	93.3	100	93.3	0.865
% Belong to microcredit	25.0	13.3	43.8	13.3	17.6	0	66.7	20	13.3	0	40.0	66.7	0.000*
% Have health insurance	81.3	80.0	50.0	86.7	76.5	60.0	60.0	60.0	80.0	80.0	66.7	60.0	0.560

Table A5. Continued

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
% Electricity	93.8	93.3	93.8	80.0	94.1	86.7	93.3	100	100	100	100	93.3	0.482
% Radio	37.5	13.3	18.8	26.7	47.1	13.3	26.7	60.0	46.7	46.7	26.7	33.3	0.119
% Phone	93.8	80.0	68.8	80.0	76.5	66.7	80.0	80.0	80.0	93.3	40.0	73.3	0.086
% Television	100	73.3	87.5	86.7	82.4	80.0	86.7	93.3	86.7	93.3	86.7	93.3	0.743
% Grinder	81.3	33.3	50.0	53.3	70.6	60.0	73.3	73.3	60.0	66.7	33.3	33.3	0.048*
% Refrigerator	6.3	0	0	13.3	5.9	0	0	40.0	0	6.7	6.7	6.7	0.001*
% Vehicle	46.8	13.3	31.3	26.7	52.9	33.3	26.7	33.3	46.7	6.7	13.3	33.3	0.149
% Bicycle	62.5	73.3	43.8	20.0	76.5	53.3	60.0	40.0	53.3	53.3	53.3	46.7	0.161

*Significant at the 0.05 level

Table A6. Post-intervention household characteristics among the 12 study villages

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
% Respondents female	86.7	80.0	86.7	73.3	66.7	86.7	93.3	86.7	93.3	86.7	80.0	73.3	0.721
Respondent age	42.9	38.6	38.1	36.7	39.0	30.3	34.1	37.0	40.2	49.6	36.8	34.1	0.199
% HH Male	100	93.3	100	86.7	93.3	100	100	86.7	86.7	86.7	93.3	100	0.498
HH age	53.8	40.3	48.8	43.6	58.8	48.7	42.7	51.5	47.6	50.6	50.8	45.2	0.125
HH marital status													0.700
Married	93.3	86.7	100	86.7	93.3	93.3	100	86.7	86.7	80.0	80.0	93.3	
Widowed	6.7	13.3	0	13.3	6.7	6.7	0	13.3	13.3	13.3	20.0	6.7	
Single	0	0	0	0	0	0	0	0	0	6.7	0	0	
Household income (₹)	3733	3367	2467	3480	3033	2800	4200	4933	2167	4400	6200	1333	0.111
% Own land	80.0	33.3	26.7	73.3	60.0	46.7	46.7	73.3	60.0	66.7	13.3	46.7	0.004*
% Own house	80.0	80.0	66.7	93.3	100	80.0	73.3	93.3	80.0	73.3	80.0	93.3	0.299
% Households owning livestock	40.0	26.7	46.7	73.3	66.7	46.7	26.7	33.3	53.3	40.0	53.3	53.3	0.278
Average household livestock	0.7	1.4	0.8	2.7	2.3	0.9	1.7	2.7	1.2	2.9	2.3	2.2	0.661
Cow	26.7	26.7	26.7	46.7	46.7	26.7	13.3	13.3	33.3	13.3	20.0	26.7	0.506
Poultry	0	0	0	0	0	6.67	13.3	13.3	6.67	33.3	26.7	20.0	0.010*
Goat	6.67	20.0	33.3	40.0	60.0	33.3	6.67	6.67	6.67	13.3	0	26.7	0.001*
Bullock	13.3	0	0	6.67	0	0	0	13.3	13.3	0	0	6.67	0.244
Sheep	13.3	0	6.67	6.67	13.3	6.67	6.67	20.0	13.3	13.3	13.3	13.3	0.924
Buffalo	0	0	0	0	0	0	6.67	0	0	0	0	0	0.386
Single vs. mixed livestock													0.322
Single type of livestock	20.0	6.67	33.3	46.7	26.7	26.7	13.3	13.3	40.0	13.3	46.7	20.0	
Mixed livestock	20.0	20.0	13.3	26.7	40.0	20.0	13.3	20.0	13.3	26.7	6.67	33.3	
% Have a bank account	26.7	33.3	33.3	33.3	46.7	20.0	20.0	60.0	33.3	33.3	40.0	26.7	0.567
% Electricity	80.0	100	93.3	73.3	100	86.7	86.7	100	93.3	100	93.3	93.3	0.144
% Radio	6.7	26.7	33.3	13.3	6.7	0	13.3	26.7	0	26.7	13.3	26.7	0.133
% Phone	60.0	46.7	66.7	40.0	53.3	60.0	66.7	86.7	73.3	86.7	73.3	66.7	0.195

Table A6. Continued

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
% Television	80.0	86.7	93.3	60.0	86.7	93.3	86.7	93.3	73.3	80.0	93.3	80.0	0.342
% Grinder	53.3	33.3	46.7	20.0	40.0	40.0	40.0	80.0	73.3	66.7	60.0	60.0	0.039*
% Refrigerator	6.7	6.7	6.7	13.3	13.3	0	0	26.7	6.7	0	13.3	13.3	0.358
% Vehicle	26.7	40.0	40.0	33.3	66.7	26.7	46.7	53.3	20.0	33.3	40.0	20.0	0.269
% Bicycle	13.3	33.3	40.0	26.7	46.7	40.0	33.3	46.7	40.0	46.7	53.3	73.3	0.193

*Significant at the 0.05 level

Table A7. Post-intervention household characteristics between the intervention and control groups

	Intervention (n=90)	Control (n=90)	p-value
% Respondents female	80.0	85.6	0.324
Respondent age	37.6	38.5	0.697
% HH Male	95.6	92.2	0.351
HH age	49.0	48.1	0.338
HH marital status			0.443
Married	92.2	87.8	
Widowed	7.8	11.1	
Single	0	1.1	
Household income (₹)	3147	3872	0.064
% Own land	53.3	51.1	0.825
% Own House	83.3	82.2	0.596
% Households owning livestock	50.0	43.3	0.491
Average household livestock	1.5	2.2	0.155
Cow	33.0	20.0	0.059
Poultry	1.1	18.9	0.000*
Goat	32.2	10.0	0.000*
Bullock	3.3	5.6	0.440
Sheep	7.8	13.3	0.196
Buffalo	0	1.1	0.308
Single vs. mixed livestock			0.758
Single type of livestock	26.7	24.4	
Mixed livestock	23.3	18.4	
% Have a bank account	66.7	61.1	0.559
% Electricity	88.9	94.4	0.178
% Radio	14.4	17.8	0.543
% Phone	54.4	75.6	0.003*
% Television	83.3	84.4	0.839
% Grinder	38.9	63.3	0.001*
% Refrigerator	7.8	10.0	0.600
% Vehicle	38.9	35.6	0.644
% Bicycle	33.3	48.9	0.034*

*Significant at the 0.05 level

Table A8. Pre-intervention dwelling characteristics among the 12 study villages

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
Roof Type													0.003*
RCC	31.3	26.7	6.25	33.3	52.9	6.67	14.7	53.3	60.0	40.0	20.0	53.3	
Tile	37.5	26.7	56.3	53.3	29.4	80.0	40.0	33.3	40.0	53.3	33.3	20.0	
Thatch/Palm	31.3	46.7	37.5	13.3	17.6	13.3	13.3	13.3	0	6.67	46.7	26.7	
Floor Type													0.032*
Cement	68.8	66.7	87.5	46.7	70.6	73.3	93.3	60.0	93.3	60	46.7	80.0	
Earth/dung	18.8	33.3	12.5	46.7	23.6	26.7	6.67	13.3	6.67	26.7	40.0	20.0	
Mosaic/Tile	12.5	0	0	6.67	5.9	0	0	26.7	0	13.3	13.3	0	
No toilet-Open Space	87.5	86.7	93.8	93.3	80.0	93.3	93.3	40.0	100	80.0	86.7	73.3	0.001*
# Rooms													0.724
1 or 2	68.7	80.0	80.0	66.7	64.7	73.3	86.7	53.3	73.3	66.7	86.7	80.0	
3 or more	31.3	20.0	20.0	33.3	35.3	26.7	13.3	46.7	26.7	33.3	13.3	20.0	
Separate Kitchen	31.3	20.0	31.3	33.3	64.7	53.3	33.3	60.0	46.7	46.7	20.0	46.7	0.173
Cooking Fuel													0.000*
Firewood	100	100	100	93.3	94.1	100	100	53.3	100	86.7	86.7	86.7	
Other fuel	0	0	0	6.67	5.9	0	0	46.7	0	13.3	13.3	13.3	

*Significant at the 0.05 level

Table A9. Post-intervention swelling characteristics among the 12 study villages

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
Roof Type													0.000*
RCC	53.3	6.67	53.3	20.0	46.7	33.3	93.9	73.3	60.0	80.0	33.3	60.0	
Tile	33.3	66.7	46.7	40.0	33.3	66.7	6.67	20.0	40.0	6.67	53.3	40.0	
Thatch/Palm	6.67	26.7	0	33.3	13.3	0	0	6.67	0	13.3	13.3	0	
Missing	6.67	0	0	6.67	6.67	0	0	0	0	0	0	0	
Floor Type													0.000*
Cement	93.3	93.3	93.3	93.3	73.3	93.3	100	66.7	73.3	53.3	40	93.3	
Earth/dung	0	6.67	0	0	6.67	0	0	6.67	20.0	6.67	40.0	0	
Mosaic/Tile	0	0	6.67	0	13.3	0	0	26.7	6.67	40.0	20.0	6.67	
Missing	6.67	0	0	6.67	6.67	6.67	0	0	0	0	0	0	
No toilet-Open Space	86.7	100	100	86.7	73.3	100	93.3	26.7	93.3	80.0	60.0	86.7	0.000*
# Rooms													0.104
1 or 2	46.7	60.0	46.7	46.7	40.0	53.3	46.7	33.3	40.0	40.0	60.0	60.0	
3 or more	13.3	6.67	6.67	6.67	6.67	0	13.3	33.3	40.0	46.7	26.7	26.7	
Missing	40.0	33.3	46.7	46.7	53.3	46.7	40.0	33.3	20.0	13.3	13.3	13.3	
Separate Kitchen	46.7	26.7	6.67	6.67	46.7	13.3	40.0	73.3	46.7	60.0	53.3	66.7	0.000*
Cooking Fuel													0.000*
Firewood	86.7	93.3	93.3	86.7	80.0	100	86.7	40.0	86.7	60.0	66.7	73.3	
Other fuel	6.67	6.67	6.67	0	13.3	0	13.3	60.0	6.67	40.0	33.3	26.7	
Missing	6.67	0	0	13.3	6.67	0	13.3	0	6.67	0	0	0	

*Significant at the 0.05 level

Table A10. Post-intervention dwelling characteristics between the intervention and control groups

	Intervention (n=90)	Control (n=90)	p-value
Roof Type			0.000*
RCC	36.7	66.7	
Tile	48.9	27.8	
Thatch/Palm	13.3	5.5	
Missing	1.1	0	
Floor Type			0.000*
Cement	82.2	72.2	
Earth/dung	2.2	12.2	
Mosaic/Tile	3.3	15.6	
Missing	2.2	0	
No toilet-Open Space	93.3	73.3	0.000*
# Rooms			0.001*
1 or 2	51.1	46.7	
3 or more	6.7	31	
Missing	42.2	22.2	
Separate Kitchen	24.7	56.7	0.000*
Cooking Fuel			0.000*
Firewood	94.3	69.7	
Other fuel	5.7	30.3	

*Significant at the 0.05 level

Table A11. Pre-intervention water characteristics among the 12 study villages

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
Drinking Water													0.000*
Unprotected surface or well water	0	0	0	26.7	11.8	0	0	0	0	0	0	0	
Protected well or tanker truck	0	6.7	0	0	0	26.7	13.3	33.3	26.7	33.3	6.7	13.3	
Public tap or tap near yard	93.7	86.7	100	66.7	88.2	73.3	86.7	60.0	73.3	66.7	93.3	87.7	
Piped into house or bottled water	6.3	6.7	0	6.7	0	0	0	6.7	0	0	0	0	
Other use Water													0.000*
Unprotected surface or well water	0	6.7	6.3	13.3	0	0	0	33.3	0	0	6.7	6.7	
Protected well or tanker truck	6.3	6.7	12.5	0	0	26.7	13.3	26.7	26.7	33.3	13.3	13.3	
Public tap or tap near yard	62.5	80.0	75.0	73.3	100	73.3	86.7	33.3	73.3	66.7	80.0	80.0	
Piped into house or bottled water	31.3	6.7	0	13.3	0	0	0	6.7	0	0	0	0	
Missing	0	0	6.3	0	0	0	0	0	0	0	0	0	
Water location													0.000*
In own dwelling	25.0	6.7	0	0	5.9	0	0	6.7	0	0	6.7	0	
In own yard	0	0	0	0	11.8	0	0	0	0	0	6.7	6.7	
Same street	75.0	66.7	81.3	93.3	82.3	100	100	46.7	100	100	86.7	93.3	
Same village	0	26.7	18.8	6.7	0	0	0	46.7	0	0	0	0	
Time to fetch water													0.957
Less than 10 minutes	68.8	66.7	75.0	80.0	76.5	73.3	93.3	73.3	80.0	80.0	73.3	80.0	
More than 10 minutes	31.3	33.3	25.0	20.0	23.5	26.7	6.7	26.7	20.0	20.0	26.7	20.0	
Who fetches the water?													0.426
Female	83.8	80.0	75.0	86.7	76.5	73.3	93.3	80.0	93.3	100	100	93.3	
Male	6.3	13.3	12.5	13.3	11.8	26.7	0	6.7	6.7	0	0	0	

Table A11. Continued

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
Other person	0	6.7	12.5	0	11.8	0	6.7	13.3	0	0	0	6.7	
Do you do anything to make your water safe?													0.023*
Nothing	46.8	73.3	81.3	33.3	76.5	73.3	80.0	40.0	66.7	46.7	53.3	33.3	
Don't know	6.3	0	6.3	0	0	0	0	0	0	0	0	0	
Strain through cloth	31.3	6.7	6.3	20.0	5.9	13.3	0	20.0	6.7	0	20.0	0	
Boil	18.8	20.0	6.3	40.0	17.6	13.3	20.0	40.0	26.7	53.3	26.7	66.6	
Water filter	0	0	0	6.7	0	0	0	0	0	0	0	0	
Drinking water covered	100	80.0	100	86.7	100	93.3	93.3	86.7	86.7	73.3	93.3	86.7	0.290
Water dipper clean	81.3	53.3	68.8	60.0	64.7	80.0	73.3	73.3	86.7	80.0	53.3	73.3	0.553

*Significant at the 0.05 level

Table A12. Post-intervention water characteristics among the 12 study villages

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
Drinking Water													0.247
Unprotected surface or well water	0	0	0	0	0	0	0	6.7	0	0	0	0	
Protected well or tanker truck	13.3	0	6.7	0	0	6.7	0	0	6.7	6.7	0	0	
Public tap or tap near yard	86.7	100	93.3	80.0	86.7	93.3	100	80.0	86.7	93.3	80.0	100	
Piped into house or bottled water	0	0	0	13.3	6.7	0	0	13.3	6.7	0	20.0	0	
Missing	0	0	0	6.7	6.7	0	0	0	0	0	0	0	
Other use Water													0.520
Unprotected surface or well water	6.7	0	0	0	0	0	0	0	0	0	0	0	
Protected well or tanker truck	13.3	0	6.7	0	6.7	20.0	0	6.7	6.7	6.7	0	0	
Public tap or tap near yard	80.0	100	86.7	86.7	80.0	80.0	100	80.0	86.7	93.3	93.3	100	
Piped into house or bottled water	0	0	6.7	6.7	6.7	0	0	13.3	6.7	0	6.7	0	
Missing	0	0	0	6.7	6.7	0	0	0	0	0	0		
Water location													0.001
In own dwelling	0	0	0	6.7	6.7	0	0	13.3	6.7	6.7	6.7	0	
In own yard	0	0	0	0	0	0	6.7	33.3	6.7	0	26.7	0	
Same street	100	100	100	86.7	86.7	100	93.7	53.3	66.7	93.3	66.7	100	
Same village	0	0	0	0	0	0	0	0	6.7	0	0	0	
Elsewhere	0	0	0	0	0	0	0	0	13.3	0	0	0	
Missing	0	0	0	6.7	6.7	0	0	0	0	0	0	0	
Time to fetch water													0.174
Less than 10 minutes	66.7	80.0	86.7	66.7	86.7	93.9	100	86.7	86.7	93.3	100	86.7	
More than 10 minutes	33.3	20.0	13.3	26.7	6.7	6.7	0	13.3	13.3	6.7	0	13.3	

Table A12. Continued

	1	2	3	4	5	6	7	8	9	10	11	12	p-value
Who fetches the water?													0.185
Female	93.3	80.0	100	93.3	86.7	93.3	100	100	93.3	93.3	100	100	
Male	0	20.0	0	0	6.7	6.7	0	0	6.7	0	0	0	
Other person	0	0	0	0	0	0	0	0	0	6.7	0	0	
Missing	6.7	0	0	6.7	6.7	0	0	0	0	0	0	0	
Do you do anything to make your water safe?													0.716
Nothing	40.0	33.3	33.3	46.7	26.7	53.3	66.7	33.3	66.7	60.0	40.0	53.3	
Other	6.7	20.0	6.7	0	13.3	6.7	0	13.3	0	0	0	0	
Boil	20.0	20.0	20.0	13.3	20.0	13.3	6.7	33.3	13.3	13.3	13.3	26.7	
Water filter	33.3	26.7	40.0	26.7	33.3	26.7	26.7	33.3	33.3	26.7	33.3	13.3	
Missing	0	0	0	13.3	6.7	0	0	0	0	0	13.3	6.7	
Drinking water covered	86.7	66.7	60.0	60.0	60.0	66.7	46.7	66.7	53.3	60.0	66.7	66.7	0.000*
Water dipper clean	86.7	66.7	46.7	53.3	60.0	60.0	26.7	60.0	40.0	33.3	66.7	53.3	0.000*

*Significant at the 0.05 level

Table A13. Post-intervention water characteristics between the intervention and control groups

	Intervention (n=90)	Control (n=90)	X^2
Drinking Water			0.557
Unprotected surface or well water	0	1.1	
Protected well or tanker truck	4.4	2.2	
Public tap or tap near yard	91.1	90.0	
Piped into house or bottled water	4.4	6.7	
Other use Water			0.431
Unprotected surface or well water	1.1	0	
Protected well or tanker truck	7.8	3.3	
Public tap or tap near yard	86.7	92.2	
Piped into house or bottled water	4.4	4.4	
Water location			0.003*
In own dwelling	3.3	5.6	
In own yard	0	12.2	
Same street	96.7	78.9	
Same village	0	1.1	
Elsewhere	0	2.2	
Time to fetch water			0.028*
Less than 10 minutes	81.1	92.2	
More than 10 minutes	18.9	7.8	
Who fetches the water?			0.194
Female	93.3	97.8	
Male	5.6	1.1	
Other person	0	1.1	
Missing	1.1	0	
Do you do anything to make your water safe?			0.112
Nothing	41.1	53.3	
Other	8.9	2.2	
Boil	17.8	17.8	
Water filter	31.1	23.3	
Missing	1.1	3.3	
Drinking water covered	66.7	58.8	0.001*
Water dipper clean	62.2	46.7	0.000*

***Significant at the 0.05 level**

REFERENCES

1. Robinson, M. C., An epidemic of virus disease in Southern Province, Tanganyika Territory, in 1952-53. I. Clinical features. *Trans R Soc Trop Med Hyg* **1955,** *49* (1), 28-32; Lumsden, W. H., An epidemic of virus disease in Southern Province, Tanganyika Territory, in 1952-53. II. General description and epidemiology. *Trans R Soc Trop Med Hyg* **1955,** *49* (1), 33-57.

2. Shriram, A. N.; Sugunan, A. P.; Manimunda, S. P.; Vijayachari, P., Community-centred approach for the control of Aedes spp. in a peri-urban zone in the Andaman and Nicobar Islands using temephos. *Natl Med J India* **2009,** *22* (3), 116-20; Toledo, M. E.; Vanlerberghe, V.; Baly, A.; Ceballos, E.; Valdes, L.; Searret, M.; Boelaert, M.; van der Stuyft, P., Towards active community participation in dengue vector control: results from action research in Santiago de Cuba, Cuba. *Trans R Soc Trop Med Hyg* **2007,** *101* (1), 56-63; Baly, A.; Toledo, M. E.; Boelaert, M.; Reyes, A.; Vanlerberghe, V.; Ceballos, E.; Carvajal, M.; Maso, R.; La Rosa, M.; Denis, O.; Van der Stuyft, P., Cost effectiveness of Aedes aegypti control programmes: participatory versus vertical. *Trans R Soc Trop Med Hyg* **2007,** *101* (6), 578-86.

3. Krauss, H., *Zoonoses : infectious diseases transmissible from animals to humans*. 3rd ed.; ASM Press: Washington, D.C., 2003; p xvii, 456 p.

4. Angelini, P.; Macini, P.; Finarelli, A. C.; Pol, C.; Venturelli, C.; Bellini, R.; Dottori, M., Chikungunya epidemic outbreak in Emilia-Romagna (Italy) during summer 2007. *Parassitologia* **2008,** *50* (1-2), 97-8.

5. Preechaporn, W., The Larval Ecology of Aedes aegypti and Ae. albopictus in Three Topographical Areas of Souther Thailand. *Dengue Bulletin* **2006,** *30*, 10.

6. World Health Organization., *Dengue haemorrhagic fever : diagnosis, treatment, prevention, and control*. 2nd ed.; World Health Organization: Geneva, 1997; p viii, 84 p.

7. Ng, L. C.; Tan, L. K.; Tan, C. H.; Tan, S. S.; Hapuarachchi, H. C.; Pok, K. Y.; Lai, Y. L.; Lam-Phua, S. G.; Bucht, G.; Lin, R. T.; Leo, Y. S.; Tan, B. H.; Han, H. K.; Ooi, P. L.; James, L.; Khoo, S. P., Entomologic and virologic investigation of Chikungunya, Singapore. *Emerg Infect Dis* **2009,** *15* (8), 1243-9.

8. Gratz, N. G., Critical review of the vector status of Aedes albopictus. *Med Vet Entomol* **2004,** *18* (3), 215-27.

9. Service, M. W., *Mosquito ecology : field sampling methods*. 2nd ed.; Elsevier Applied Science: London ; New York, 1993; p xiii, 988 p.

10. Sang, R. C.; Ahmed, O.; Faye, O.; Kelly, C. L.; Yahaya, A. A.; Mmadi, I.; Toilibou, A.; Sergon, K.; Brown, J.; Agata, N.; Yakouide, A.; Ball, M. D.; Breiman, R. F.; Miller, B. R.; Powers, A. M., Entomologic investigations of a chikungunya virus epidemic in the Union of the Comoros, 2005. *Am J Trop Med Hyg* **2008,** *78* (1), 77-82.

11. Krishnamoorthy, K.; Harichandrakumar, K. T.; Krishna Kumari, A.; Das, L. K., Burden of chikungunya in India: estimates of disability adjusted life years (DALY) lost in 2006 epidemic. *J Vector Borne Dis* **2009,** *46* (1), 26-35; Gopalan, S. S.; Das, A., Household economic impact of an emerging disease in terms of catastrophic out-of-pocket health care expenditure and loss of productivity: investigation of an outbreak of chikungunya in Orissa, India. *J Vector Borne Dis* **2009,** *46* (1), 57-64.

12. Lozano-Fuentes, S.; Elizondo-Quiroga, D.; Farfan-Ale, J. A.; Lorono-Pino, M. A.; Garcia-Rejon, J.; Gomez-Carro, S.; Lira-Zumbardo, V.; Najera-Vazquez, R.; Fernandez-Salas, I.; Calderon-Martinez, J.; Dominguez-Galera, M.; Mis-Avila, P.; Morris, N.; Coleman, M.; Moore, C. G.; Beaty, B. J.; Eisen, L., Use of Google Earth to strengthen public health capacity and facilitate management of vector-borne diseases in resource-poor environments. *Bull World Health Organ* **2008,** *86* (9), 718-25.

13. Chang, A. Y.; Parrales, M. E.; Jimenez, J.; Sobieszczyk, M. E.; Hammer, S. M.; Copenhaver, D. J.; Kulkarni, R. P., Combining Google Earth and GIS mapping technologies in a dengue surveillance system for developing countries. *Int J Health Geogr* **2009,** *8*, 49.

14. Raude, J.; Setbon, M., The role of environmental and individual factors in the social epidemiology of chikungunya disease on Mayotte Island. *Health Place* **2009,** *15* (3), 659-69; Sissoko, D.; Moendandze, A.; Malvy, D.; Giry, C.; Ezzedine, K.; Solet, J. L.; Pierre, V., Seroprevalence and risk factors of chikungunya virus infection in Mayotte, Indian Ocean, 2005-2006: a population-based survey. *PLoS One* **2008,** *3* (8), e3066.

15. Feinstein, J. S., The relationship between socioeconomic status and health: a review of the literature. *Milbank Q* **1993,** *71* (2), 279-322; Krieger, N.; Williams, D. R.; Moss, N. E., Measuring social class in US public health research: concepts, methodologies, and guidelines. *Annu Rev Public Health* **1997,** *18*, 341-78.

16. Galobardes, B.; Shaw, M.; Lawlor, D. A.; Davey Smith, G.; Lynch, J., Indicators of socioeconomic position. In *Methods in social epidemiology*, 1st ed.; Jossey-Bass: San Francisco, CA, 2006; pp xxv, 478 p.

17. Wolff, E. N.; Twentieth Century Fund., *Top heavy : a study of the increasing inequality of wealth in America*. Twentieth Century Fund Press: New York, 1995; p vi, 93 p.

18. (MORD), M. o. R. D., Report of the Expert Group to advise the Ministry of Rural Development on the methodology for conducting the Below Poverty Line (BPL) Census for 11th Five Year Plan. Ministry of Rural Development, G. o. I., Ed. New Delhi, 2009.

19. Shahrawat, R.; Rao, K. D., Insured yet vulnerable: out-of-pocket payments and India's poor. *Health Policy Plan* **2011**.

20. Mukherjee, S.; Haddad, S.; Narayana, D., Social class related inequalities in household health expenditure and economic burden: evidence from Kerala, south India. *Int J Equity Health* **2011,** *10* (1), 1.

21. Po, J. Y.; Subramanian, S. V., Mortality burden and socioeconomic status in India. *PLoS One* **2011,** *6* (2), e16844.

22. Balarajan, Y.; Selvaraj, S.; Subramanian, S. V., Health care and equity in India. *Lancet* **2011,** *377* (9764), 505-15.

23. Tiwari, S. C.; Kumar, A., Development & standardization of a scale to measure socio-economic status in urban & rural communities in India. *Indian J Med Res* **2005,** *122* (4), 309-14.

24. Gupta, R. N., A scale to measure socio-economic status in urban & rural communities in India. *Indian J Med Res* **2005,** *122* (4), 288-9.

25. Valente, T. W., *Evaluating health promotion programs*. Oxford University Press: New York, 2002; p xviii, 305 p.

26. McIver, S. B., Host preferences and discrimination by the mosquitoes Aedes aegypti and Culex tarsali (Diptera: Culicidae). *J Med Entomol* **1968,** *5* (4), 422-8.

27. Steib, B. M.; Geier, M.; Boeckh, J., The effect of lactic acid on odour-related host preference of yellow fever mosquitoes. *Chem Senses* **2001,** *26* (5), 523-8; Scott, T. W.; Chow, E.; Strickman, D.; Kittayapong, P.; Wirtz, R. A.; Lorenz, L. H.; Edman, J. D., Blood-feeding patterns of Aedes aegypti (Diptera: Culicidae) collected in a rural Thai village. *J Med Entomol* **1993,** *30* (5), 922-7.

28. Adaikalam, F., District-wise study Plan for Housing in the Districts of Sivagangai and Pudukottai, Tamil Nadu. (RESSO), R. E. S. S. O., Ed. Tirumayam, Pudukkottai District, Tamilnadu, 2009.

29. Hatcher, L.; Stepanski, E., *A Step-by-Step Approach to Using SAS for Factor Analysis and Structural Equation Modeling*. SAS Publishing: 1994; p 608.

30. Pett, M. A.; Lackey, N. R.; Sullivan, J. J., *Making sense of factor analysis : the use of factor analysis for instrument development in health care research*. Sage Pub.: Thousand Oaks, Calif., 2003; p xvi, 348 p.

31. Kolenikov, S.; Angeles, G., The Use of Discrete Data in PCA: Theory, Simulations, and Application to Socioeconomic Indices. In *MEASURE/Evaluation project*, Carolina Population Center, University of North Carolina: Chapel Hill, 2004.

32. Filmer, D.; Pritchett, L. H., Estimating wealth effects without expenditure data--or tears: an application to educational enrollments in states of India. *Demography* **2001,** *38* (1), 115-32.

33. Marmot, M. G.; Kogevinas, M.; Elston, M. A., Social/economic status and disease. *Annu Rev Public Health* **1987,** *8*, 111-35.

34. Kaiser, H. F., The Varimax Criterion for Analytic Rotation in Factor Analysis. *Psychometrika* **1958,** *23* (3), 187-200.

35. Ramanujam, C.; Selvam, J.; Ramasamy, R., Developmental Indicators at District Level in Tamil Nadu. Centre, P. R., Ed. The Gandhigram Institute of Rural Health and Family Welfare Trust: Ambathurai.

36. Reproductive and Child Health: Dristrict Level Household Survey Tamil Nadu 2002-04. Welfare, M. o. H. F., Ed. 2004.

37. Sciences, I. I. f. P., District Level Household and Facility Survey, 2007-08 Tamil Nadu. IIPS: Mumbai, 2010.

38. Gopalakrishnan, S., Tamil Nadu Houses Household Amenities and Assets: All Indicators. Operations, D. o. C., Ed. Government of India: 2011.

39. Desai, S., *Human development in India : challenges for a society in transition*. Oxford University Press: Oxford ; New York, 2010; p xxii, 234 p.

40. Desai, S.; Vanneman, R.; National Council of Applied Economic Research, N. D.; Health, U. S. D. o. H. a. H. S. N. I. o., Indian Human Development Survey (IHDS), 2005.
Inter-university Consortium for Political and Social Research (ICPSR): 2010; Vol. 22626.

41. Jolliffe, I. T., *Principal component analysis*. 2nd ed.; Springer: New York, 2002; p xxix, 487 p.

42. Cattell, R. B., The Scree Test For The Number Of Factors. *Multivariate Behavioral Research* **1966,** *1* (2), 245-276.

43. Nkonki, L. L.; Chopra, M.; Doherty, T. M.; Jackson, D.; Robberstad, B., Explaining household socio-economic related child health inequalities using multiple methods in three diverse settings in South Africa. *Int J Equity Health* **2011,** *10*, 13.

44. Kaiser, H. F., The application of electronic computers to factor analysis. *Educational and Psychological Measurement* **1960,** *20*, 141-51.

45. Cronbach, L. J., My Current Thoughts on Coefficient Alpha and Successor Procedures. *Educational and Psychological Measurement* **2004,** *64* (3), 391-418; Wallis, A. B.; Brinzaniuc, A.; Chereches, R.; Oprescu, F.; Sirlincan, E.; David, I.; Dirle, I. A.; Dungy, C. I., Reliability and validity of the Romanian version of a scale to measure infant feeding attitudes and knowledge. *Acta Paediatr* **2008,** *97* (9), 1194-9.

46. Merrill, R. M., *Introduction to Epidemiology*. 5th ed.; Jones and Bartlett Publishers, LLC: 2010.

47. India, G. o., The Constitution of India. Justice, M. o. L. a., Ed.

48. Pham, H. V.; Doan, H. T.; Phan, T. T.; Minh, N. N., Ecological factors associated with dengue fever in a Central Highlands province, Vietnam. *BMC Infect Dis* **2011,** *11*, 172.

49. Malvy, D.; Ezzedine, K.; Mamani-Matsuda, M.; Autran, B.; Tolou, H.; Receveur, M. C.; Pistone, T.; Rambert, J.; Moynet, D.; Mossalayi, D., Destructive arthritis in a patient with chikungunya virus infection with persistent specific IgM antibodies. *BMC Infect Dis* **2009,** *9*, 200.

50. Hemme, R. R.; Thomas, C. L.; Chadee, D. D.; Severson, D. W., Influence of urban landscapes on population dynamics in a short-distance migrant mosquito: evidence for the dengue vector Aedes aegypti. *PLoS Negl Trop Dis* **2010,** *4* (3), e634.