2 Effect of a Community Health Volunteer Led Mobile Phone Technology in Public Health Surveillance of Bed Bug Infestation among Households in Nakuru County; Kenya

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Abstract

Globally there has been a resurgence of bed bug infestation after decades of suppression using modern pesticides such as pyrethroids. The dramatic rise in bed bug infestation has been reported in Canada, USA, Australia and Africa causing panic and significant public attention. Bed bug is widely found in temperate and in sub-tropical countries and is broadly distributed in regions north and south of the equator. Bed bug infestation is shallowly studied and thus limited information regarding the parasite especially in developing countries such as Kenya. The objective of this study was to establish effect of a Community Health Volunteer (CHV) led mobile phone intervention in Public Health Surveillance of bed bug Infestation among households in Nakuru County. The study deign was a quasi-experiment conducted in intervention and control sites. Flamingo and Kivumbini wards where intervention sites while Menengai and Kiratina were control sites respectively. Sample size for intervention and control sites were354 and 362 households respectively. Purposive and systematic sampling methods were used to identify the study participants. Ethical approval will be sought from Mt. Kenya University Ethical approval board and the National Council of Science and Technology (NACOSTI). At baseline, crude and adjusted Odds Ratios indicated that there was no significant difference in public health surveillance of bedbugs [Crude OR=1.005, 95% CI=0.812-1.244, P>0.05)] and [(Adj. OR=1.41995%CI=0.797-2.524, P>0.05)]. However, in the end term survey, both crude and adjusted ORs indicated a significance difference in public health surveillance of bed bugs in intervention site compared to control site. Crude OR. =0. 339, 95% CI: 0.184-0.623; P<0.05)], and adjusted OR=1.621, 95%CI: 1.064-2.468)]. The Community Health worker Mobile led Intervention increased the probability of bedbug detection and reporting (Surveillance) by 62% in the intervention site. The community health worker based mobile application is effective in carrying out public health surveillance of bedbugs. The ministry of health should adopt such technologies and scale up to entire Country to help in controlling the menace caused by bedbugs in Kenya.

Keywords: Public health surveillance, bed bugs, CHV, mobile phones

Introduction

Globally there has been a resurgence of bed bug infestation after decades of suppression using modern pesticides such as pyrethroids (Hwang *et al.*, 2005). The dramatic rise in bed bug infestation has been reported in Canada, USA, Australia and Africa causing panic and significant public attention (Wang & Wen, 2011). The current resurgence of bed bug infestation has been linked to changes in pest control strategies, international travel, stigma associated with reporting bed bug infestation and presence of insecticide resistance bed bug strains (Doggett *et al*., 2004). However in some countries there have been no resurgence of bed bug infestations and the reasons for the hampered resurgence are still not clear (Wang & Wen, 2011).

Bed bug is widely found in temperate and in sub-tropical countries and is broadly distributed in regions north and south of the equator. The temperate conditions facilitate biological functioning as well as normal development of the bed bugs (WHO, 2008). Before the invention of insecticides such as DDT bed bug infestation was rampant and was regarded as a nuisance pest, their elimination was difficult and treatments used were harazadous to the people (Pooter, 2008)

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The prevalence of bed bug infestation is estimated to be about 33% in London (Pooter, 2008). In Australia a 45% increase in bed bug infestation was reported in 2006 (Doggett *et al*., 2011). Additionally in the USA bed bug infestation was reported in all the 50 states of America. For instance in New York city the bed bug complaints to the local authorities rose from 537 in 2004 to 10, 985 in 2009. In Africa bed bug infestation is still a big menace. In Nigeria the prevalence of bed bug infestation in homes and school hostels is about 50% (OKwa & Omoniyi, 2008). Similarly in Sierra Leone the prevalence of bed bug infestation in internally displaced camps is about 98% (Gbakima *et al*., 2002). There is still limited research regarding bed bug infestation in Africa.

In Kenya about 4000 homes in Nakuru County were found to be infested by bed bugs. Furthermore by 2017, seven estates in Nakuru County were reported to be suffering from bed bug infestation with about 5000 households being affected. Additionally there are other more cases of bed bug infestation in Kenya but they are not well reported.

Several strategies have been put in place to suppress the bed bug infestation. Some of these strategies include use of active monitors, visual inspection, passive monitors and trained canines (Buczkowski & Gibb, 2015). Chemicals such as pyrethroids are also widely used in the control of bed bug infestation. Use of Mobile phone technology coupled with Community health Volunteers led interventions have not yet been fully implemented in the reporting and control of bed bug resurgence and infestation. This study aimed at establishing the effectiveness of Community Health Volunteers led mobile phone technological intervention on reporting and the control of bed bug infestation in Nakuru County.

Null Hypothesis: *There is no difference in detecting and reporting (surveillance) of bed bags in intervention site compared to control site.*

Methodology

Study Area

This study was conducted in two wards in Nakuru County. Flamingo/Kivumbini ward was the intervention site while Menengai/Kiratina was the control site.

Study Design

This was a quasi-experiment with one pretest and one post-test survey in both intervention and control sites.

Key Elements of CHV led Mobile Application Intervention

The following were the key elements of the CHV led mobile application for Surveillance and Control of bedbugs;

i. Development and testing of a mobile application to help in reporting detected bedbugs at household level
ii. Procuring mobile phones for use in the project
iii. Procurement of pesticides for control of bedbugs
iv. Identifying and training CHVs on the following;
    a) Visual detection of bedbugs.
    b) Reporting of households in which bedbugs have been detected.
    c) Use of pesticides in the control of detected bedbugs.

Variables in the Study

The Quasi-independent variable was the CHV led Mobile application Intervention. The dependent variables in the experiment were bedbug detection and reporting (surveillance).

Study Population

The study population was households in Nakuru County. The Study target population was households in Menengai/Kiratina (control) and Kivumbini/Flamingo wards (intervention site).

Inclusion Criteria

All household heads from the study area that showed willingness to participate in the study by signing the informed consent were included as participants in this study.

Exclusion Criteria

Any household head in the study area that were not willing or not able to participate in the study were excluded from taking part in this study.

Sample Size Determination

The total number of households in Kivumbini/Flamigo and Menengai/Kiratina were 4600 and 6400respectively. Samples were therefore determined by using a formula used by fisher *et al.,* 1998 formula. The following is the adopted formula as used by (Fisher A.A, Laing J.E, Stoeckel J.E., 1998)

The formula is as follows;

$$n = \frac{Z^2pq}{d^2}$$

Where; n = is the desired sample size (when the study target population is over 10,000)

Z - is the standard normal deviate=1.96. (Corresponding to 95% Confidence Interval)

p - Proportion of the target population estimated to have the desired characteristics.

$q = 1.0 - p$

d= Degree of accuracy required usually set as 0.05

p= 50/100 or 0.50

$q = 1 - p = 1 - 0.50 = 0.50$

Hence, the desired sample size (***n***) has been calculated as follows.

$$n = \frac{Z^2pq}{d^2} = \frac{1.96^2 \times 0.50 \times 0.50}{(0.05)^2}$$

$$n = \frac{0.9604}{0.0025}$$

n= 384.16 which is approximately 384.

Now that the total population (N) is less than 10,000 in both intervention and control sites Fisher et al 1998 proposes application of a second formula to further make the sample size representative;

$N_f = n/1+(n/N)$

Where $\mathbf{N_f}$= the desired sample size (when population is less than **10,000**)

n =. the desired sample size (when the population is more than 10,000).

N = the estimate of the population size (in this case we have used 6400

Sample size for intervention siteN_f=384/1(384/4600 households) = 354 households

Sample size for control site N_f=384/1(384/6400) = 362 households

Sample size for intervention and control sites were **354** and **362** households respectively.

Sampling Procedures

Purposive and systematic sampling methods were used. Purposive sampling was used to identify the intervention and control sites. Purposive sampling was also be used to sample sub-county public health officers to collect data on detection and reporting of bed bugs by CHVs. Systematic sampling was used to identify the households in the study sample.

Data Collection Tools

Data was collected using a structured questionnaire and an Observation checklist and a mobile phone application.

Piloting of the Study Tools

The study was piloted at Kaptembwa ward before implementation of the study. Piloting data will be subjected to Cronbach Alpha to test whether the coefficient of reliability is within the recommended limits.

Data Management, Analysis and Presentation

Data was managed using SPSS version 20. Proportions, measures of central tendency, Chi square tests and Odds ratios will be used to analyze data. Difference in Differences, and regression analysis were used to test study hypotheses. Appropriate tables and graphs were used for data presentation.

Research Ethical Considerations

Research ethical approval was sought from Mount Kenya University Ethics and Research Committee (ERC). Research permits were issued by NACOSTI and County Government of Nakuru.

Findings

Socio Demographic Characteristics of Respondents

In the baseline survey majority of the respondents in the control and intervention sites were aged 31-35 years while the least were aged 41- 45 years. In the end term survey a majority of the respondents in the control and intervention sites were aged 31-35 years and 26-30 years respectively while the least in the control and intervention sites were aged 41-45 years. Baseline survey data showed that over half and over a third of the respondents in the control and intervention site respectively had attained secondary school education. Similarly end term survey data showed that a most of respondents in both control and intervention sites had secondary school education. Data from baseline and end term survey showed that over two thirds of respondents in the control and intervention sites were married. In the baseline survey most of the households had four members in both the control and intervention site while the least had one member in both sites. Data from the baseline survey showed that over half and half of the respondents were peasant farmers in the control and intervention site respectively. Similarly, in the end term survey close to two thirds and more than half of the respondents in the control and intervention sites respectively were peasant farmers.

Proportion of Households Infested with Bed Bugs in Nakuru County

Baseline data showed that over three quarters of the households in control and intervention sites had bed bug infestation. However, end term survey revealed that most of the households in the intervention site (over two thirds of the households) had no bed bug infestation compared to control site which reported that over two thirds of households were invested with bedbugs. The following figures represent a summary of the findings.

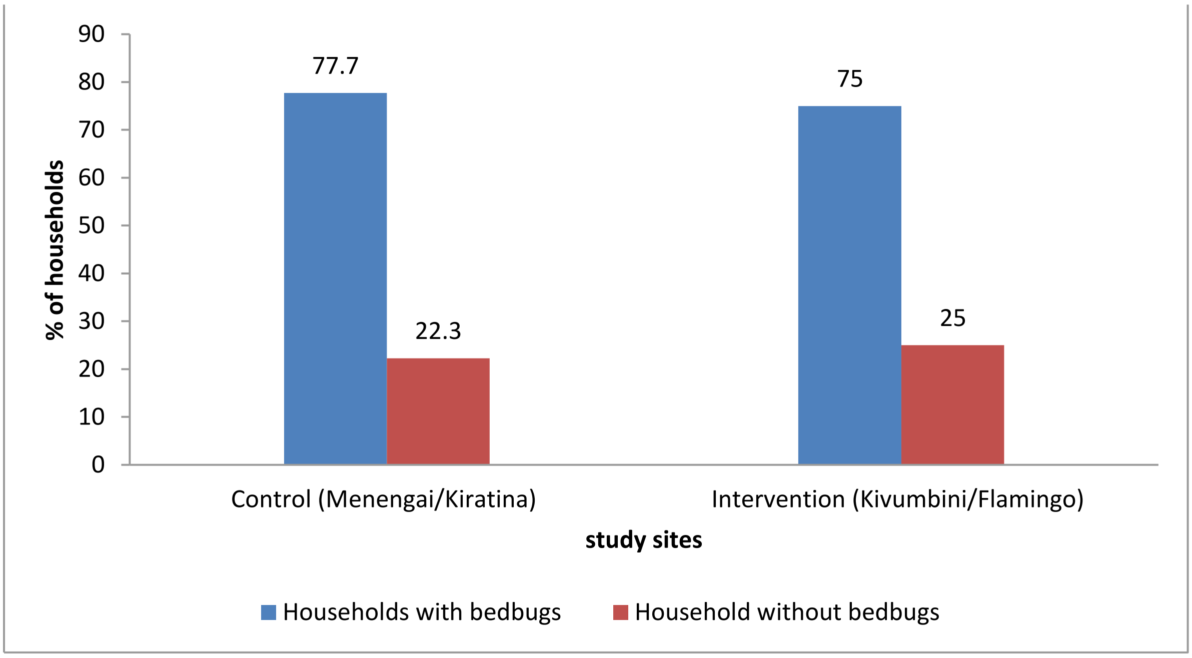

Figure 1: Proportion of bed bug infestation in control and intervention site at baseline

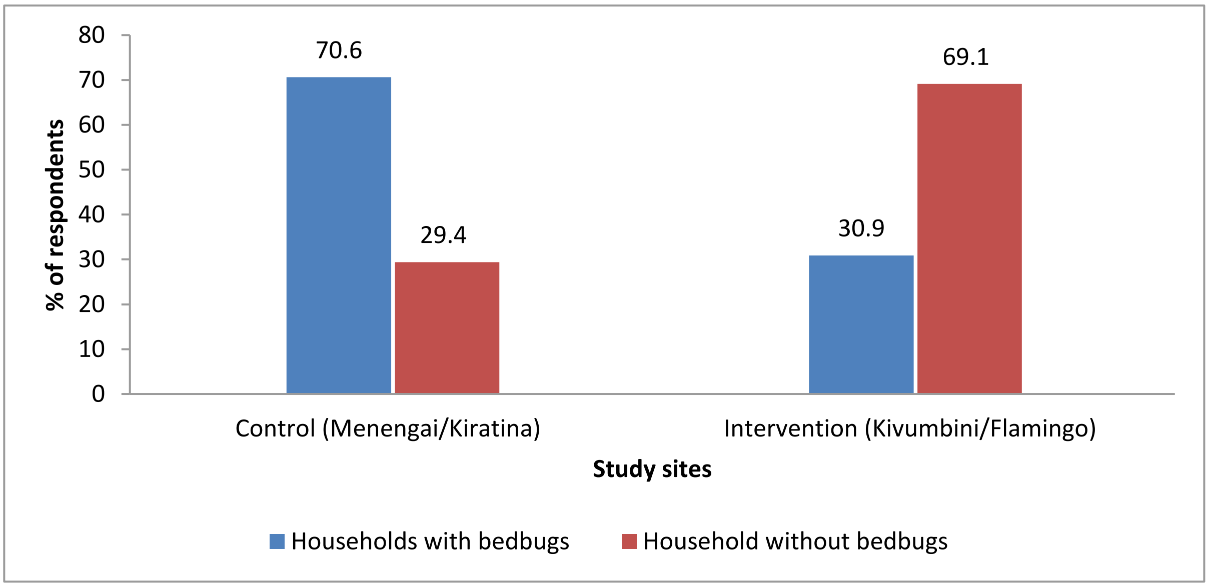

Figure 2: Proportion of bed bug infestation in control and intervention site at end term

Effect of CHV Mobile Phone Technology in Reporting of Be Bug Infestation to Public Health Officers

At baseline, there was no significant difference in means of households who had reported bed bug infestation to the public health authority between the control and intervention site (t= -0.518, P<0.05). However, end term data shows that there was significance difference in means of households who had reported of bedbug infestation to the public health authority between the control and intervention site (t= -5.8, P < 0.05). These data is summarized in the following table;

Table 1

Student T Test for Detection and Reporting of Bed Bug Infestation to Public Health Officers in Intervention Versus Control Site at End Term

Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (-2 tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Household head Reporting	Equal variances assumed	151.936	.000	-5.800	805	.000*	-.150	.026	-.201	-.099
Bedbugs To local Public Health Officers	Equal Variances not assumed			-5.792	705.438	.000	-.150	.026	-.201	-.099

Odds of Detecting and Reporting Bedbugs to Public Health Authorities between Intervention and Control Sites

Crude odd ratios showed that there was significant differense in end term survey in detecting and reporting of bed bugs infestation to public health authorities between the control and intervention site [(OR = 0.339, 95% CI = 0.184 – 0.623, P<0.05)]. These data is summarized in the following table.

Table 2

Crude odds Ratios for reporting of Bed Bug Infestation to Public Health Authorities Comparing Intervention and Control

Variables in the Equation

			B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
End term Survey	Step 1[a]	Reporting Bed bugs	-1.083	.311	12.109	1	**.001***	**.339**	**.184**	**.623**
		Constant	1.952	.634	9.469	1	.002	7.043		
Baseline Survey	Step 1[a]	Reporting Bedbugs infestation	-.091	.164	.308	1	.579	.913	.663	1.258
		Constant	-.140	.379	.137	1	.711	.869		

After adjusting for potential confounders at baseline there was no significant difference in reporting of bed bug infestation to public health authorities between control and intervention sites while at end term survey there was significance difference in reporting of bed bug infestation to public health authorities between the control and intervention site (OR = 0.790, 95% CI = 0.458- 1.364, P<0.05). However, at the end term survey households in the intervention site were 1.6 times more likely to report bed bug infestation to public health authorities as compared to households in the control site (OR = 1.62, 95% CI = 1.064 – 2.468, P < 0.005). These data is summarized in the following table.

The key highlights in the data shows that at baseline, there was no significant difference in the mean of households that visually detected and reported bedbugs as indicated by the student T tests, (t=0.363, P>0.05) and (t=0.518, P>0.05) respectively. Crude and Adjusted Odds ratios also indicated that there was no significant difference in houses that visually detected and reported bedbugs (Crude OR=1.005, 95% CI=0.812-1.244, P>0.05) and (Adj. OR=1.41995%CI=0.797-2.524, P>0.05). However in the end term survey, student T tests indicated that there was a significant difference in the means of households that had visually detected bedbugs and reported the same to public health officials; t test statistic where (t= 8.774, P<0.05) and (t=5.800, P<0.05) respectively. This was further confirmed by both crude and adjusted ORs that indicated a significance difference in public health surveillance of bed bugs in intervention site compared to control site. Crude OR. =0. 339, 95% CI: 0.184-0.623; P<0.05)], and adjusted OR=1.621, 95%CI: 1.064-2.468)].

This data indicates that the intervention site households were 62% more likely to detect and report bedbugs compared to the control site. 62% has been derived from subtracting 0.341 or 0.339 Odds Ratios from 100% which are Adjusted ORs of reporting and detection respectively) because both the lower and upper end of the 95% CIs are less than 1). This gives an estimate of 62% increment. In the context of this research surveillance of bedbugs was measured using visual detection of bedbugs and reporting using the community led mobile based application intervention. Therefore, based on the observations in this data, it is plausible then to argue that the community led mobile app intervention increased bedbug surveillance by 62% in the intervention site as compared to control site.

Globally, this is perhaps the first mobile application that has been employed to help in the control of bed bugs. This is based on the fact that there is absolutely no study in either the grey internet literature or online published journals available for review and comparison. It is even more unique by the fact that it integrates Community Health Volunteers to carry out surveillance and control bed bugs using the mobile application. This notwithstanding studies done in USA have documented the employment of a surveillance system which incorporates the use of a non-emergency city service system through which complains are aired and a periodic inspection program done (Sutherland *et al.,* 2020). Additionally in a study done in Canada have reported on the use of heat rooms to eradicate bedbugs (Comack & Lyons, 2011).

Conclusion and Recommendations

Data indicated a significant difference in the mean of households visually detecting and reporting bedbugs in intervention site compared to control site. The Community Health worker Mobile led Intervention increased the probability of bedbug detection and reporting (Surveillance) by 62% in the intervention site. The community health worker based mobile application has showed that it is effective in carrying out bedbug surveillance and control. The ministry of health should adopt such technologies and scale up to entire Country to help in controlling the menace caused by bed bugs in the country.

References

Bennet, G. W., Gondhalekar, A. D., Wang, C., Buezkowski, G., & Gibb, T. J. (2015). Using research and education to implement practical bed bug control programs in multifamily housing. https://doi.org/10.1002/ps.4084

Comack, E., & Lyons, J. (2011). *What Happens When the Bed Bugs Do Bite ? The Social Impacts of a Bed Bug Infestation on Winnipeg ' s Inner-City Residents* (Issue June).

Doggett, S. L., Geary, M. J., & Russell, R. C. (2004). *The Resurgence of Bed Bugs in Australia : With Notes on Their Ecology and Control*. *4*(2), 30–38.

Doggett, S. L., Orton, C. J., Lilly, D. G., Russell, R. C., Hospital, W., Wales, S., Division, P. E., & Hill, C. (2011). *Bed Bugs : The Australian Response*. 96–111. https://doi.org/10.3390/insects2020096

Fisher A.A, Laing J.E, Stoeckel J.E., T. J. W. (1998). *Handbook for Family Planning Operations Research* (Second Edi). Population Council.

Gbakima, A., Terry, B. C., Kanja, F., Kortequee, S., Dukuley, I., & Sahr, F. (2002). High prevalence of bedbugs Cimex hemipterus and Cimex lectularis in camps for internally displaced persons in Freetown, Sierra Leone: a pilot humanitarian investigation. *West African Journal of Medicine*, *21*(4), 268–271.

Hwang, S. W., Svoboda, T. J., Jong, I. J. De, Kabasele, K. J., & Gogosis, E. (2005). *Bed Bug Infestations in an Urban Environment*. *11*(4), 533–538.

OKwa, O., & Omoniyi, O. A. (2008). The prevalence of headlice (Pediculus humanus capitis) and bedbug (Cimex hemipterus) in selected human settlement areas in southwest Lagos state, Nigeria. *Journal of Parasitology and Vector Biology*, *2*(2), 8–13.

Pooter, M. F. (2008). The history of bed bug management: lessons from the past. *Pest Control Technology*, *36*, 12–36.

Sutherland, C., Greenlee, A. J., & Schneider, D. (2020). Socioeconomic drivers of urban pest prevalence. *People and Nature*, *June*. https://doi.org/10.1002/pan3.10096

Wang, C., & Wen, X. (2011). *Bed Bug Infestations and Control Practices in China: Implications for Fighting the Global Bed Bug Resurgence*. 83–95. https://doi.org/10.3390/insects2020083

WHO. (2008). *Public health significance of urban pests*.Geneva, WHO