Knowledge, Risk Factors and Practices about Bed bugs in Rural Eastern Tanzania

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Abstract

Background: Evidence-based strategies are needed to counter the increasing problem of bed bug infestations. We assessed community knowledge, risk factors and practices on bed bugs because they are essential for enhancing community commitment to control efforts. Methods: We conducted a descriptive social survey using structured questionnaire and direct observations in selected villages of Morogoro Rural District, Eastern Tanzania. Results: Total of 260 respondents participated, 53.08% (138/260) females and 46.92% (122/260) males; and majority had primary education (68%, 177/260). Majority were aware of at least one control measure against bed bugs including chemical insecticides, washing bedclothes and sunlight. Insecticides were considered the most powerful measure (Mkuyuni 81.82%, 27/33; Mfumbwe 44.82%, 26/58; Changa 34.91%, 59/169). Majority were able to identify bed bugs (Mfumbwe 87.93%, 51/58, Changa 63.31%, 107/169; Mkuyuni 51.52%, 17/33). Over 95% of respondents were aware that bed bugs reproduce by laying eggs and could identify them. Considerable proportion was aware of certain effects of bed bugs (Mkuyuni 75.76%, 25/33; Changa 53.87%, 91/169; Mfumbwe 46.55%, 27/58). Over 60% (156/260) of households presented several risk features and main ones were cracks on walls (85.75%, 223/260) and floors (92.50%, 241/260), not sleeping on beds (88.09%, 229/260), dusty floors (92.05%, 239/260) and hiding spaces on beds (71.25%, 185/260). Households controlling bed bugs ranged from 41.38% to 45.45%, with up to 100% of those using insecticides. Majority indicated controlling other household pests (Changa 69.23%, 117/169; Mfumbwe 63.79%, 37/58; Mkuyuni 63.64%, 21/33) mainly through insecticides and improved sanitation. The frequency of applying insecticides varied significantly; up to 67.52% of respondents reported periods >1 and ≤4 years. Conclusions: Majority of households in the study communities are in high risk of bed bug infestation. Over 60% of them presented multiple risk features and main ones were cracks on walls/floors, dusty floors, not sleeping on beds, and hiding spaces on beds. Insecticides were the most commonly known/used control measure. Insecticide applications were done without professional guidance and on irregular frequencies thus exposing study communities to high risk of insecticide resistance.

Introduction

Bed bugs are cosmopolitan blood-feeding insects belonging to the order Hemiptera and family Cimicidae. Tens of nuisance bed bug species have been described so far. However, *Cimex lectularius* and *C. hemipterus* are the most prolific and widely distributed species. The two species are most commonly encountered in temperate and tropical climates respectively [1]. Identification of the two and other bed bug species is confirmed using molecular techniques [2].

Female and male bed bugs are both hematophagous and can live for 12 months or more without feeding. Males prefer mating recently fed females and they undergo 5 traumatic inseminations per feeding [3]. A single female produces 200 – 500 eggs in her lifetime. Bed bugs fear light and are generally active in the dark. Because of that they prefer hiding and undisturbed places like bedclothes, mattresses, springs, bed frames, cracks and crevices on inner walls of houses. They emit an easily recognized, offensive odor

caused by an oily secretion produced by special glands [3,4]. Rapid infestations has been observed in schools, prisons, universities, hotels, hospitals, barracks and related premises mostly due to unsanitary conditions, human population movements and crowding [5,6].

Eradication of bed bugs from infested sites and/or facilities is often challenging. Their successful control is largely dictated by good cooperation between the owners of infested premises and the pest control managers. Such cooperation enables thorough inspection, identification, and eventual eradication of the bed bugs [1]. The control of bed bugs relies almost exclusively on chemical insecticides. Complementary control measures include use of traps in highly infested premises and improvement of general sanitation. Insecticide applications which are done most frequently non-professionals, do not penetrate deeply into bedbug hiding places therefore fail to provide desirable residual protection, and can pose an immediate health risk to the user. The most advocated approach is the use of residual insecticides applied by professional personnel throughout the hiding harborages/habitats, identified well in advance [7,8].

The interaction of bed bugs with humans poses a public health challenge due to their characteristic and continuous biting and blood feeding ability [9]. Frequent bites by bed bugs cause allergy, sleeplessness, insomnia, stigmatization and can in extremes lead to iron deficiencies in infants [5, 10-12]. Furthermore, household dust containing bed bug feces and moulted shells triggers asthma attacks in sensitized individuals [13,14]. Bed bugs have been associated with over 28 human disease causing pathogens/parasites; however, there is no substantial evidence on whether or not they can transmit them to humans [10,15,16]. Nevertheless, such possibilities should not be overlooked under the milieu of climate and anthropogenic changes, which are increasingly reported to influence the transmission landscape of many infectious disease pathogens/parasites.

The global population of bed bugs has significantly resurged in many parts of the world since the late 1990s; likely due to increased mobility, trade, and insecticide resistance [17]. The population is estimated to be increasing by 100 – 500 % annually [17]. Bed bug populations throughout the world, including Tanzania, are increasingly becoming resistant to all insecticide classes particularly pyrethroids [17]. The resurge of bed bugs population is correspondingly expected to increase associated health and socio-economic problems, thus calling for more control efforts in all endemic countries.

To ensure timely, effective and sustainable control of bed bugs, vulnerable and affected communities must participate and own the control efforts and strategies. Such endeavor is dictated by communities' attitude, practices and knowledge about fundamental aspects of bed bugs including risk features/factors which predispose households and other premises to high infestations. In the present study we assessed level of knowledge, risk factors and practices towards bed bugs in randomly selected villages of rural Eastern Tanzania.

Materials And Methods

Study area

Morogoro region lies between 5°58’ and 10°00’ South and 35°25’ and 38°30’ East. The climate translates into a bimodal rainfall distribution, which is characterized by two rainfall peaks and a dry spell separating the short rains. The short rains run from October – December; and the long rains run from March – May. The area receives average rainfall of between 800 and 1,000 mm annually. The highest annual rainfall is mainly experienced in high altitudes of the eastern slopes of the Uluguru Mountains. The temperature ranges between 18°C and 25°C. However, the moderate temperature of around 25°C is experienced in most of the year. The hottest (32°C) month is February. The study was conducted in 3 randomly selected villages within Mkuyuni ward in the Morogoro Rural District: Mfumbwe, Mkuyuni and Changa. Most households registered complaints on high prevalence of bed bugs during our previous studies on malaria.

Study design and data collection

This was a descriptive social survey done by means of structured questionnaire and personal observations. The survey was done by a team of trained field workers and young graduates. The questionnaire contained a set of questions with the aim of gathering information on demographic characteristics, knowledge (identification of bed bugs and eggs, control measures, mode of reproduction), predisposing/risk factors (e.g. presence of cracks on walls and floor, poor sanitation, keeping animals inside living room) and control practices (e.g. control measures, frequency of application) in relation to bedbugs. The questionnaire and direct observations were administered in 260 households over 4-week time between February and April 2020. The head of household or any other responsible adult was interviewed; and only one person per household was interviewed. All respondents gave verbal consent before participation in this study. Direct observations were mainly done to assess structures/features inside houses that predispose the houses to bed bug infestation, and confirm evidences associated with certain responses from participants. The data were double entered in Excel database and descriptively analyzed using SPSS version 10.

Results

Socio-demographic characteristics

A total of 260 respondents were surveyed across the study sites from February – March 2020; 53.08% (138/260) females and 46.92% (122/260) males. Most respondents aged between 20 – 44 years (63.08%, 164/260) and had primary level education (68%, 177/260). About 24.23% (63/269) had formal education. The results are summarized in Table 1.

Knowledge on bed bugs

Most respondents were aware of at least one control measure, which can be used against bed bugs. The control measures included insecticides, washing bedclothes and sunlight. Majority of the respondents were aware of insecticides as the main control measure against bed bugs except in Changa (Mkuyuni

81.82%, 27/33; Mfumbwe 44.82%, 26/58; Changa 34.91%, 59/169) followed by sunlight (Changa 51.47%, 87/169; Mfumbwe 43.11%, 25/58; Mkuyuni 18.18%, 6/33) and washing bedclothes (Mfumbwe 12.07%, 7/58; Changa 4.73%, 8/169; none in Mkuyuni; P <0.001). More than 45% of respondents across the study villages knew how to control bed bugs, and that was significantly higher in Mkuyuni 81.82% (27/33) and Changa 74.56% (126/169) as compared to Mfumbwe 44.83% (27/58) (P <0.001). Most respondents were able to describe and identify bed bugs; with significantly high proportion recorded in Mfumbwe (87.93%, 51/58) relative to Changa (63.31%, 107/169) and Mkuyuni (51.52%, 17/33). Importantly, over 98% of the respondents across the study villages were aware that bed bugs reproduce by laying eggs; and up to 97.17% were able to describe and identify their eggs. The trend of these responses was equally the same across the three study villages. Moreover, considerable proportion of respondents was aware of the effect of bed bugs; with the highest proportion recorded at Mkuyuni 75.76% (25/33) compared with Changa 53.87% (91/169) and Mfumbwe 46.55% (27/58) (P <0.001). The results are summarized in Table 2.

Risk factors for bed bug infestation

The commonly encountered risk factors throughout the three study villages were cracks on walls (85.75%, 223/260), cracks on floors (92.50%, 241/260), not sleeping on beds (88.09%, 229/260), dusty floors (92.05%, 239/260), hiding spaces on beds (71.25%, 185/260) and keeping chicken inside living houses (62.58%, 163/260). More than 60% (156/260) of the households had all six different risk factors (Figure 2).

Bed bugs control practices

Respondents who reported controlling bed bugs in their households ranged from 41.38% to 45.45%. The remaining respondents indicated that they had stopped controlling bed bugs because their previous control efforts had not shown convincing outcome. All respondents (100%) controlling bed bugs in Changa and Mkuyuni village were using chemical insecticides. For Mfumbwe village, 82.75% (48/58) and 17.24% (10/58) were using chemical insecticides and hot water respectively. Therefore, chemical insecticides were the most commonly used bed bugs control measure (P <0.001). Most respondents indicated that they were also controlling household pests other than bed bugs and the proportion was similar throughout (Changa 69.23%, 117/169; Mfumbwe 63.79%, 37/58; Mkuyuni 63.64%, 21/33). The pests grouped as ‘others’ (cockroaches, mosquitoes and ticks) were indicated by significantly higher proportion of respondents (51.35% – 87.18%) than fleas (0 – 48.65%) and mites (0 – 19.05%) (P <0.001). These other pests were controlled by means of insecticides, hot water and improved sanitation. All responses reported under ‘others’ generally belonged to improved sanitation. The proportion of respondents that reported using either insecticides or improved sanitation was higher than the proportion using hot water (P <0.001). The proportion of respondents that reported using insecticides was similar throughout (Changa 57%; Mkuyuni 47.62%; Mfumbwe 45.95%). The proportion of respondents that reported employing improved sanitation measures ‘others’ was Changa 65.04%, Mkuyuni 52.38% and Mfumbwe 43.24%. None of the respondents reported using botanicals. The frequency at which respondents reported controlling bed bugs varied significantly within and between the study villages (P

<0.001). The majority of respondents (up to 67.52%) reported variable time periods, between >1 and ≤4 years, depending on the intensity of bed bugs infestation and financial position. The results are summarized in Table 3.

Presence of bed bugs

Considerable proportion of respondents reported presence of bed bugs in their respective households (Changa 61%; Mfumbwe 58%; Mkuyuni 45.45%; Figure 3). Nevertheless, more than 95% of respondents reported that their respective households had been infested with bed bugs several times in the past.

Table 1: Socio-demographic characteristics for respondents across the study sites (n=260)

		Proportion (%)
Sex	Female	53.08
	Male	46.92
Age category	20 -24	21.92
	25-34	22.31
	35-44	18.46
	45-54	12.69
	55-64	13.08
	65-74	9.23
	≥75	2.31
Level of education	Primary	68.08
	Secondary	6.54
	College	1.15
	Informal	24.23

Table 2: The percentage of respondents in different study sites who are knowledgeable on different aspects of bed bugs

		Mfumbwe(n=58)	Changa(n=169)	Mkuyuni(n=33)
Which control measures do you know?	Insecticides	44.82	34.91	81.82
	Washing	12	4.73	0
	Sunlight	43.11	51.47	18.18
	Others	0	8.89	0
Do you know how to control bed bugs		44.83	74.56	81.82
Can you identify a bed bug?		87.93	63.31	51.52
How do bed bugs reproduce?		98.04	100	100
How do the eggs look like?		62.96	97.17	70.49
Do you know the effects of bed bugs		46.55	53.87	75.76

Table 3: Common practices towards the control of bedbugs across the study sites

		Proportion of respondents (%)		
	Village	**Mfumbwe(n=58)**	**Changa(n=169)**	**Mkuyuni(n=33)**
Do you control bedbugs?	Yes	41.38	47.34	45.45
	No	58.62	52.66	54.55
Which measures do you use?	Insecticides	82.75	100	100
	Hot water		0	0
	Others	17.25	0	0
Do you control other pests?	Yes	63.79	69.23	63.64
	No	36.21	30.77	36.36
What are those pests?	Fleas	48.65	10.26	0
	Mites	0	2.56	19.05
	Others	51.35	87.18	80.95
What measures do you use?	Insecticides	45.95	57	47.62
	Hot water	16.22	17.09	0
	Others	43.24	65.04	52.38
	Botanicals	0	0	0
How frequent is the control?	6 months	59.46	22.22	23.81
	>1 yr	16.22	10.26	14.29
	Variable	24.32	67.52	61.9

Discussion

We assessed community knowledge, risk factors and control practices about bed bugs in order to inform development of appropriate awareness, surveillance and control strategies. Most respondents aged between 20 – 44 years, and had primary level education; with similar proportion of females (138/260) and males (122/260). The respondents were all household heads or guardians with responsibility of the home.

The study communities had considerable knowledge on bed bugs. Up to 82% of them were aware of how to control bed bugs and could list most commonly used control measures. The indicated control

measures in the order of importance included chemical insecticides, sunlight and washing bedclothes. Most of the respondents associated bed bug infestation with beds, mattresses and clothes, thus they were more attentive to the hygiene of bedclothes than that of the entire house. Although integrated pest management (IPM) approaches that incorporate chemical and nonchemical methods have been proposed as an effective bed bug management [18-20], insecticide treatments remain to be the most common approach for bed bug control worldwide [21-24]. Therefore, it is not surprising that many people in the study communities considered insecticides as the most powerful control approach against bed bugs. Furthermore, placement of bedclothes under sunlight is one of the indigenous measures that have been used against bed bugs for many years particularly in resource poor and marginalized communities. This measure however provides only a marginal relief and does not kill immature and adult bed bugs. Both the immature and adult bed bugs require prolonged exposure to temperature above 40^0C [25] which is difficult to attain with sunlight. Besides, owing to high sensitivity to temperature changes, bed bugs oftentimes respond quickly by moving to cooler zones of the bedding or any other materials on treatment [26]. Because of these, bed bugs only remain quiescent for short periods of time and thereafter retreat and continue surviving. Despite these challenges, many resource poor and marginalized communities still use this approach. This could be due to high cost of chemical insecticides and reluctance to apply them on indoor structures particularly beds and bedding materials [9]. Because bed bugs overwhelmingly infest mattresses and other bedding materials, many people are reluctant to treat them with chemical insecticides [25].

The observed level of knowledge on control of bed bugs could be contributed by long-term experience of bed bugs problem and improved literacy mostly primary level education. The basics of public health pests, particularly their control, are often taught during the primary level education; and that might have contributed to the observed level of awareness. Nevertheless, this study did not show an association between literacy level and knowledge about bed bugs however some respondents coincidentally admitted that basics acquired during their primary education enhanced their overall awareness and urge to look for more information on bed bugs and other household pests.

Moreover, the vast majority of respondents were able to describe and eventually identify adult bed bugs presented in form of pictures. Nevertheless, the level of knowledge on the two aspects varied significantly across villages; with highest proportion recorded in Mfumbwe (87.93%, 51/58), followed by Changa (63.31%, 107/169) and Mkuyuni (51.52%, 17/33). Interestingly, more than 95% of the respondents were aware that bed bugs reproduce by laying eggs and were able to identify the eggs. Bed bug eggs is probably one of the most common features that owners of infested houses see on mattresses, bed frames and other bedding materials.

More than 60% of the households presented multiple risk factors/features and the main ones were cracks on walls/floors, not sleeping on beds, dusty floors and hiding spaces on beds. This implies that the vast majority of households in the study communities are in high risk of bed bugs. The observed features provide excellent hiding and undisturbed microhabitats in which bed bugs prefer to live and reproduce. Studies have reported disproportionately high proportions of bed bugs in cracks and crevices on walls,

floors, and other parts and/or structures inside houses where people sleep or sit for extended period of time 17,27-28]. These microhabitats are not evenly distributed throughout the host's dwelling [29]. Thus, the uneven distribution and nature of these and other types of microhabitats render the exercise of inspecting and locating them particularly in poor and overcrowded houses a rather difficult and time consuming exercise. Furthermore, because of their cryptic nature, live bedbugs can be very difficult to detect when the infestation is small [30]. Due to these challenges, the control of bed bugs is complex and thus most control efforts particularly those done without professional guidance or physical help become unsuccessful. As a consequence, most resource poor and marginalized communities including the present study communities increasingly ignore the control of bed bugs. However, there are some potential opportunities to alter the situation if they are exploited systematically and routinely. Currently, majority of local people have at least the primary level education, therefore they are able to follow educational materials on regular inspections of bed bugs, repair of cracks and crevices, hygiene and other essential information. Likewise, house styles are rapidly changing to concrete walls and floors, thus it is becoming much easier and cheaper if local people are trained and encouraged to repair and prevent cracks, crevices and other risk features on continuous basis. Respondents in across the study communities indicated their confidence and support on this proposition. Many studies advocate a similar endeavor that caulking cracks and crevices in walls, other parts of the houses, furniture and other indoor structures coupled with proper hygiene can remarkably reduce bed bug infestations [16,21,31]. These alone will not be sufficient to eliminate bed bugs, however routine integration with insecticides and/or other non-traditional technologies will make a significant improvement. After all, integrated pests management is the most recommended and best way of combating arthropod and other pests.

This study indicated that only about 45% of the respondents were controlling bed bugs in practice, however most of them were complaining that the outcome was still poor. The majority indicated that they were not controlling bed bugs at all despite admitting that bed bugs were a nuisance. Up to 100% of respondents who reported controlling bed bugs in Changa and Mkuyuni village were using chemical insecticides. For Mfumbwe village, 82.75% and 17.24% were using chemical insecticides and hot water respectively. High proportion of people using chemical insecticides was not surprising considering the global reliance on the control approach. Interventions based on chemical insecticides are still the most powerful and reliable control measures against bed bugs and other arthropod pests of humans, animals and crops [21]. Households that reported not controlling bed bugs were willing to do that but they were unable to incur the cost of insecticides. High cost of chemical insecticides and operations is considered to be one of the most important barriers for successful control of arthropods. Control failure due to development of insecticide resistance, particularly against pyrethroids [32-38] is increasingly forcing people to refrain from controlling bed bugs. Ubiquitous development of resistance to pyrethroids and the fact that pyrethroids resistance generally confers cross-resistance to other insecticides make bed bug management a difficult task [6]. Purportedly, insecticide resistance, inappropriate application and use of inappropriate chemical products could be the causes of reported control failures. Our recent susceptibility tests indicated that wild population of bed bugs in the present study villages are resistant to commonly used insecticide products (Mnyone and Bavuruga, Unpublished data). The control failures could have

also resulted from the use of inappropriate insecticide products and application by house owners without professional guidance and/or direct help.

High proportion of respondents in the study villages was controlling other household pests including mosquitoes, cockroaches and ticks. Likewise, insecticide use was one of the commonly used control measures next to general sanitation. Presumably, the lack of professional guidance on appropriate chemical products and application procedures is also a problem in this case. These deficiencies coupled with irregular frequency of insecticide applications recorded in this study will certainly pose great risk of resistance to target and non-targeted household pests. The actives of public health insecticides are closely related; and therefore non-targeted pests can develop resistance consequent to exposure to insecticides applied against other pests. Such scenarios are increasingly reported in Africa and beyond [39-41]. It appears that imperfect pest-management-related practices have probably contributed to the magnitude of the bed bug resurgence in many other parts of the world [42,43].

During this study between 45.45% and 61% reported bed bug infestation in their households. Nevertheless, more than 95% of the respondents reported to have experienced the same in the past. Although we admit that the rate of bed bug infestation may have decreased in certain households because of improved housing and sanitation, the extent of risk factors we recorded suggest underestimation. Based on the presence of multiple risk features in most households and insignificant improvement of the house style and sanitation as well as improper and infrequent application of insecticides, it is unlikely that houses which were infested in the recent past are completely free from bed bugs. Besides, some of the respondents could have been reluctant to report the true situation because of considering bed bugs as an indicator or dirtiness. Such social stigma associated with bed bugs has also been reported from elsewhere [44]. Correspondingly our subsequent studies in the present study areas and beyond will consider physical inspection of bed bugs in order to establish a rather realistic prevalence. Surveys that rely upon resident interview alone include false reports of bed bugs and fail to account for unreported infestations.[19]

As useful as these findings are, we admit some limitations to this study which will need to be critically considered during the follow-up studies. We did not inspect immature and adult stages of bed bugs in the study households in order to determine how the prevalence of bed bugs varied with different risk features we identified. Because of that, the prevalence of bed bug infestation reported herein also relied on respondents rather than physical inspection. Furthermore, we did not gather details on commonly used chemical insecticides and their general application and disposal procedures.

Conclusion

The vast majority of households in the study areas are in high risk of bed bugs infestation. More than 60% of the households had multiple risk features which predispose them to bed bugs. Commonly identified risk features were cracks on walls and floors, not sleeping on beds, dusty floors and hiding spaces on beds, and keeping chicken inside living houses. Insecticides formed the most commonly

known and used control measure against bed bugs. Considerable proportion of people was also using insecticides against other important household arthropod pests. Insecticide applications are done on irregular frequencies by house owners themselves and without professional guidance, thus exposing the study areas to potentially high risk of resistance development. We recommend exploitation of these and other findings herein as a basis for creation of awareness, and development of surveillance and control strategies.

Declarations

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Author's contributions

All authors contributed to data collection and analysis, drafting or revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Availability of data and materials

The datasets generated and/or analysed during the present study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

All participants gave verbal consent prior to their participation in this study; and all personal data were excluded from the analysed data and final report.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

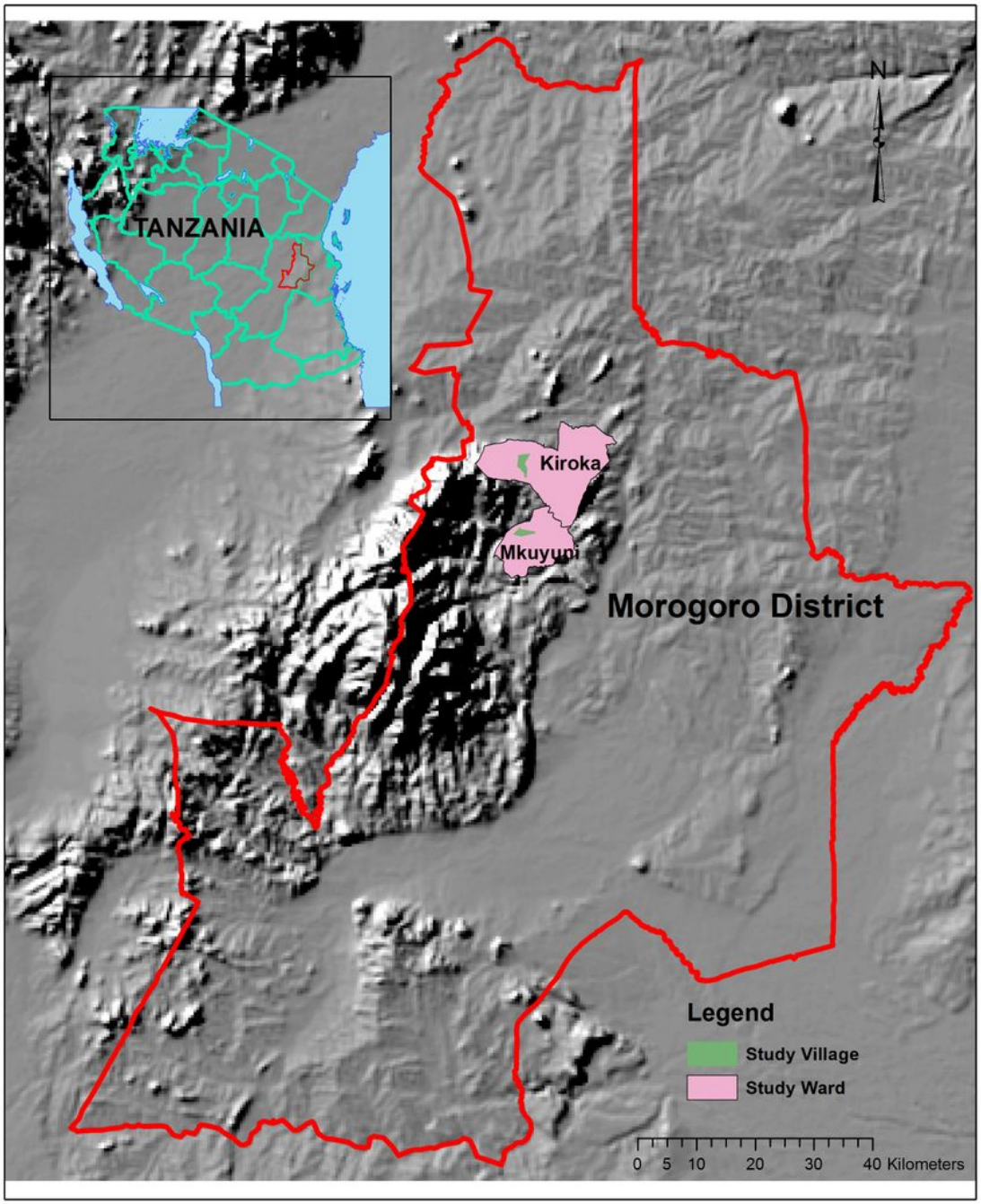

Figure 1

A map of Morogoro Rural District, Eastern Tanzania, showing the study areas.

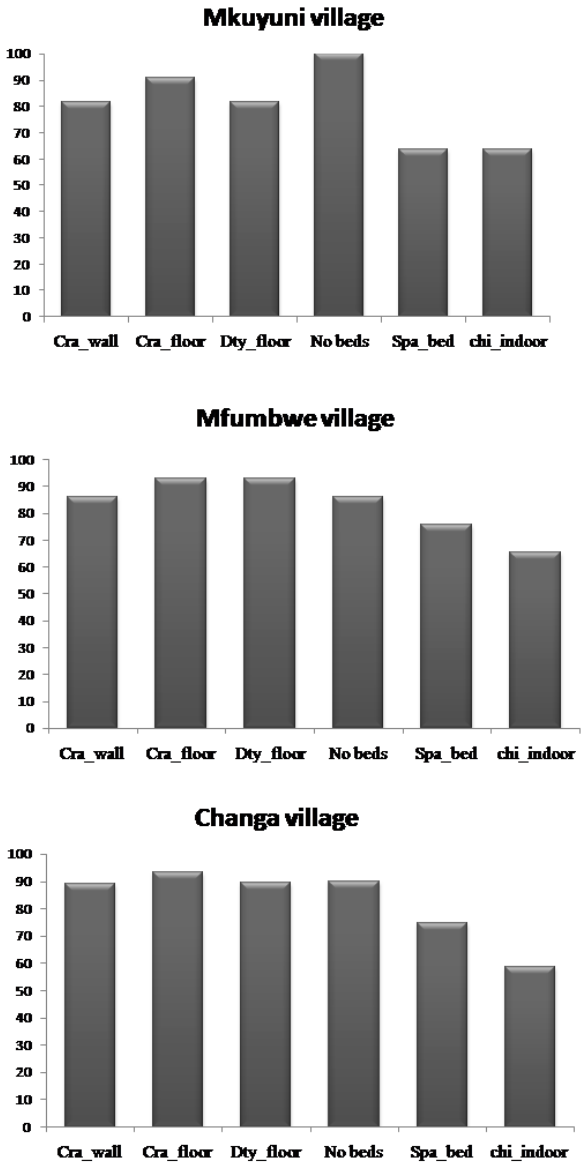

Figure 2

The proportion of bed bug predisposition/risk features commonly identified in households across study villages, Mkuyuni, Mfumbwe and Changa.

Mnyone & Massawe Figure 3

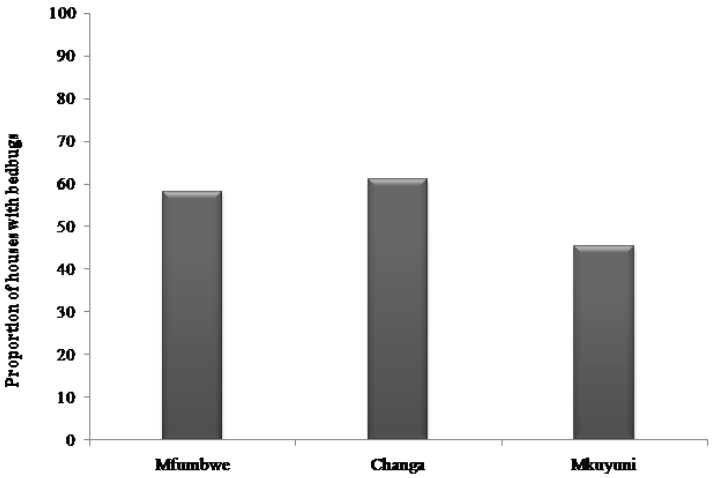

Figure 3

The proportion of households in households across villages that were reported to have bed bugs during the period of the study.

Supplementary Files

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