

Evaluation of personal protection afforded by repellent-treated sandals against mosquito bites in south-eastern Tanzania.

Peter Onyango Sangoro (✉ psangoro@icip.e.org)

Ifakara Health Institute <https://orcid.org/0000-0001-8289-0171>

Tegemeo Gavana

Ifakara Health Institute

Marceline Finda

Ifakara Health Institute

Winfrida Mponzi

Ifakara Health Institute

Emmanuel Hape

Ifakara Health Institute

Alex Limwagu

Ifakara Health Institute

Nicodem J. Govella

Ifakara Health Institute

Prosper Chaki

Ifakara Health Institute

Fredros O. Okumu

Ifakara Health Institute

Research

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Abstract

Background: The Indonesian government has put malaria as a priority disease that needs to be addressed. Lampung is one of the provinces with a high malaria incidence with Annual Paracite Incidence at 4.44 per 1000 population. The most cases occurred in Pesawaran Regency. There were 1.915 malaria cases in 2016. The highest positive case of malaria occurred in the Hanura Health Center with 1.738 cases, with the most cases being vivax malaria. The high case of malaria in the region is due to the favorable natural conditions as mosquito breeding places such as forests, lagoons and abandoned ponds. One of the biggest challenges in the treatment of malaria is the decline in the efficacy of even anti-malaria drug resistance due to low adherence in taking the drug. So this research is important to know the level of adherence to take medication in patients with vivax malaria in the work area of the Hanura Health Center.

Methods: This research was a descriptive analytic study with survey methods. Morisky Medication Adherence Scale (MMAS-8) questionnaire was used as the instrument. Eligible patients who had undergone treatment with Artemisinin-based Combination Therapy and primaquine for 14 days were the subject of study. They were numbered 68 people in the working area of Hanura Health Center.

Results: The level of adherence to take medication in patients with vivax malaria in the working area of Hanura Health Center is classified as low, namely a high compliance rate of 44.1% and a low compliance rate of 55.9%. The highest proportion of respondents with low levels of adherence were aged 25-45 years (55.3%), low education level (81.6%), working (57.9%), and having a history of malaria more than once (94, 7%).

Conclusions: The level of adherence to take treatment in patients with vivax malaria in the working area of Hanura Health Center is relatively low, with the highest proportion of adults, low education, work and have a history of malaria more than once.

Background

Mosquito control using long lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) has had a substantial impact on malaria transmission globally (1–3). However, deliberate scale up of LLINs and IRS has led to the emergence of behaviourally resilient malaria vectors (4) that evade these tools by increasingly feeding and resting outdoors (5–8). These changes, associated with the suppression of the once predominant local vector (4–9) attenuate the impact of LLINs and IRS (4). This shift in mosquito species composition and consequently to mosquito behaviour that define the biological limits of LLINs and IRS, coupled with practices that expose human hosts to outdoor mosquito biting (10,11) have resulted in persistent malaria transmission outdoors (residual transmission) (12,13).

With the increasing significance of outdoor malaria transmission (12), there is need to develop and deploy tools that control mosquito bites outdoors (14). There are several strategies that are being developed that can be used to tackle transmission outdoors; Killing adult mosquitoes when they feed

upon sugar using attractive toxic sugar baits (ATSB) (15–21), when they feed on livestock that have been sprayed with or ingested endectocides (22,23), use of odour baited mosquito landing boxes outdoors (24–26), use of topical repellents in the early evenings (27,28) and larval source management (29,30).

In addition to the above tools, spatial repellents are also being proposed as supplementary to LLINs (31,32). Spatial repellents are insecticidal products that act in the vapour phase to prevent human-vector contact by causing mosquitoes to move away from the source of chemical stimulus, interferes with the vector response to stimuli or otherwise causes feeding inhibition (33,34). There are several formats through which spatial repellents are dispensed, such as mosquito coils, vaporizer mats and liquid vaporizers (24,35,36). Recently, an alternative emanator delivery format for volatilizing transfluthrin at ambient temperatures have proven efficacious against mosquito bites (37–41). Although effective, these emanator formats require that the host is confined to a protected air space, therefore limiting mobility (38–40). In order to impact outdoor biting, spatial repellents delivery formats must be optimized to protect users wherever they are outdoors (42).

It has previously been reported that the malaria vector, *An. gambiae* s.l. prefers to bite humans on the lower limbs and that this behaviour is mediated by convection currents arising off the host (43,44). A recent study demonstrated that the highest densities of bites from these vectors occur on host body parts that are closest to the ground (45), and that protecting these body parts results in significant reduction in mosquito bites to the host (45,46).

Exploiting this mosquito behaviour, this study assessed the impact of integrating spatial repellents into sandals on mosquito bites outdoors. In addition to reducing mosquito bites overall on the human host (45,46), treating footwear with long lasting spatial repellents also presents an opportunity to overcome concerns of frequent reapplication, which is often encountered when using topical repellents (27), making it prohibitively expensive. Using footwear as a delivery format of spatial repellents will also overcome the challenge of limited mobility of recently developed emanator formats that require the host to be within the treated air space of stationary emanators (37–39). Integrating insecticide into footwear that is locally made, low cost and worn ubiquitously across communities on a daily basis will likely promote uptake and the attendant effectiveness as it does not require any change in human behaviour (27,47,48).

Methods

This research was a descriptive analytic study with survey method. This research was conducted in October to December 2019 in the working area of the Hanura Public Health Center in Pesawaran District to determine the level of compliance with taking treatment in patients with vivax malaria in the region. Samples numbered 68 people with malaria who were diagnosed with malaria in October to November 2019. The research instrument used was the Morisky Medication Adherence Scale (MMAS-8) questionnaire that had been tested for validity and reliability before.

Sample inclusion criteria were vivax malaria sufferers who were diagnosed using the Rapid Diagnostic Test (RDT) and microscopic examination, had finished treatment with a combination of ACT and

primaquine for 14 days, aged ≥ 17 years, lived in the working area of the Hanura Community Health Center and agreed to participate in the study by agreeing informed consent. Sample exclusion criteria were malaria patients who were pregnant and people with severe malaria.

Ethical considerations

The protocol for the study was evaluated and approved by the Health Research Ethics Committee of Faculty of Medicine The University of Lampung under the opinion No. 3174/ UN2.18/ PP.05.00/ 2019. Those patients who showed malaria symptoms during the interview were referred to the public health centres for medical re-evaluation. Those patients who reported non-adherence to the therapy instructions or still had medication tablets, were instructed to return to the public health centre if their symptoms recur.

Results

From the results of the study obtained the frequency distribution of the characteristics of respondents as listed in table 1. In general, all people potentially infected with malaria. The difference in malaria prevalence according to sex and age was related to the level of immunity and variation in susceptibility to mosquito bites [17] Based on sex, it was found that there were more male respondents at 51.5%.

Table 1 Demography of respondent characteristics

Characteristics	Frequency (n)	Percentage (%)
Sex		
Male	35	51.5%
Female	33	48.5%
Age (Years)		
17-25	25	36.8%
26-45	33	48.5%
>45	10	14.7%
Level of education		
Low (elemntary-junior high school)	50	73.5%
High (senior high school)	18	26.5%
Jobs		
Student	10	14.7%
Housewife	18	26.5%
Fisherman	15	22.1%
Trader	12	17.6%
Others	8	11.8%
Unemployed	5	7.4%
History		
Once	15	22.1%
More than onces	53	77.9%
Adherences level		
Low	38	55.9%
High	30	44.1%
Total	68	100%

Based on age, it was found that respondents aged 26-45 years had the most amount which was 48.5%. This happens because this age was a productive age, where a person usually worked outside the home so it was more susceptible to Anopheles mosquito bites. Busyness due to this activity also made

respondents less concerned about the prevention of mosquito bites that should be done. This result was in accordance with [18] that 87.65% of malaria patients were from the adult age group.

Based on the level of education, it was found that there were more respondents with lower levels of education, amounting to 73.5%. This was because the level of education was affect a person in understanding information or knowledge [19]. The low level of education was related to the low awareness to seek and receive information about efforts that can be made to prevent malaria. These results were in accordance with [20] which stated that 68.6% of malaria sufferers have a low level of education.

Based on work, it was found that most respondents were housewives at 26.5%. This was because many people in the work area of the Hanura Community Health Center operate inside the house but did not close the door of the house due to the hot air, so that mosquitoes could enter the house and caused malaria infection. Malaria patients 44% were housewives [21]. Most respondents other than housewives were fishermen and fish traders who operated in the coastal area at night until early morning, making it possible to be exposed to *Anopheles* mosquito bites at that time. This was consistent with the results of the study [22].

Based on the history of malaria, it was found that the majority of respondents had a history of malaria more than once, amounting to 77.9%. This was because the working area of the Hanura Health Center was an endemic area with a high parasitic density so that recurrent malaria infections often occur. Infections that occur were not only vivax malaria, but also *Falciparum malaria*, ovale malaria and mixed malaria to severe malaria. The high cases in the region due to natural conditions that supported mosquito breeding places such as forests, lagoons and abandoned ponds

Based on the level of medication adherence, it was found that the majority of respondents had a low level of adherence, which was 55.9%.

The distribution of the results of the MMAS-8 questionnaire by respondents can be seen in table 2.

Table 2 Distribution of questionnaire results of MMAS-8

Questions	Yes		Not	
	n	%	n	%
1. Have you ever forgotten to take medicine?	37	54,4%	31	45,6%
2. For other reasons. In the past 2 weeks have you ever not taken a medicine?	31	45,6%	37	54,4%
3. Have you ever reduced or stopped taking medicine without the knowledge of your doctor because you felt the medicine given made your condition worse?	12	17,6%	56	82,4%
4. Have you ever forgotten to bring medicine in traveling?	11	16,2%	57	83,8%
5. Are you still taking your medicine yesterday?	33	48,5%	35	51,5%
6. Do you stop taking treatment when you feel the symptoms have been resolved?	16	23,5%	52	76,5%
7. Taking medicine every day is an inconvenience for some people. Did you bother having to take medicine every day?	11	16,2%	57	83,8%
8. How often do you forget to take medicine?	35	51,5%	33	48,5%
a. Never				
b. Once in a while (1 times in a week)				
c. Sometimes (2-3 times in a week)				
d. Usually (4-6 times in a week)				
e. Always (7 times in a week)				
a=1				
b-e=0				

Information: n = number of respondents

Based on table 2 it was known that the majority of respondents did not take medication due to forgetfulness (question number 1). So there needs to be an effort from the health center, for example by assigning PMO (supervisors taking medication) from the family to remind them to take medicine according to the specified schedule. Besides that, education can be done to activate an alarm or reminder to take medicine every day.

Respondents at least answered "yes" to questions number 4 and number 7. This was show the high awareness of respondents to carry drugs when traveling during the treatment period. Respondents also

did not feel bothered having to take medication every day because of their desire to recover.

The level of adherence to take medication in patients with vivax malaria in the working area of Hanura Health Center was still relatively low as listed in table 1. This was influenced by various factors, including health service system factors, drug factors, health personnel factors, and patient factors (age, education level, occupation and history of malaria infection).

The level of adherence to take medication in patients with vivax malaria by age category can be seen in table 3. In patients with low adherence, the age category of 25-45 years has the greatest proportion of 55.3%. This was because patients in adulthood (25-45 years) were included in the productive age which requires them to work and carry out daily activities. This busyness tends to make patients forget and irregular in undergoing malaria treatment until completion. This was consistent with Farouk's study which states that 62% of patients aged 15-50 years have low levels of adherence [12].

Table 3 Adherence level based on age

Adherence level	17-25 years		25-45 years		>45 years		Total	
	n	%	n	%	n	%	n	%
High	12	40%	12	40%	6	20%	30	100%
Low	13	34.2%	21	55,3%	4	10,5%	38	100%
Total	25		36		10		68 100%	

Information :

n = number of respondents

The level of adherence to take medication in patients with vivax malaria based on their level of education can be seen in table 4. In patients with low adherence, the proportion of patients with low education was greater namely 81.6%. This was because education affected all aspects of human life, both thoughts, feelings, and attitudes, including compliance with taking treatment [23].

Table 4 Adherence level based on education level

Adherence level	High education		Low education		Total	
	n	%	n	%	n	%
High	11	36,7%	19	63,3%	30	100%
Low	7	18,4%	31	81,6%	38	100%
Total	18		50		68 100%	

Information :

n = number of respondents

The higher the level of education, the easier it would be to receive information from health workers about the importance of malaria treatment until completion and what risks could occur if treatment was not done properly. This was consistent with research by Wuryanto in Banjarnegara which stated that the level of education would influence a person in understanding information or knowledge [13]. This fact seems to be a problem in the working area of the Hanura Community Health Center, because 73.5% of the population was still low educated. Therefore it was necessary to make efforts to improve medication adherence on the part of the Hanura Community Health Center continuously with a simple language and easily understood by all levels of education.

The level of adherence to take medication in patients with vivax malaria based on work can be seen in table 5. In patients with low adherence, the number of patients who work had a greater proportion of 57.9%.

Table 5 Adherence level based on jobs

Adherence level	Employe		Unemploye		Total	
	n	%	n	%	n	%
High	23	76,7%	7	23,3%	30	100%
Low	22	57,9%	16	42,1%	38	100%
Total	45		23		68	100%

Information :

n = number of respondents

This was because the majority of malaria sufferers work as fishermen and fish traders who are active in catching fish and buying and selling fish at night until early morning. This time is in conjunction with the medication schedule that was determined by the Hanura Health Center, at 21:00 at night so patients were tend to forget to take treatment at that time. The results of this study were consistent with Okuboyejo's research which stated that respondents who worked tend to have low treatment adherence [24]. Therefore it was necessary to do education from the Hanura Health Center to carry and continue taking the drug even though working.

The level of adherence to take medication in patients with vivax malaria based on a history of malaria could be seen in table 6.

Table 6 Adherence level based on history of malaria

Adherence level	History of malaria >1x		History of malaria 1x		Total	
	n	%	n	%	n	%
High	17	56,7%	13	43,3%	30	100%
Low	36	94,7%	2	5,3%	38	100%
Total	53		15		68	100%

Information :

n = number of respondents

Discussion

There were more male respondents infected malaria. This was because the activities of male respondents were done outside the house at night when Anopheles mosquitoes were actively looking for food. The activities carried out were night patrols and working as fishermen and fish traders who were active near the beach at that time. This study was consistent with data from the 2017 Pesawaran District Health Profile which stated that the number of males with malaria was greater than that of females [5].

Patients at productive age were more active outside the home so that it increased the likelihood of being bitten by mosquitoes. The condition of settlements that were closed to mangroves as potential mosquito habitat correlated with the low level of education dominated by women who are mostly housewives. They had low awareness of the potential for mosquito bites when mosquitoes enter the house. It was made them less concerned about the dangers of malaria so they suffer more than once upon malaria. They had a greater proportion of 94.7%. They were assumed that malaria was an ordinary disease so that it did not need special treatment and tended to stop taking treatment when the symptoms that were felt had been resolved.

This differed from research by Farouk which stated that respondents with a history of malaria were more than once likely to be obedient 0.8 times [12]. This fact could be caused by the lack of information from the public health center regarding the importance of undergoing treatment completely to avoid the occurrence of relapse and drug resistance. Counseling that had been carried out only explains about ways to prevent malaria with mosquito nets and maintain environmental cleanliness without the presence of specific and specific information about treatment.

Conclusions

The level of adherence to take medication in patients with vivax malaria in the working area of Hanura Health Center was still relatively low. In malaria sufferers with low levels of adherence, the highest proportion were aged 25-45 years, low education level, working as fishermen and fish traders, and had a history of suffering from malaria more than once.

Declarations

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Author details

¹Department of Biology, Faculty of Mathematics and Natural Sciences, ²Bachelor of Medicine, Faculty of Medicine, University of Lampung, University of Lampung Jl. Prof. Sumantri Brojonegoro 1, Bandarlampung 35145, Indonesia.

Authors' contributions

ER, and DO conceived and designed the study, IDS conducted the field work and supervised the interview data collection. IDS and AA participated in data management and analysis and wrote the draft of the manuscript. All authors contributed during writing, read and approved the manuscript.

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Ethics approval and consent to participate

The protocol for the study was evaluated and approved by the Health Research Ethics Committee of Faculty of Medicine The University of Lampung under the opinion No. 3174/ UN2.18/ PP.05.00/ 2019. Assent and written informed consent was obtained from participants and their parents/guardians, respectively.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Data and material availability

Data and material was available on Mendeley data.

References

1. Singh B, Daneshvar C: Human infections and detection of Plasmodium knowlesi. *Clinical Microbiology Reviews* 2013, 26(2):165–84
2. Arsin AA: Malaria di Indonesia tinjauan aspek epidemiologi. Makassar: Masagena Press, 2012.
3. World Health Organization (WHO): Global technical strategy for malaria 2016–2030. Geneva : WHO 2015.
4. Kementerian Kesehatan RI: Buku saku penatalaksanaan kasus malaria. Jakarta : Kementerian Kesehatan RI, 2017
5. Dinas Kesehatan Kabupaten Pesawaran: Profil kesehatan Kabupaten Pesawaran. Pesawaran : Dinas Kesehatan Kabupaten Pesawaran, 2017.
6. Simamora D, and Fitri LE: Resistensi obat malaria : mekanisme dan peran obat kombinasi anti malaria untuk mencegah. *Jurnal Kedokteran Brawijaya* 2007, 23(2).
7. Butler AR, Khan S, Ferguson E: A brief history of malaria chemotherapy. *JR Coll Physicians Edinb* 2010, 40: 172-177
8. Anindita V, Mutiara H, Mutiara UG: Mutasi gen Kelch 13 dan resistensi Plasmodium falciparum terhadap antimalarial golongan artemisinin. *Jurnal kedokteran Unila* 2017, 7 (5) : 149-153
9. Suwandi JF: Gen PfATP6 dan resistensi Plasmodium falciparum terhadap golongan artemisinin. *Jurnal kedokteran Unila* 2015, 5 (9) : 141-146
10. Petersen I, Eastman R, and Lanzer M: Drug-resistant malaria : molecular mechanism and implications for public health. *FEBS Letters* 2011, 585:1551-62
11. Koziar: Buku ajar praktik keperawatan klinis. Edisi 5. Jakarta : EGC, 2010
12. Farouk A: Analisis faktor yang berhubungan dengan kepatuhan pengobatan malaria di Kabupaten Sarolangun Provinsi Jambi tahun 2015. *Jurnal Ilmiah Universitas Batanghari Jambi* 2016, 16(1)
13. Wuryanto MA: Beberapa faktor risiko kepatuhan berobat penderita malaria vivax [tesis]. Semarang : Universitas Diponegoro 2005.
14. Utomo DS: Hubungan pengetahuan dan sikap tentang malaria dengan kepatuhan menelan obat pada penderita malaria di Puskesmas Mayong I Jepara tahun 2007 [skripsi]. Semarang : Universitas Dian Nuswantoro 2007
15. Case Management Society of America: Case management adherence guidelines version 2. USA : Case Management Society of America 2006

16. Okuboyejo S: Non-adherence to medication in outpatient setting in Nigeria: the effect of employment status. *Global Journal of Health Science* 2014, 6 (3) : 37-44
17. Gunawan S: Epidemiologi Malaria. Dalam : Malaria : Epidemiologi, Manifestasi Klinis dan Penanganan. Jakarta : EGC 2000
18. Syah IF: Hubungan karakteristik individu, perilaku dan lingkungan dengan kejadian malaria di wilayah Puskesmas Girian Weru Kota Bitung tahun 2012 [skripsi]. Program Studi Kesehatan Masyarakat : Universitas Indonesia
19. Notoatmodjo S: Kesehatan masyarakat. Ilmu dan seni. Jakarta : PT. Rineka Cipta. 2009
20. Manumpa S: Pengaruh faktor demografi dan riwayat malaria terhadap kejadian malaria. *Jurnal Berkala Epidemiologi* 2016, 4 (3) : 338-348
21. Mooduto PT: Karakteristik penderita malaria di wilayah kerja Puskesmas Bongomeme Kabupaten Gorontalo. [skripsi] Jurusan Kesehatan Masyarakat. Universitas Negeri Gorontalo 2012
22. Novelina C: Karakteristik penderita malaria di wilayah kerja Puskesmas Sambau Kecamatan Nongsa Kota Batam. *Jurnal Gizi, Kesehatan Reproduksi dan Epidemiologi* 2012, 1 (1)
23. Astuti W: Hubungan perilaku vulva hygiene dengan kejadian keputihan pada remaja putri kelas X di SMU Negeri 2 Ungaran Semarang. *Jurnal Kebidanan dan Keperawatan* 2008, 4 (2) : 59-65
24. Okuboyejo S: Non-adherence to medication in outpatient setting in Nigeria : the effect of employment status. *Global Journal of Health Science* 2014, 6 (3): 37-44

Figures



Figure 1

Pictorial illustration of Ifakara Health Institute (IHI) semi field cages, a) large multi-compartment system; b) Inside sections of the long tunnel-shaped, semi-field system; c) Outside view of the long tunnel-shaped semi-field system.



Figure 2

Prototype designs of the transfluthrin-treated sandals; a). design using hessian fabric measuring 240cm² and b). design with hessian fabric measuring 48cm².



Figure 3

Prototypes of transfluthrin treated sandal designs developed; A. Male sandal design 1. B. Male sandal design 2. C. Male sandal design 3. D. Male sandal design 4. E. Female sandal design 1. F. Female sandal design 2. G. Female sandal design 3. H. Female sandal design 4.

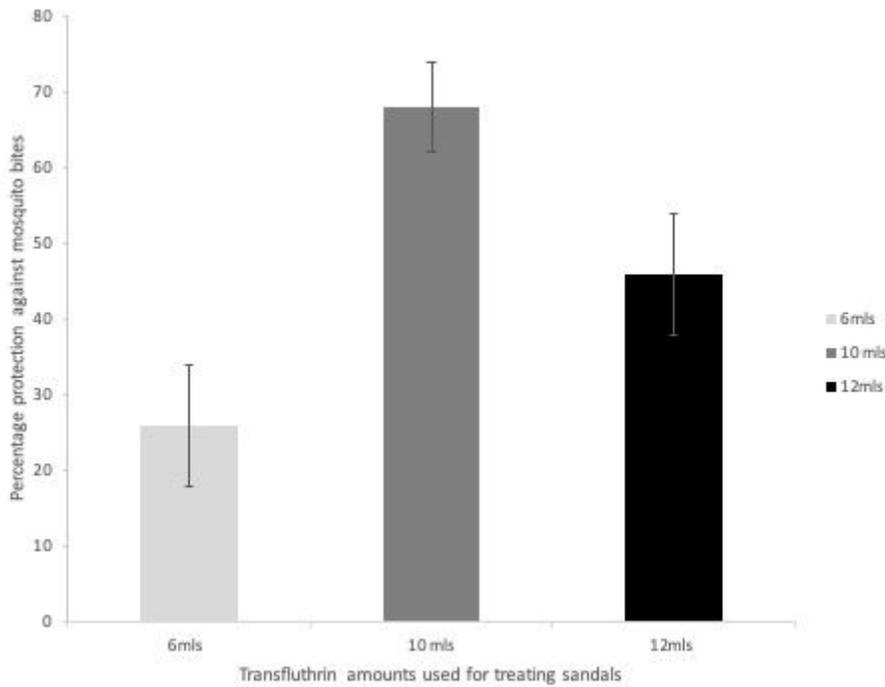


Figure 4

Graph showing the protection conferred by sandals treated with different amounts of transfluthrin against *An. arabiensis* mosquito bites in semi field experiments

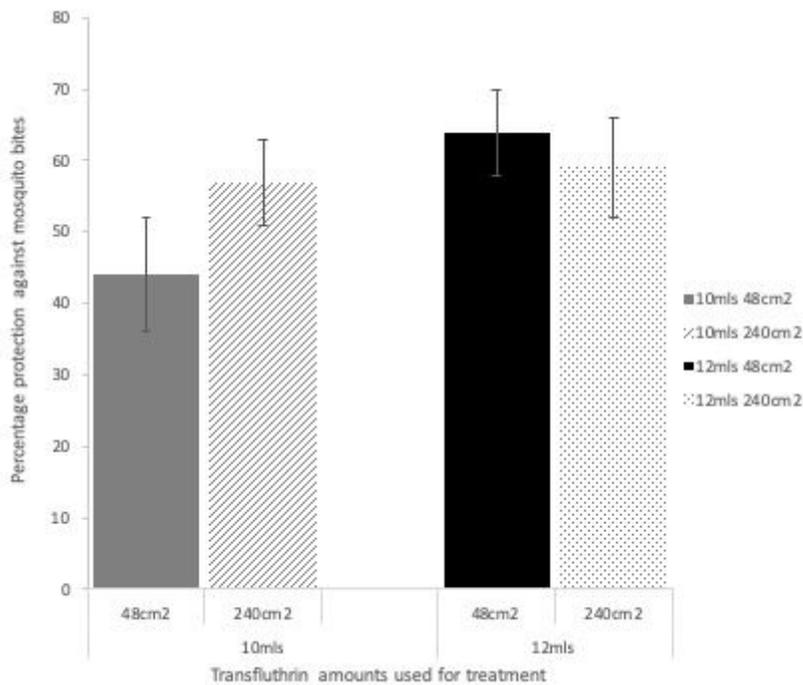


Figure 5

Graph assessing the impact of the surface area of transfluthrin treated hessian fabric on protection against laboratory reared *An. arabiensis* mosquito bites in semi field experiments