Electronic mosquito repellents for preventing mosquito bites and malaria infection (Review)

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[Intervention Review]

Electronic mosquito repellents for preventing mosquito bites and malaria infection

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ABSTRACT

Background

Electronic mosquito repellents (EMRs) are marketed to prevent mosquitoes biting and to prevent malaria.

Objectives

To assess whether EMRs prevent mosquito bites, and to assess any evidence of an effect on malaria infection.

Search strategy

In March 2009, we searched the Cochrane Infectious Diseases Group Specialized Register, CENTRAL, MEDLINE, EMBASE, LILACS, Cambridge Scientific Abstracts, and the Science Citation Index. We also checked conference proceedings, contacted international specialist centres and EMR manufacturers, and checked reference lists.

Selection criteria

Field entomological studies, which controlled for geographic site, time, and attractiveness of human participants, of EMRs for preventing mosquito bites; and randomized and quasi-randomized controlled trials of EMRs to prevent malaria infection.

Data collection and analysis

Two authors assessed trial quality, and extracted and analysed the data.

Main results

Ten field entomological studies met the inclusion criteria. All 10 studies found that there was no difference in the number of mosquitoes caught from the bare body parts of the human participants with or without an EMR. No randomized or quasi-randomized controlled trials on the efficacy of EMR on malaria infection were found.

Authors' conclusions

Field entomological studies confirm that EMRs have no effect on preventing mosquito bites. Therefore there is no justification for marketing them to prevent malaria infection.

PLAIN LANGUAGE SUMMARY

Electronic mosquito repellents for preventing mosquito bites and malaria infection

Malaria is a major health problem that particularly affects people living in sub-Saharan Africa and other tropical parts of the world. It often causes considerable morbidity and mortality especially in children under five. It is transmitted by mosquito bites from infected female mosquitoes. Several strategies and approaches are available for preventing mosquito bites and malaria infection, including repellents, and these approaches will be considered by those living in affected areas and by travellers to areas where there is high risk of infection. Electronic mosquito repellents (EMRs) are designed to repel female mosquitoes by emitting high-pitched sounds almost inaudible to the human ear. EMRs are claimed by their manufacturers to be effective in repelling mosquitoes and preventing disease. No randomized controlled trials were found, but 10 field studies looking at the number of mosquitoes caught on the bare body parts of humans were assessed. These studies were conducted in various parts of the world with different species of mosquitoes and were controlled for factors such as locality and timing. One study used just one observer with seven observations, while the highest assessment included 18 observers with 324 observations. There was no evidence in the field studies to support any repelling effects of EMRs, hence no evidence to support their promotion or use. Future randomized controlled trials are not proposed as there was no suggestion in the field studies that EMRs show any promise as a preventive measure against malaria.

BACKGROUND

Malaria affects more than 250 million people and causes more than a million deaths each year (WHO 2005). One important control strategy against this and other mosquito-borne diseases is mosquito control, which aims to reduce human-mosquito contact. Different control measures are used routinely against mosquitoes and their larvae, including chemical (eg insecticide), biological (eg larvivorous fish or pathogenic fungi), environmental (eg land filling or drainage), and personal protection (eg mosquito repellents formulated as pills, coils, ointments, lotions, and sprays; and insecticide-treated or untreated bed nets).

Electronic mosquito repellents (EMRs) are marketed in response to a huge demand from the public for convenient, safe, and effective antimosquito products. Female Anopheles mosquitoes transmit malaria by sucking blood from humans, and these small handheld, battery-powered EMRs are intended to repel them by emitting a high frequency buzz almost inaudible to the human ear. They can be used both indoors and outdoors, and are claimed to repel mosquitoes within a range of up to 2.5 metres (Kutz 1974; Helson 1977). No adverse effects have been reported in the literature. Mobile phone companies also market a ring tone that is claimed to repel mosquitoes within a one-metre radius (BBC 2003).

Some of the EMRs seem to be based on known aspects of mosquito behaviour, while others have no scientific data to substantiate their claims. Manufacturers have put forward at least two reasons to explain the alleged repellent action of sound against mosquitoes. One reason is that the flight sound of males repels females once they have been inseminated (Foster 1985); hence, whatever mimics the males' flight sound may repel females. However, research has shown that male mosquitoes are actually the ones attracted by the female flight sound and females normally have a very weak sensitivity for sound compared with the males (Wigglesworth 1965; Chapman 1982; McIver 1985; Michelsen 1985). Another reason is that mosquitoes avoid the ultrasonic cries of bats (Foster 1985). Although both explanations may be conceivable, there is no published scientific information to support either idea.

Different brands of EMRs have been examined for their efficacy under laboratory conditions, none of which showed any effects for the devices tested (Singleton 1977; Curtis 1982; Iglisch 1983; Foster 1985; Jensen 2000; Andrade 2001; Cabrini 2006). There are review articles concluding that the EMRs are ineffective in repelling mosquitoes (Coro 1998; Coro 2000). Scientific skepticism over the last 30 years and a successful prosecution of EMR sellers under the UK Trade Description Act in 1980s (Curtis 1994; BBC 2005) seems to have done little to deter manufacturers marketing EMRs and the people who buy them. This is a concern because it is likely to lead to consumers not using other protective methods that are proven to work. This could result in an increased risk of infection with mosquito-borne diseases, especially malaria (Jensen 2000).

Despite the scientific view and research findings, EMRs are still widely promoted and used by the public. We therefore decided to systematically review all reliable research about the effects of high-pitched sounds in preventing mosquito bites and, hence, to assess whether there is any evidence that EMRs have any potential in preventing malaria in the field setting. We included only field studies since laboratory studies do not reflect influences on mosquito behaviour, including climate, mosquito density, and composition of different species in the same locality.

OBJECTIVES

To assess whether EMRs prevent mosquito bites, and to assess evidence of impact on malaria infection.

METHODS

Criteria for considering studies for this review

Types of studies

Preventing mosquito bites

Field entomological studies that control for geographic site (conducted in same locality), time (conducted at same time), and attractiveness of human participants (by rotating participants between the experiments with and without the EMR).

Preventing malaria infection

Randomized and quasi-randomized controlled trials.

Types of participants

Adults or children.

Types of interventions

Intervention

- EMRs with any operational wavelength.

Control

- Dummy EMRs, inoperable EMRs, EMRs switched off, or no EMRs. We excluded other repellents and treated or untreated bed nets as control.
- If used, malaria chemoprophylaxis must be identical in both the intervention and control groups.

Types of outcome measures

- The number of mosquitoes of any species landing on exposed body parts of humans acting as baits. Time period defined by entomological collection procedures.
- Malaria infection, defined as clinical malaria (fever with malaria parasitaemia detected by microscopy or rapid test); or asymptomatic malaria parasitaemia.

Search methods for identification of studies

We attempted to locate all relevant studies regardless of language or publication status (published, unpublished, in press, and in progress).

Databases

The following databases were searched using the search terms and strategy described in Appendix 1 : Cochrane Infectious Diseases Group Specialized Register (March 2009); Cochrane Central Register of Controlled Trials (CENTRAL), published in *The Cochrane Library* (2009, Issue 1); MEDLINE (1966 to March 2009); EMBASE (1974 to March 2009); LILACS (1982 to March 2009); Cambridge Scientific Abstracts (CSA) (1982 to March 2009); and Science Citation Index (SCI) (1945 to March 2009).

Conference proceedings

The following conference proceedings were searched for relevant abstracts: XV International Congress of Tropical Medicine and Malaria, Cartagena, Colombia, August 2000; First MIM Pan-African Malaria Conference, Dakar, Senegal, 6 to 9 January 1997; Second MIM Pan-African Malaria Conference, Durban, South Africa, 15 to 19 March 1999; Third MIM Pan-African Malaria Conference, Arusha, Tanzania, 17 to 22 November 2002; Fourth MIM Pan-African Malaria Conference, Yaoundé, Cameroon, 13 to 18 November 2005; International Conference on Entomology, Brisbane, Australia, 15 to 21 August 2004; and Medicine and Health in the Tropics, Marseille, France, 11 to 15 September 2005.

Researchers, organizations, and manufacturers

We contacted some corresponding authors and field and clinical experts (Professor Chris Curtis, London School of Hygiene and Tropical Medicine; Dr Morteza Zaim, WHO Pesticide Evaluation Scheme (WHOPES), Geneva, to enquire about other published or unpublished relevant studies (September 2006). We also contacted EMR manufacturers (Isotronic, Lentek International Inc., Electronic Pest Controls Ltd.) for unpublished and ongoing trials or studies (September 2005).

Reference lists

We also checked the reference lists of all studies identified by the above methods.

Data collection and analysis

Selection of studies

AAE scanned the results of the literature search for potentially relevant studies and then retrieved the full articles. AAE and PG independently assessed the potentially relevant studies using an eligibility form based on the inclusion criteria; disagreements were resolved through discussion.

Data extraction and management

We independently extracted data from all included studies using a data extraction form and resolved any disagreements in the extracted data by referring to the original paper and through discussion. We described the devices tested and the number of observations made, and assessed the quality of the studies in relation to whether they controlled for study locality, time of day or night, participants (used same people to bait mosquitoes), and whether the observers were blinded. We also assessed the number of times observations were repeated to gain some quantitative measure of quality and grouped this with an arbitrary cut off into adequate (20 or more) or inadequate (less than 20).

Assessment of risk of bias in included studies

We summarized the results of the risk of bias assessment in Table 1.

Table 1. Study methodological quality (risk of bias)

Study	Controlled			Observers blind	No. observations
	Locality	Time	Bait		
Belton 1981	Yes	Yes	Yes	Unclear	Inadequate
Garcia 1976	Yes	Unclear	Unclear	Unclear	Adequate
Gorham 1974	Yes	Yes	Yes	Not blinded	Inadequate
Helson 1977	Yes	Yes	Yes	Unclear	Inadequate
Kutz 1974	Yes	Yes	Yes	Unclear	Inadequate
Lewis 1982	Yes	Yes	Yes	Not blinded	Inadequate
Rasnitsyn 1974	Yes	Yes	Yes	Not blinded	Inadequate
Schreck 1977	Yes	Yes	Yes	Not blinded	Adequate
Snow 1977	Yes	Yes	Yes	Unclear	Inadequate
Sylla 2000	Yes	Yes	Yes	Blinded	Adequate

Data synthesis

The number of landings on which the rates were calculated varied considerably according to different ecological and geographical situations, mosquito species, and season and time of day of the tests. If possible, we would have tested for a difference using the original data to measure a mean difference between arms within one study and to calculate 95% confidence intervals. Had a difference been shown, we would also have examined the effects of EMR by a variety of factors: EMR frequency (< and ≥ 20 kHz); mosquito population density; malaria endemicity (< and ≥ entomological inoculation rate of 1/person/night); and mosquito species.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

We identified 18 potentially relevant studies of EMR to prevent mosquito bites and included 10 (see 'Characteristics of included studies' for study details); none were randomized or quasi-randomized controlled trials that used EMR to prevent malaria. We excluded eight studies because they were only laboratory based or because they did not provide any data or did not control for locality, time, and blinding (see 'Characteristics of excluded studies'). The papers for the 10 included studies contained 22 experiments, of which 15 were field experiments that met the reviews inclusion criteria; the excluded seven experiments were only laboratory based or used chemical repellents.

Seven studies were carried out in the North America, three in Canada (Helson 1977; Belton 1981; Lewis 1982) and four in the USA (Gorham 1974; Kutz 1974; Garcia 1976; Schreck 1977). Two studies were done in Africa, in Gabon (Sylla 2000) and in The Gambia (Snow 1977). One study was undertaken in Russia (Rasnitsyn 1974).

Seven studies gave the commercial name of the EMRs tested (Rasnitsyn 1974; Helson 1977; Schreck 1977; Snow 1977; Belton 1981; Lewis 1982; Sylla 2000); five studies gave some information about the ultrasound frequencies used, which ranged from 125 Hz to 74,600 Hz (Kutz 1974; Belton 1981; Rasnitsyn 1974; Snow 1977; Sylla 2000). The other studies gave no commercial name and no details of the frequencies used.

All studies counted mosquitoes landing on the bare body parts (mostly arms, legs and/or feet) of the human participants for definite time periods with the EMR switched on or off, or, in some studies, with or without a functional EMR as case and control. None of the field studies performed in North America and Russia were on Anopheles mosquitoes; they used Aedes, Culex, Culiseta, and Mansonia mosquitoes. The two studies in Africa were on Anopheles as well as other mosquitoes. The lowest number of observers was one (with 7 observations; Gorham 1974) and the highest was 18 (with 324 observations; Sylla 2000). Also, timing and length of collections varied, ranging from one minute (Kutz 1974) to over a 12-hour period (Sylla 2000).

Risk of bias in included studies

As shown in Table 1, all studies made some attempts to control for locality (geography) of the study area (wooded area, forest, plain, beach) as they measured landing rates with and without the EMR in the same geographical area. Different individuals may have different attraction for the mosquitoes, and the studies controlled for this, usually by swapping the EMR between the participants so that the same individuals acted as both case and control.

The density of mosquitoes and the intensity with which they attempt to bite varies throughout day and night. Our inclusion criteria required studies to attempt to control for time. This was clearly described in all but one study (Garcia 1976).

One study blinded the observers to whether they were measuring during a control or experimental phase (Sylla 2000). The use of blinding was unclear or not used in the other studies.

In order to test significance, we intended to consider rates per person in participants in control or intervention areas. As landing rates were not given per person, we were unable to compare these data statistically. We recorded the number of times observations were repeated to gain some insight into data quality, arbitrarily defining this as adequate (with 20 or more repeated observations or human participants) and inadequate (less than 20 observations). Three studies were of adequate quality by this criterion.

Effects of interventions

The number of mosquitoes landing per collection with and without EMR are presented in Table 2. All 10 studies reported that the landing rates with and without the EMR were little different and that the EMRs failed to repel mosquitoes. These results occurred regardless of the study location, mosquito density, mosquito genera, or time of study (ie day or night with day-biting and night-biting mosquitoes).

Table 2. Mosquito landing rates

Study[a]	Landing rate	
	With EMR[b]	LR without EMR
Belton 1981	[c]	[c]
Garcia 1976	240	193
Gorham 1974	213%[d] greater than the control	68.78
Helson 1977: ME Electronic Mosquito repellent	8.9	8.4
Helson 1977: Buzz-Off repellent	16.8	14.9
Kutz 1974: Person A	12.2	12.8
Kutz 1974: Person B	16.8	14.2
Lewis 1982	561.5	538
Rasnitsyn 1974	500	497
Schreck 1977: Buzz-Off repellent	25	30
Schreck 1977: Norris Device	36	As above
Snow 1977: Experiment 1	157	140
Snow 1977: Experiment 2	472	425
Snow 1977: Experiment 3	177	155
Sylla 2000	23.4	22.7

[a] See 'Characteristics of included studies' for study details.
[b] Using crude units, data given in paper.
[c] Landing rates between 2 and 7/min with no significant difference between groups.
[d] Based on recalculation of the crude data in the paper.

No trials were found to assess the effects of EMRs on malaria infection.

DISCUSSION

The included studies were of good quality, had controlled for locality, and all but one had explicitly controlled for time of day or night, and the human bait for the mosquitoes. The results of this review provide clear evidence from field-based studies that there is no hint that these devices have any effect on mosquito landing rates. The studies reported here examined the effectiveness of the EMRs with different methods, settings, mosquito species (since they may respond differently to the high-pitched sounds emitted by the EMRs), frequencies of the sound emitted by the EMRs (since mosquitoes may respond to a particular sound wavelength), and times of day (since day-biting and night-biting mosquitoes may behave differently to the sound emitted by the EMRs), and mosquito density (since this may affect EMR efficacy), but none of them supported the claims of the EMRs' effectiveness. Although we did not conduct a meta-analysis of the included studies, there was no suggestion of difference in landing rates between cases and controls in any trial. In 12 of the 15 experiments, the landing rates in the groups with functioning EMR was actually higher than in the control groups. The absolute number of mosquitoes landing on the human participants during the experiments while the EMR was functioning was too high to consider the EMR a repellent.

EMRs are claimed to be effective by mimicking the sound waves produced by the beating of male mosquitoes' wings, especially during swarms. Female mosquitoes, which bite humans, are claimed to be repelled by this sound since they mate only once in their lives. Hence the repellent mechanism should be based on the hearing mechanism in females. However, this theory is implausible since the hearing ability of the females is relatively weak (Wigglesworth 1965; Chapman 1982; Michelsen 1985). It is the hearing system of males that is relatively strong, and the presence of numerous sound and vibration receptors (known as Johnston organ) on their plumose antennae enables them to detect the vibration in the environment as well as the sound of female mosquitoes (Chapman 1982). Thus it is not surprising that the included studies did not produce any evidence that EMRs act as repellents.

AUTHORS' CONCLUSIONS

Implications for practice

EMRs are not effective in repelling mosquitoes and should not be recommended or used.

Implications for research

There is no evidence of an effect of EMRs on landing rates. Thus there is no evidence that these EMRs could potentially be useful in preventing malaria in humans. Given these findings from 10 carefully conducted studies, it would not be worthwhile to conduct further research on EMRs in preventing mosquitoes biting or in trying to prevent the acquisition of malaria.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Belton 1981

Methods	Design: field study of experimental intervention versus control Two human participants with an exposed arm carried out 6 x 5 min catches once with the electronic mosquito repellent (EMR) switched on and once off Number of observers: 12 Number of observations: 12
Participants	Human adults
Interventions	1. EMR switched on 2. EMR switched off (control) EMR suppliers: Murray Distributors Ltd., North Vancouver B.C.; Peak Distributions Ltd., Surrey; Moziquit supplied by Electronic pest control Ltd., Montreal P.Q. EMR frequency: 2 to 5 KHz
Outcomes	Aedes and Culex mosquito landing rates/min/participant
Notes	Location: Canada The raw number of landings with EMR switched off was not provided, but it was mentioned that the differences of the landing rates with a EMR on and off was not significant

Garcia 1976

Methods	Design: field study of experimental intervention versus control Catches carried out in 18 different locations in a forest at 2, 5, and 10 min (a total period of 102 min) intervals in the late afternoon to early evening with electronic mosquito repellent (EMR) on or off Number of observers: 6 Number of observations: 30
Participants	Human adults
Interventions	1. EMR switched on 2. EMR switched off (control) EMR supplier: unclear EMR frequency: not mentioned
Outcomes	Anopheles, Aedes, and Culex mosquito landing rates/person
Notes	Location: USA

Gorham 1974

Methods	Design: field study of experimental intervention versus control 5 min landing counts carried out on 7 occasions by single catchers with and without electronic mosquito repellent (EMR) Number of observers: 1 Number of observations: 7
Participants	Human adults
Interventions	1. EMR 2. No EMR (control) EMR supplier: not mentioned EMR frequency: not mentioned
Outcomes	Aedes and Culiseta mosquito landing rates/person/h
Notes	Location: Alaska, USA

Helson 1977

Methods	Design: field study of experimental intervention versus control Participants 30 m apart in a wooded area caught mosquitoes landing on their arm and hand for 4 min with or without 2 types of electronic mosquito repellent (EMR). So for each, EMR 8 min collection with EMR and 8 min collection without EMR Number of observers: 5 Number of observations: 12
Participants	Human adults
Interventions	1. 2 types of EMR 2. No EMR (control) EMR source: ME Electronic Mosquito Repellent; Buzz-Off repellent EMR frequency: not mentioned
Outcomes	Aedes mosquito mean landing rate/person
Notes	Location: Canada

Kutz 1974

Methods	Design: field study of experimental intervention versus control 5 x 1 min biting counts made by 2 participants walking 20 paces along a path once with the electronic mosquito repellent (EMR) on and the other time off Number of observers: 2 Number of observations: 10
Participants	Human adults

Kutz 1974 (*Continued*)

Interventions	1. EMR switched on 2. EMR switched off (control) EMR supplier: not mentioned EMR frequency: 5.2 KHz
Outcomes	Aedes and Culex mosquito mean landing rates/person/min
Notes	Location: USA

Lewis 1982

Methods	Design: field study of experimental intervention versus control 3 participants carried out catches in 3 sites 10 m apart in 4 x 45 min catching experiments each consisting of 3 x 15 min and each of those to 3 x 5-min intervals once with electronic mosquito repellent (EMR) and once without. Participants with and without EMR were rotated Number of observers: 3 Number of observations: 12
Participants	Human adults
Interventions	1. EMR 2. No EMR (control) EMR supplier: Antipic EMR frequency: not mentioned
Outcomes	Aedes and Mansonia total bites
Notes	Location: Canada

Rasnitsyn 1974

Methods	Design: field study of experimental intervention versus control 3 participants carried 15 observations x 5 min with the electronic mosquito repellent (EMR) on or off Number of observers: 3 Number of observations: 15
Participants	Human adults
Interventions	1. EMR switched on 2. EMR switched off EMR supplier: Skeeter Skat, Anti-parasite block, local Russian produced device EMR frequency: 125 to 74,600 Hz
Outcomes	Aedes, Culiseta, and Culex mosquito landing rates/person/h
Notes	Location: Russia

Schreck 1977

Methods	Design: field study of experimental intervention versus control 4 participants carried out the catches once without the electronic mosquito repellent (EMR) and once 2 participants carried one type of EMR and the other 2 two carried other type while walking in a wooded area where Aedes taeniorhynchus mosquitoes were abundant. They stopped every 20 paces and counted the mosquitoes on their arms. After each count the mosquitoes were killed to avoid recounting Number of observers: 4 Number of observations: 44
Participants	Human adults
Interventions	1. 2 types of EMR 2. No EMR (control) EMR supplier: Buzz-Off; Norris Electronic Mosquito Repeller EMR frequency: not mentioned
Outcomes	Aedes mosquito landing rate/person
Notes	Location: USA

Snow 1977

Methods	Design: field study of experimental intervention versus control Experiment 1: 2 teams of 2 catchers each seated 30 m apart. Each catcher collected mosquitoes for 30 minutes at 2 periods during the night. In the first period, the first team were exposed to the electronic mosquito repellent (EMR) and in the second period, the second team was exposed. Repeated on 2 consecutive nights Experiment 2: single catchers (1 with EMR and other without) sat 25 m apart and made 2 x 30 min catches over 6 nights, so a total of 2 x 2 x 30 x 6 min catches. EMRs were swapped each night between catchers Experiment 3: single catchers (1 with EMR and other without) sat 25 m apart made 2 x 30 min catches over 4 nights, so a total of 2 x 2 x 30 x 4 min catches. EMRs were swapped each night between catchers Number of observers: 4 (experiment 1); 1 (experiments 2 and 3) Number of observations: 16 (experiment 1); 12 (experiment 2 and 3)
Participants	Human adults
Interventions	1. EMR 2. No EMR (control) EMR supplier: Moziquit from Electronic Pest Controls Ltd. EMR frequency: 2.2.5 KHz
Outcomes	Number of Anopheles, Aedes, and Culex mosquitoes landing
Notes	Location: The Gambia

Sylla 2000

Methods	Design: field study of experimental intervention versus control 18 houses chosen and grouped into 9 pairs. Each pair with a pair of working and not working electronic mosquito repellents (EMRs) that were swapped every night. 18 catches were undertaken in each house, 9 with and 9 without EMR. So a total of 9 x 9 catches in 18 houses, all together 324 catches each for 12 hours were made which makes a total catch of 3888 person hours Number of observers: 18 Number of observations: 324
Participants	Human adults
Interventions	1. Functional EMRs 2. Inoperable EMRs (control) EMR supplier: Isotronic, Horb, Germany EMR frequency: 3 to 11 KHz
Outcomes	Anopheles, Aedes, Culex, and Mansonia mosquito landing/house/night
Notes	Location: Gabon

Characteristics of excluded studies *[ordered by study ID]*

Andrade 2001	Laboratory-based EMR study
Arevad 1982	Field-based EMR, but unclear if time, locality and bait were controlled
Cabrini 2006	Laboratory-based EMR study
Curtis 1982	Laboratory-based EMR study
Foster 1985	Laboratory-based EMR study
Iglisch 1983	Laboratory-based EMR study
Jensen 2000	Field trial but no proper control used; number of caught mosquitoes pooled together for 2 chemical repellents and EMR such that mosquito landing rates with and without EMR could not be calculated
Singleton 1977	Laboratory-based EMR study

DATA AND ANALYSES

This review has no analyses.

APPENDICES

Appendix 1. Search methods: detailed search strategies[a]

Search set	CIDG SR[b]	CENTRAL	MEDLINE	EMBASE	LILACS, CAS, SCI
1	mosquito repellent	mosquito*	mosquito*	mosquito$	mosquito
2	mosquito control	repel*	repel*	repel$	repel*
3	-	control	control	control	control
4	-	2 or 3	2 or 3	2 or 3	2 or 3
5	-	1 and 4	1 and 4	1 and 4	1 and 4
6	-	MOSQUITO CONTROL	MOSQUITO CONTROL	ultrasound	ultrasound
7	-	5 or 6	INSECT REPELLENTS	electronic	electronic
8	-	electronic	INSECT BITES AND STINGS/PREVENTION AND CONTROL	device$	6 or 7
9	-	device$	5 or 6 or 7 or 8	6 or 7 or 8	5 and 8
10	-	ultrasound	ultrasound	5 and 9	-
11	-	8 or 9 or 10	electronic	-	-
12	-	7 and 11	device$	-	-
13	-	-	10 or 11 or 12	-	-
14	-	-	9 and 13	-	-

[a] Upper case: MeSH or EMTREE heading; lower case: free text term.
[b] Cochrane Infectious Diseases Group Specialized Register.

WHAT'S NEW

Last assessed as up-to-date: 8 March 2009.

15 February 2010	Review declared as stable	Given the current evidence, there appears little justification for further trials of electronic mosquito repellents and they should not be recommended or used. The authors therefore do not plan to update this review.

HISTORY

Protocol first published: Issue 3, 2005

Review first published: Issue 2, 2007

9 March 2009	New search has been performed	Search updated. No new studies found
18 August 2008	Amended	Converted to new review format with minor editing.

CONTRIBUTIONS OF AUTHORS

AA Enayati developed and wrote the review. P Garner helped develop the review, developed and applied inclusion and quality criteria, extracted data, and helped write the review. J Hemingway initiated the review and helped with technical issues. AA Enayati is the guarantor.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- Liverpool School of Tropical Medicine, UK.

External sources

- Department of International Development, UK.

INDEX TERMS

Medical Subject Headings (MeSH)

*Anopheles; Electronics; Insect Bites and Stings [*prevention & control]; Malaria [*prevention & control]; Mosquito Control [*instrumentation]; Population Density

MeSH check words

Animals; Female; Humans