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The Effectiveness of Installing Long-lasting Insecticidal Nets as Malaria Prevention Efforts: A Systematic Literature Review

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A B S T R A C T

Malaria is a parasitic disease that is often the cause of death, especially in tropical and subtropical areas. One way to eradicate malaria is to break the chain of disease transmission in order to control the mosquito vector of malaria. The use of insecticide-treated mosquito nets can be used as an alternative in controlling malaria vectors for people who refuse to use the Indoor Residual Spraying (IRS) method. The review articles were obtained through a search using the Pubmed, Google Scholar, Garuda, and ScienceDirect databases. The keywords used were (LLINs OR "Long Lasting Insecticidal Nets") AND Malaria. 1843 articles were obtained, and extraction was carried out based on the restriction criteria so that 13 articles were obtained. In conclusion, the use of insecticide-treated mosquito nets LLIN is effective in killing mosquito vectors so that it has the potential to prevent malaria.

1. Introduction

Malaria is a parasitic disease that is still a cause of death, especially in tropical and subtropical areas.¹ Malaria can be acute or chronic due to infection with the Plasmodium. The prevalence of malaria is estimated at around 229 million people who are positive for malaria, and there are around 409,000 deaths.² The prevalence of malaria in Indonesia from a positive history of malaria blood tests by health workers showed 1,017,290.³ One way to eradicate malaria is to break the chain of disease transmission in order to control the mosquito vector of malaria.⁴

Insecticidal bed nets are not only a physical barrier to mosquito vectors but are also an effective preventive measure against mosquito bites due to the insecticidal

activity contained in the mosquito nets and reduce the risk of malaria transmission, especially to infants and pregnant women.⁵ The use of insecticide-treated mosquito nets can be used as an alternative in controlling malaria vectors for people who refuse to use indoor residual spraying (IRS) or as an additional effort to prevent malaria transmission. The use of long-lasting insecticidal nets (LLIN) can be a program to reduce the risk of malaria infection. Previous studies have shown that the application of insecticide-treated mosquito nets can reduce malaria cases. Around 78.3% of respondents who experienced malaria did not use mosquito nets.⁶ This study is a systematic literature review to obtain scientific evidence of the efficacy of insecticidal nets in preventing malaria.

2. Methods

This study is a systematic literature review that examines original articles related to the efficacy of using insecticide-treated bed nets to prevent malaria. The original article search process is carried out on search engine journals, namely Google Scholar, PubMed, ScienceDirect, and Garuda. The journal identification technique used follows the PRISMA diagram. The keywords used were (LLINs OR "Long

Lasting Insecticidal Nets") AND Malaria. This research journal is accumulated and designed to be a journal summary that includes the name of the researcher, year of publication of the journal, research area, research title, method, type of insecticide, and summary of results. After the data has been collected and then entered into a simple table and then found the similarities and differences are used to draw conclusions.

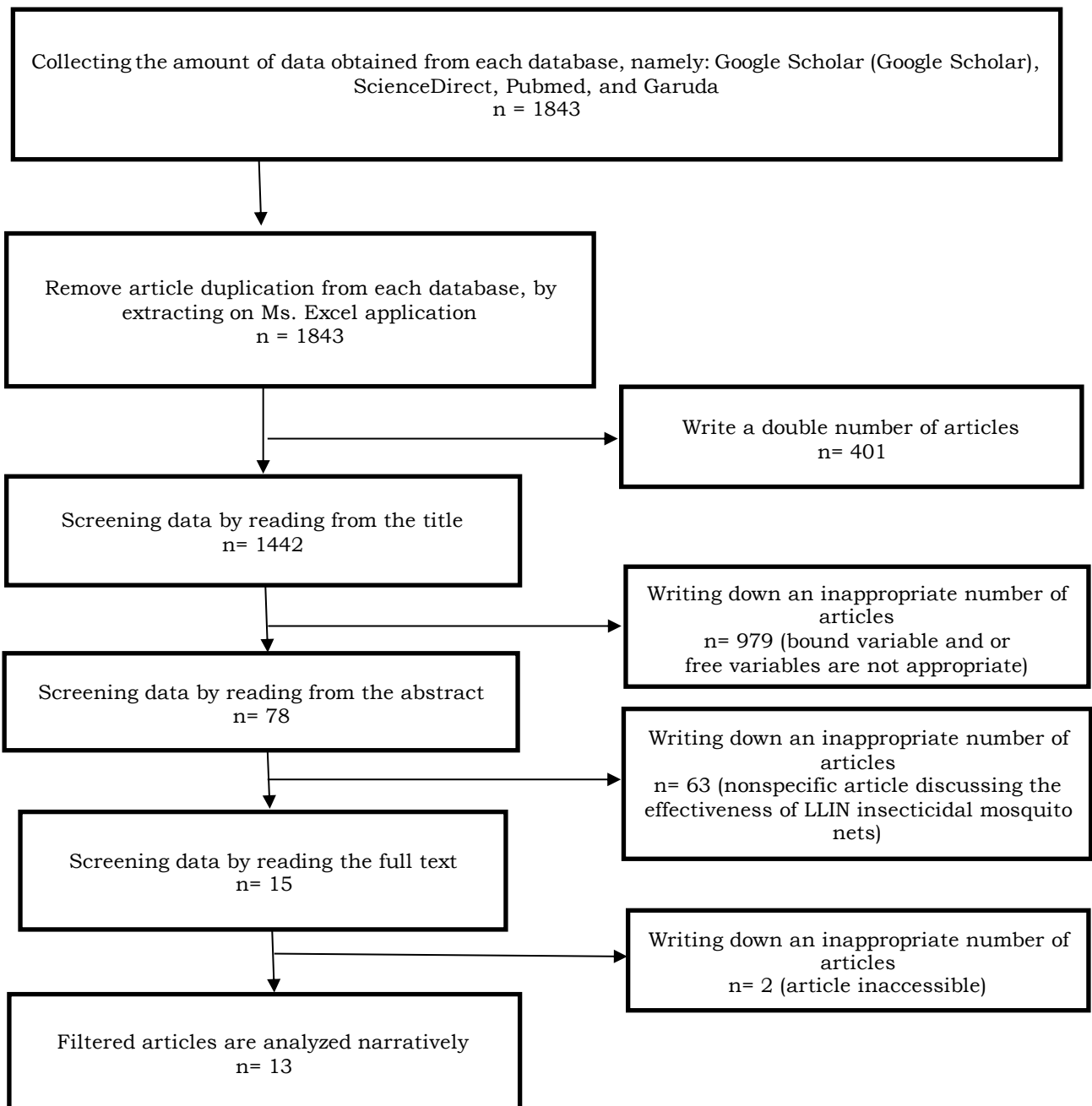


Figure 1. Diagram flowchart PRISMA

3. Results and Discussion

This research was conducted using the keywords (LLINs OR "Long Lasting Insecticidal Nets") AND Malaria through the search results of Google Scholar, Pubmed, ScienceDirect, and Garuda articles. There were 1182 articles from Google Scholar, 481 articles from Pubmed, 176 articles from ScienceDirect, and 4

articles from Garuda that matched these keywords. There were 401 duplicated articles, then the remaining 1442 articles for title screening. There were 78 articles with appropriate titles. Then abstract screening was carried out. Obtained 15 articles with appropriate abstracts, then full-text screening was carried out. So, we got 13 articles for review.

Table 1. Characteristics of the original article

No	References	Title	Research method	Sample	Area	Type of insecticide	Outcome
1	Fokam et al. ⁷	The effect of long-lasting insecticide bed net use on malaria prevalence in the Tombel Health District, South West Region-Cameroon	Case-control	31,657 patients with confirmed malaria for the pre-and post-distribution period LLIN	Cameroon, Central Africa	Deltamethrin	There was a decrease in the number of malaria cases in 2012 after the distribution of LLIN to the area.
2	Dev et al. ⁸	A cross-sectional study assessing the residual bio-efficacy and durability of field-distributed long-lasting insecticidal nets in malaria-endemic ethnic communities of Assam, Northeast India	Experimental	391 households were randomly selected using LLIN Olyset and PermaNet	Assam, India	Permethrin on Olyset and Deltamethrin PermaNet	LLIN used in 2011 can kill mosquitoes from 57%-79%, while in 2013, the mosquito mortality rate was almost >80%.
3	Ilmawati et al. ⁹	The Effectiveness of Using Insecticide Netting (LLIN) Against Malaria Cases (Study in Ngereco Village, Tegalombo District, Pacitan Regency in 2016)	Experimental	29 houses using insecticide-treated mosquito nets	Ngereco Village, Indonesia	Deltamethrin PermaNet	There was a decrease in new malaria cases in Ngereco Village by around 2 in 2011-2015, while in 2007-2010, there were 23 new cases of malaria added.
4	Tan et al. ¹⁰	A longitudinal study of the durability of long-lasting insecticidal nets in Zambia	Cohort	74 LLINs were randomly selected from Luapula	Luapula, Central Africa	Deltamethrin from PermaNet 2.0 and permethrin from OlysetNet	LLIN still worked well at killing mosquitoes for 12 months and decreased effectiveness at 24 months of use.
5	Villalta et al. ¹¹	Evaluation of the durability and use of long-lasting insecticidal nets in Nicaragua	Experimental	1732 houses given by LLIN	Nicaragua, Central America	Deltamethrin on Netting PermaNet 2.0 LLINs	The use of LLIN mosquito nets decreased effectiveness in the 12 th month.
6	Sugiarto et al. ¹²	Evaluation of Insecticide Mosquito Nets for An. Sundaicus (Diptera: Culicidae) on Sebatik Island, North Kalimantan	Experimental	15 samples of insecticidal bed nets at >6 months, 12-23 months, and >24 months	Sebatik district, Indonesia	Polyester-deltamethrin	Insecticide mosquito nets used for 6 months are still effective

7	Boussougou-Sambe et al. ¹³	Physical integrity and survivorship of long-lasting insecticidal nets distributed to households of the same socio-cultural community in Benin, West Africa.	Cross-Sectional	241 houses with LLIN in Limbe, Tiko, and Buea	Cameroon, Africa	Deltamethrin from PermaNet 2.0 net and permethrin from Olyset net	LLIN was less effective at killing mosquitoes in the Limbe and Buea areas, while in the Tiko area, it was still quite effective at killing mosquitoes.
8	Ketoh et al. ¹⁴	Efficacy of two PBO long-lasting insecticidal nets against natural populations of <i>Anopheles gambiae</i> s.l. in experimental huts, Kolokopé, Togo	Experimental	Trial house given mosquito net LLIN	Togo, Africa	LLINs with PBO (PermaNet1 3.0 and Olyset1) and LLIN Yorkool standard	PermaNet mosquito nets with Olyset LLIN proved to be more effective in controlling malaria vectors than LLIN Yorkool Pyteroid alone.
9	Allosogbe et al. ¹⁵	WHO cone bio-assays of classical and new-generation long-lasting insecticidal nets call for innovative insecticides targeting the knock-down resistance ...	Cross-Sectional	7 selected areas of Benin	Benin, East Africa	Pyteroids in conventional LLIN and pyroids with PBO in the new generation of	LLINs LLINs with LifeNet and PBO (Olyset plus and PermaNet 3.0) show better effectiveness than conventional LLINs (PermaNet 2.0 and Olyset Net).
10	Staedke et al. ¹⁶	Effect of long-lasting insecticidal nets with and without piperonyl butoxide on malaria indicators in Uganda (LLINEUP): a pragmatic, cluster-randomised trial embedded in a national LLIN distribution campaign	Cross-Sectional	104 areas granted LLIN mosquito nets	Uganda, Africa	LLIN with non-PBO PBO and LLIN	The use of LLIN in the PBO group resulted in a lower prevalence of malaria parasites compared to the non-PBO group.
11	Gunasekaran et al., ¹⁷	Bio-efficacy of LifeNet, a Deltamethrin incorporated long-lasting insecticidal net, as assessed in experimental huts against <i>Anopheles fluviatilis</i> , a major malaria vector in east-central India	Experimental	<i>Anopheles fluviatilis</i>	India	Deltamethrin on LifeNet and Polyester Net (CTN)	Insecticidal mosquito nets with LifeNet were better at killing mosquitoes than conventional mosquito nets (Polyester Net) even after washing 20 and 30 times.
12	Toe et al. ¹⁸	Assessing the impact of the addition of pyriproxyfen on the durability of permethrin-treated bed nets in Burkina Faso, a compound-randomized controlled trial	Experimental	<i>Anopheles gambiae</i>	Burkina Faso, West Africa	PPF-Permethrin (Olyset Duo) and standard LLIN (Olyset)	The durability of PPF-Permethrin nets can provide good protection for malaria compared to standard Permethrin nets.
13	Mansiangi et al. ¹⁹	Comparing the durability of the long-lasting insecticidal nets DawaPlus® 2.0 and DuraNet® in northwest Democratic Republic of Congo	Cohort	240 houses given LLIN mosquito nets	Kongo, Africa	Deltamethrin with DuraNet and DawaPlus mosquito nets	LLIN under the DuraNet brand is effective for up to 3 years while LLIN with the DawaPlus brand is effective for up to 24 months.

Based on the results of the journal analysis, it was found that the 13 articles carried out above showed that the use of insecticide nets was still effective in reducing the risk of malaria in several countries. Types of insecticides that are quite effective in LLIN are deltamethrin and permethrin. There was a decrease in the number of malaria cases in children <5 years and >5 years who were LLIN and outpatient to the area. LLIN PermaNet 2.0 and Olyset used in 2009 can cause mosquito mortality by 22%-27%. In 2011 mosquitoes were killed by 57%-79%, while in 2013, the mosquito mortality rate was almost >80%. This is because people are increasingly obedient in using mosquito nets and understand how to use them properly. There was a decrease in malaria cases in Ngereco Village in 2011-2015 compared to 2007-2010. This study aims to determine the role of the use of mosquito nets after distribution. In 2007-2015, there were 23 cases of malaria, while in 2011-2015, there were 2 cases of malaria. From 2011-2015 there was a decrease in cases due to the fact that many residents obeyed using mosquito nets and the habit of not going out at night.

LLIN mosquito nets are considered to still meet the optimal effectiveness standard, namely in the event of 80% death or 95% knock-down in mosquitoes. PermaNet 2.0 mosquito nets that have been used for 12 months are still quite effective compared to use at month 30. The study states that the use of the 12th month got 84-88% results and the 30th month got 64-72% results. The aim of this study was to determine the effectiveness of mosquito nets provided in the Ngereco Village area, and the results obtained showed that mosquito nets were still effectively used within 12 months of use and slightly decreased in effectiveness at 30 months of use. This is because people wash in a way that is not right.

LLIN is still quite effective in killing mosquitoes within 12 months, and its effectiveness has decreased sharply at 24 months of use. LLIN PermaNet 2.0 and Olyset may experience a decrease in effectiveness at

24 months of use due to a lack of knowledge about the correct use of mosquito nets. Another study found that tucking a mosquito net under the mattress would make a hole or make the insecticide erode in the mosquito net. PermaNet 2.0 LLIN mosquito nets were effective for up to 6 months of use and decreased in effectiveness at 12 months. Deltamethrin mosquito nets for 6 months were still effective, while at 12-24 months, they decreased. Mosquito nets are still effective enough to be used within 6 months of use. This is due to the low level of public knowledge about the use and how to wash properly. Therefore, it is necessary for the community to know how to use and care for mosquito nets properly.

LLIN PermaNet 2.0 and Olyset were less effective at killing mosquitoes in the Limbe and Buea areas, while the Tiko areas were still quite effective at killing mosquitoes. This is because the buildings in Buea use wood so that mosquitoes can enter the gaps in the wooden holes, and the public's low interest in keeping the mosquito nets from tearing. The ceiling difference in the Limbe area is thinner than that of the Tiko. This allows for physical damage to the mosquito net.

Currently, malaria mosquitoes are starting to develop resistance to one of the insecticides, namely pyroides. Therefore WHO made a new innovation by combining pyroids with PBO to eliminate these vulnerabilities. PermaNet 2.0 and Olyset nets on LLIN proved to be able to control malaria vectors more than Pyroid Yorkool LLIN alone. The study also wanted to determine the effectiveness of bed nets with PBO and special python nets in areas experiencing resistance to malaria. PermaNet and Olyset showed >80% effectiveness even after washing 20 times, while Yorkool showed 65% after washing 20 times. This indicates that the LLIN PBO mosquito net is still effective in use in areas that are resistant to pyreroid even after washing has been carried out.

LLIN with PBO (PermaNet 3.0 and Olyset Plus) showed better effectiveness than conventional LLIN

(Olyset and PermaNet 2.0). The study also wanted to determine the effectiveness of LLIN PBO mosquito nets in areas that have experienced resistance, and the results showed that PermaNet 3.0 and Olyset Plus could make knock-down better than the conventional type. PermaNet 3.0 and Olyset Plus can kill mosquitoes in areas where there has been the retention of the pyroid insecticides. The PBO group LLIN had a lower prevalence of malaria parasites compared to the Non-PBO group. The prevalence of parasites in the PBO group at 6 months got a result of 11% compared to the non-PBO group, which got a result of 15%. This study has the same goal, namely to determine the effectiveness of using LLIN PBO mosquito nets in areas that are already experiencing resistance, and it was found that PBO can be a solution for areas experiencing resistance because PBO can inhibit P450 enzymes and inhibit mosquito defense against insecticides. Can eliminate these vulnerabilities.

Insecticidal mosquito nets with LifeNet are better at killing mosquitoes than conventional mosquito nets (polyester nets) even after washing 20 or 30 times. Another study examined the bioassay method using 50 mosquitoes that were studied for 24 hours.⁹ The results of the study stated that LifeNet after the bioassay caused >90% mortality in unwashed mosquito nets and 73.8% mortality after washing 30 times. Conventional LLIN after bioassay caused 39.7% mortality in unwashed mosquito nets and resulted in 12.2% mortality after washing 20 times. The study did not specifically address the causes of the differences in the mosquito nets, but this mosquito net can be a solution for people who are less concerned about maintaining mosquito nets. Washing mosquito nets is one of the factors that can maintain the effectiveness of a mosquito net.

4. Conclusion

The use of insecticide-treated mosquito nets LLIN is effective in killing mosquito vectors or optimally increasing the number of mosquito deaths so that it has the potential to prevent malaria. LLIN insecticide

net is effective if it meets 80% mortality or 95% knock-down on mosquitoes. Other factors that also affect the effectiveness of mosquito nets are frequency of washing, detergent for washing, duration of use of nets, and behavior in maintaining good mosquito nets.

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