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Research Article

Quality Assurance

Efficacy of Indoor Residual Spray (Bendiocarb 80%) for Malaria Control in Sennar State, Sudan

Walid Adam Eltahir[1], Mohamed Osman Elamin[2]*, Ahmed A Osman[2], Hatim Abdullah Natto[2] and Nazik Hassan Mohamed[2]

[1]*Environmental Health Department, Ministry of Health, Sudan.*

[2]*Faculty of Public Health and Health Informatics, Umm Al-Qura University, Saudi Arabia.*

Abstract: Malaria is a worldwide public health problem, in 2017, and an estimated 237 million cases of malaria occurred worldwide compared with 211 million cases in 2010 and 219 million cases in 2015. Several countries used Indoor Residual Spray (IRS) (Bendiocarb 80%) to combat Malaria. The study aimed to evaluate the efficacy of IRS (Bendiocarb 80%) applied in Sennar state, Sudan in which Malaria is endemic. We used Pyrethrum spray collection, Bio efficacy of IRS using Cone methods and Malaria cases reporting to evaluate the efficacy of Indoor Residual Spray. The efficacy of IRS was tested by cone bioassay for four months (August- November 2017) for susceptible strains of Anopheles Mosquitoes. The recorded mortality of the 4 months was 99±1.23, 95±5.14,48±18.37, 23±9.26 respectively and mortality for the field strain of Anopheles mosquito in the study period was 100±0.0; 88.5±7.4; 43.8±20.1; and 0.7±0.8 respectively. The Malaria incidence rates for four months after application of Indoor Residual Spray in Sennar State (September, October, November and December 2017) were (5.18±3.4; 5.0±3.3; 4.31±3.1; and 5.15±3.9 respectively). This study found that there was a reduction in the total number of the collected Anopheles gambiae, female mosquito from 143 to 46, in unfed mosquitoes (UF) from 22 to 0, in fresh feed mosquitoes (FF) from 60 to18, in half gravid mosquitoes (HG) from 0.29 to 18, in gravid mosquitoes (G) from 32 to16, in density/room from 4.1 to 1.3, and in Man Biting Rate (MBR) from 2.5 to 0.7.Data analysed using statistical package for social sciences, version (22), Chi- square test used for the analysis of comparison, probability value of less than 0.05 considered statistically significant. The study concluded that there was a reduction in (Anopheles gambiae) density and Malaria cases after Indoor Residual Spray application in Sennar state, Sudan.

Keywords: Bendiocarb 80%; Indoor Residual Spray; Malaria; Sennar State, Sudan

***Corresponding Author**

Mohamed Osman Elamin , Faculty of Public Health and Health Informatics, Umm Al-Qura University, Saudi Arabia.

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1. INTRODUCTION

Malaria is a major public health problem throughout the world and particularly in sub-Saharan Africa.[1] According to the latest World malaria report, released in November 2020; there were 229 million cases of malaria in 2019 compared to 228 million cases in 2018. The estimated number of malaria deaths stood at 409000 in 2019; compared with 411000 deaths in 2018.[2] The WHO African Region carries a disproportionately high share of the global malaria burden. In 2019, the region received 94% of malaria cases and deaths.[3]Children aged under 5 years are the most vulnerable group affected by malaria; in 2019, they accounted for 274000 (67%) of all malaria deaths worldwide.[4]Although Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected female Anopheles mosquitoes, it is one of the preventable and curable diseases.[3]There are about 400 different species of Anopheles mosquitoes, but only 30 of them are the major vectors of mortality and morbidity cases.[4] Historically, the Anopheles gambiae Giles was known as a major vector of malaria in Africa, exhibiting a wide range of biological attributes. Ecologically, it was highly diverse; with feeding patterns indoors or outdoors on humans or cattle, resting indoors or outdoors, and its larvae were found in a wide variety of habitats including rain pools, hoof prints, rice paddies, mineral springs and saline water. In some places, it did not even transmit malaria.[5]The strategies against malaria involve rapid diagnosis and treatment, and stopping disease transmission through vector control, which aims to prevent, interrupt or at least reduce transmission.[6] Malaria vector control is based predominant on the use of residual insecticides through indoor residual spraying (IRS) and insecticide-treated nets.[7]Historically, IRS has been the primary intervention method in vector control efforts.[8] Since its introduction as a vector control tool in 1945, IRS has proven successful in reducing the prevalence and incidence of malaria by reducing the level of transmission through killing or repelling malaria vectors.[9]The use and scaling-up of these methods can significantly decrease malaria morbidity and mortality.[10]The recent recorded results have, contributed to the consideration of malaria elimination as a feasible objective.[11] However, with the development of insecticide resistance, there are serious concerns about the maintenance of the effectiveness of these control measures.[12]The recent success in reducing malaria morbidity and mortality, particularly in African region was achieved through massive scale-up of long-lasting insecticide treated nets (LLIN), Indoor Residual Spraying (IRS) and Artemisinin-based combination therapy (ACT) for treating patients.[13]IRS product effectiveness varies depending on factors including: (i) impact on mosquito populations (for example, an ability to kill or deter mosquitoes from entering a sprayed structure); (ii) impact duration (the residual half-life); (iii) where and when sprays are deployed (local malaria endemicity, seasonality of transmission and timing of IRS, mosquito species, human behaviour and net-use), and; (iv) spray quality and coverage.[14]According to Sudan national malaria plan, IRS is sprayed in two states (Sennar and Aljazeera States), the two state were chosen based on high level of insecticides resistance. Bendiocarb belongs to a class of insecticide known as Carbamates; Bendiocarb disrupts the normal functioning of an insect's nervous system and kills the insects by either contact or ingestion. Moreover, Bendiocarb disrupts the nervous system by interfering with an enzyme necessary for normal nerve transmission.[6]The campaign of IRS conducted in August 2017 (from first of august till 21th) and the other campaign started from latent December 2017 to first of January 2018. In this study, we aimed to evaluate the efficacy of IRS (Bendiocarb 80%) applied in Sennar state, Sudan in which Malaria is endemic.

2. MATERIALS AND METHODS

In Sennar State, Sudan, which is located in south east Sudan, consisted of 7 administrative areas (localities), in which all these 7 localities of the state (town and villages) which is Sennar the capital, Singa, Abuhogar, Elmazmom, Eldinder, East Sennar and Elssuki were covered by IRS of the insecticide using Bendiocarb, which is an acutely toxic carbamate insecticide usedin public
health and agriculture and is effective against a wide range of nuisance and disease vector insects. Two tests were conducted to measure the efficacy of IRS against adult anopheles mosquitoes. The first method was the Pyrethrum Spray Collection method in which six rooms in each locality were selected randomly for pyrethrum spray catches.[7]White sheets were spread over the entire floor of each room, the doors and windows closed and the room was sprayed with 0.2% pyrethrum in kerosene. After 10-15 minutes the dead mosquitoes were collected from the white sheets, mosquitoes are placed in Petri dishes or bottles and dead mosquitoes we recorded in each room and also man biting rate.[8] On the other hand, the second method was conducted by applying Bio - efficacy of IRS using Con method (it is a cone shape plastic placed in walls used to test efficacy of insecticide). We selected one station in each locality randomly, then three houses sprayed by IRS with Bendiocarb insecticide were chosen for each station and one room/house. Four cons/room/house were tested, each containing 10 female sugar fed mosquitoes from reared lab insects. Each con was attached to a sprayed wall for an exposure period of 1/2 hours. One paper cup containing 10 female mosquitoes was used as a control for each room of the house. Temperature and relative humidity were noted at the beginning of the test and after the end of exposure (1/2 hours). Knock down were recorded at the start of the test (at zero time) and after 10, 15, 20, and 30 minutes.

2.1 Laboratory processes

At the end of exposure mosquitoes from each con were put in a cup, after that transferred to Malaria control department laboratory which used for tests, in which every cup provided with sugar solution, and the insect mortality was observed and recorded after 24 hours in the lab.[9]

2.2 Malaria cases

Malaria cases were reported from the health care facilities from each locality, which were distributed to represent all localities.Spray sheet collection method was used to evaluate the efficacy of IRS by using Bendiocarb 80% after one month of its application.

3. STATISTICAL ANALYSIS

Statistical analysis applied after the collection of laboratory data using statistical package for social sciences (SPSS) version 22, and Chi-square tests for comparison.

3.1 Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. The institutional review board of the Ministry of health, Sudan, granted approval under the number 181/2/19.

3.2 Consent to participate

The institutional review board waived the requirement for informed consent.

4. RESULTS

The Efficacy of IRS by using Bendiocarb 0.1% using WHO cons for susceptible and field strain of Anopheles gambiaein Sennar State, Sudan, in which we noticed that there was reduction of the mortality after 24 hours of application of the Bendiocarb IRS in all localities (Table 1). Moreover, this reduction was obvious clearly in November (after 3 months of the application of Bendiocarb IRS as the localities reported (0.33). Sennar locality reported 0.33±0.57;0.00±.00; 1±1.7; 0.6±0.7; 0.33±.57; 1.0±1.0; 1.3±1.2) for Sennar; Senga; East Sennar; Abu-Hogar; Elmaz Mom; and Eldender).

Table 1: WHO cons bio-efficacy test of susceptible and field strain of *Anopheles gambiae* following application of Bendiocarb IRS in Sennar State, Sudan 2017.which was showing Significant relation.

Locality	Month	% Mortality after 24 hours	
		Susceptible strain	Field strain
Sennar	August	100±0.0	100±.00
	September	97±5.7	95.± 5.0
	October	60±42.7	61±53.40
	November	18±7.6	0.33±0.57
Senga	August	97±2.8	100±0.0
	September	95±5.0	85±13.2
	October	50±21.7	63.3±55.0
	November	25±5.0	0.00±.00
East Sennar	August	100±0.00	100±0.00
	September	100±0.00	85±13.2
	October	75±21.7	3.3±5.7
	November	23±7.6	1±1.7
Elssuki	August	100±0.0	100±0.00
	September	95±5.0	75±5.0
	October	5±5.0	5.0±5.00
	November	22±2.8	0.6±0.7
Abu-Hogar	August	100±0.00	100±0.00
	September	92±7.6	93.3±7.6
	October	33±17.5	78.3±2.8
	November	17.6±12.5	0.33±.57
Elmaz Mom	August	97±5.7	100±0.00
	September	93±7.6	92±2.8
	October	100±.00	88.3±7.6
	November	38.3±17.5	1.0±1.0
Eldender	August	100±0.00	100±0.0
	September	95±5.0	95±5.0
	October	5±8.6	7±11.00
	November	18.3±11.54	1.3±1.2
Total	August	99±1.23	100±0.0
	September	95±5.14	88.5±7.4
	October	48±18.37	43.8±20.19
	November	23±9.26	0.7±0.8
P-value		0.05	

Table 1 shows the differences between the Sennar localities and the total susceptible strains and field strains mortality after
24 hours according to the four months in which the IRL applied. We noticed a reduction in the mortality from (23±9.26) to (0.7±0.8).
P value 0.05 indicating statistical significant relation.

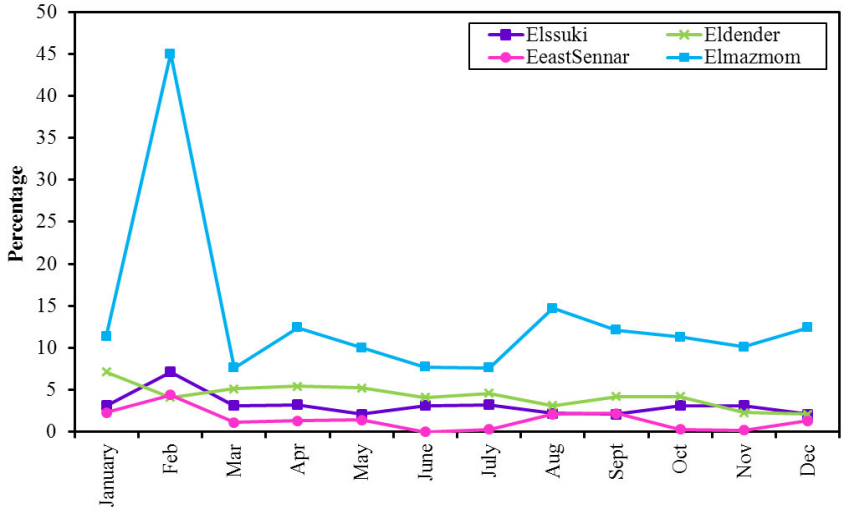

Figure 1 illustrates the differences in the malaria incidence rates pre and post application of the IRL in Sennar localities (four localities namely; Elmaz Mom, Eldender, East Sennar, and Elssuki). There is an obvious reduction in the malaria incidence rates ranging from (5.18±3.4; 5.0±3.3; 4.31±3.1; and 5.15±3.9).

Fig 1: Malaria incidence rate pre and post IRS in Sennar State, Sudan 2017.

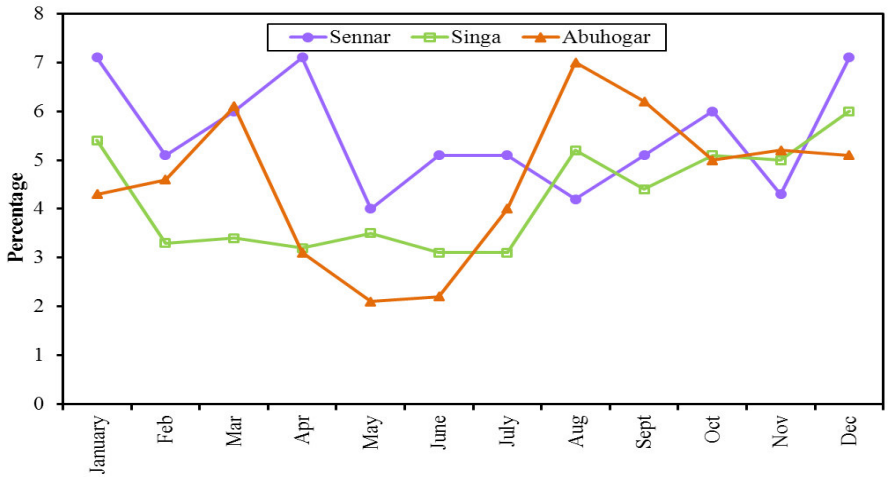

Fig 2: Malaria incidence rate pre- and post-IRS in Sennar State Sudan 2017.

Figure 2 shows the differences in the malaria incidence rates pre and post application of the IRL in Sennar localities (three localities namely; (Sennar),(Singa) and (Abuhogar). There is an obvious reduction in the malaria incidence rates ranging from (7.1±3.4; 6.0±3.3; and 4.87±3.1).In this study, our findings revealed a reduction of 68% of total female mosquitoes in Sennar State, Sudan. Referring to man biting rate, pre and post application of IRS, showed a significant decrease from 2.5 to 0.07 post application, and this most property is due to the application of the IRS . Similar results were found in early researches , which may be attributed directly to the decreasing number of gravid female Anopheles mosquitoes and female Anopheles' density per room.[16-20] Same results observed after using Bendiocarb against Anopheles mosquitoes in Mexico and the Philippines.[15] Moreover, there was a significant reduction of *Anopheles gambiae*through IRS by using Bendiocarb insecticide reported in Benin.[21]Efficacy of IRS by using Bendiocarb 0.1% using WHO cons for susceptible and field strain in Sennar State: During the first month of IRS application the mortality was about 99% in susceptible 104 strain which were decrease in the 2nd, 3rd, and 4th months (95%, 48% and 23 %) respectively, the same trend was observed using field collected Anopheles mosquitoes where 100% mortality was recorded during the first month of IRS and 88% , 43%, and 0.07%) in the 2nd,3rd , and 4th month of IRS (P value 0.01), this finding indicated a decrease in (105-106) efficacy of IRS using Bendiocarb insecticide, and this may be due to several problems in application of IRS in the seven localities of Sennar State, Sudan. Studies stated that the effectiveness of IRS depends on several factors includes, vector resting habits which means the resting behaviours of the vectors during the day, quality of spraying, spray coverage(112-113) susceptibility of the local vector(s) to the insecticide used, and the residual efficacy of the sprayed insecticides.[22]Other factors include the nature of the sprayed surfaces (mud, wood, cement, thatched, etc.) and PH of the sprayed substrates[23] as well as the 9 physicochemical properties of the sprayed insecticide (vapor pressure and volatility).[24]

4.1. Malaria prevalence pre and post application of IRS in Sennar State, Sudan 2017

Malaria cases recorded by Ministry of Health in Sudan during the period of three months of application of IRS by

Bendiocarb showed a decrease in malaria cases as 5.18 per population in September, followed by 4.5 in October and 4.3 in November 2017. This is agreed with the result of similar studies conducted in Sudan and India showed same results of using IRS.[25]A similar result found in Uganda which revealed a decreasing trend in malaria morbidity in the first 3 months following each round of application of IRS, the study was mentioned that highest decrease in the positivity rate was observed in the second month following IRS among patients above 5 years.[26]

5. CONCLUSION

The study concluded that efficacy of IRS by using Bendiocarb 0.1% for susceptible and field strain in Sennar State, were decreasing over time due to several factors like quality of spray, nature of sprayed surfaces, susceptibility of local vectors and other factors.Application of IRS leads to considerable reduction in of total female mosquitoes in Sennar State, Sudan. referring to man biting rate, which can be attributed directly to decreasing number of gravid female Anopheles mosquitoes and female Anopheles' density per room.The study concluded that there was a reduction in *Anopheles gambiae*density and Malaria prevalence after IRS application in (Sennar) State, Sudan using (Bendiocarb 80%) as IRS, and remains efficient at least one month after application.

5.1 Availability of data and materials

All data generated or analysed during this study are included in this published article.

6. AUTHORS' CONTRIBUTIONS STATEMENT

All authors contributed equally to the study conception and design. Walid Adam Eltahir performed material preparation, data collection and analysis. Mohammed Osman Elamin wrote the first draft of the manuscript and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

7. CONFLICT OF INTEREST

Conflict of interest declared none

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