ORIGINAL ARTICLE

Effect of Indoor Residual Spraying on the Incidence of Malaria in Kaoma District of Western Zambia

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ABSTRACT

Background: Indoor residual spraying (IRS), the application of a chemical to the internal walls of the structure in order to kill an insect that sits on the wall treated with such a chemical, is one of the methods adopted by World Health Organisation in combating malaria by controlling the vector mosquito. In line with the Zambian policy on malaria control Kaoma district in Western province of Zambia in 2008, started implementing IRS as the method of combating malaria. The main purpose of the study was to ascertain the effect of indoor residual spraying on incidence of malaria in Kaoma district of Western Province of Zambia.

Materials and Methods: The study was a retrospective cohort analysis of incidence data across a single spray season, mixed with cross sectional survey to assess levels of intervention, community understanding and perceptions, and quality of IRS efforts, which were compared with households sprayed. Interviewees included household heads or the representative. The other party interviewed included the supervisors for the IRS program.

Multistage sampling was used to select respondents from households and probability proportional to size (PPS) was used to select clusters in which respondents were picked. To validate the findings of the study, statistical significance was set at $p < 0.05$.

Results: The study demonstrated that areas with a larger percentage of the population (greater than 60%) protected by Indoor residual spraying had lower incidence of malaria (82/1000 and 400/1000) compared to unsprayed area (398/1000 and 773/1000) both at the beginning and pick of malaria transmission season. A chi-square test shows that there was an association between spraying and reduced malaria incidence, $p < 0.05$. Factors such as length of Insecticide Treated Nets ownership and building material for the house (p-value<0.04 and 0.03) respectively, had an association with the level of IRS acceptance. Acceptance of indoor residual spraying program was good at 64% of the 100% response rate interviewed. Reasons given for those who did not have the houses sprayed among others was absence from home (79%). There was an association between Knowledge of the use for IRS and school attendance p-value < 0.001. Management of the program was poor, negatively affecting results of indoor residual spraying, starting from ill timing (wrong season) to management of commodities such as personal protective equipment, Insecticide, inadequate transport and short notice given to the households.

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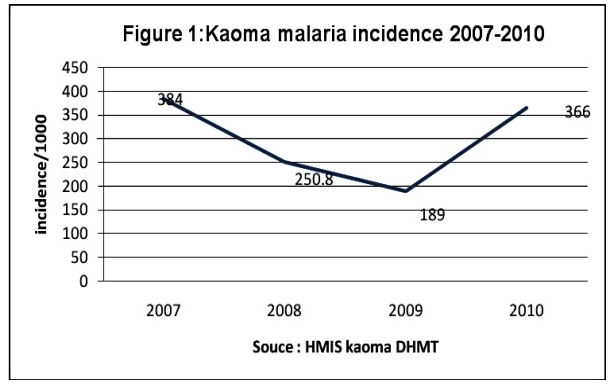
Conclusion: Indoor residual spraying was associated with reduced malaria incidence in Kaoma district in areas where it was implemented. Poor management of the programme, however, negatively affected the results. The district needs to focus on management of logistics, intensify sensitisation and improve on the starting time of IRS if it has to have the desired impact in preventing malaria.

INTRODUCTION

Malaria remains a major cause of poverty and under development. People in malaria regions live at continuous risk of this disease in the infected regions, malaria causes social and economic difficulties to both individual and governments, and it impedes economic growth in endemic countries. Projections show that economic growth per year of countries with intensive malaria was 1.3% lower than that of countries without malaria[16]. The increase in global burden of malaria in the 1950s led to the development of malaria eradication programme, whose aim was to reduce or eliminate malaria[7]. Several interventions were developed and Vector control, through the use of Indoor residual spraying, was recognised to have a significant impact on malaria control[13]. IRS is the application of the internal walls of the houses and structures with a chemical (insecticide) that remains poisonous to mosquitoes for several months once they rest on the walls[18].

In Zambia, over the past 50 years, malaria control has been introduced at various times. These were either strengthened or neglected[12] (MoH, 2011). From 1980 to 2000, relatively limited malaria prevention existed in Zambia because the ban of Dichloro-diphenly-trichloromethane (DDT) coupled with economic difficulties the country was going through[15, 5]. As a result of this, Zambia was not able to replace DDT with another insecticide because of its high cost substitute insecticides. Districts, therefore, resorted to treatment with limited prevention. The two main vector control interventions aimed at preventing malaria transmission recommended by Roll back malaria (RBM) are Insecticide Treated Nets (ITNs) and IRS. IRS was reintroduced in Zambia by the private mining company[15,5]. The goal established by the member states at the World Health Assembly and Roll Back Malaria Partnership, to which Zambia is a member, is to reduce the number of malaria cases and deaths recorded in 2000 by 50% or more by the end of 2010 and 75% or more by 2015 [17] and IRS as a major means of malaria vector control to reduce and eliminate malaria transmission.

Kaoma had by 2010, had 17 out of the 28 catchment areas implementing IRS and managed to spray 92% of the targeted structures and 75% (63 618) presumably protected[19]. The number of structures sprayed is added for each spraying season. With this increased high IRS coverage and expanding program, the incidence of malaria is expected to reduce further in the district. Kaoma, however, has shown an increase in malaria incidence from 189 per 1000 in 2009 to 366 per 1000 in 2010 despite scaling from the initial 7 catchment areas in 2008 to 17 in 2010[19]. The increase in malaria incidence threatened to reverse the achievement attained towards reaching the Millennium Development Goals (MDGs).



MATERIALS AND METHODS

The study was a retrospective analysis of incidence data across a single spray season, mixed with cross sectional survey results to assess levels of interventions, community understanding and perceptions and quality of IRS efforts. The first stage

was retrospective audit of malaria incidence data across a single spray season. The second stage was cross sectional survey to assess levels of intervention, community understanding and perceptions, and quality of IRS efforts, which were compared household sprayed by using two separate semi-structured questionnaires. The other party interviewed included the supervisors for the IRS programme.

Laboratory / RDT malaria test results in health centres in IRS and non-IRS were revealed and compared. The study sites were in Kaoma district of Western of Zambia.

Multistage sampling was used to select respondents from households to whom the questionnaire was administered. In stage one, selection of a systematic-random sample of primary sampling units with probability proportional to size (PPS) was used to select clusters in which respondents were picked. Systematic sampling of households was used to select households to be interviewed in the catchment area. Data collection from Supervisors was purposive. All the 17 supervisors involved in IRS supervision had been targeted. Data of confirmed malaria Incidence for one spray/transmission season August 2011 to August 2012 was collected from the DHIO as submitted to the National Malaria Control Centre.

Household and supervisor survey data was entered and analyzed using STATA version 11 for windows while malaria incidence data was entered and analysed using windows excel. Chi-square test was used to come up with associations. Statistical significance was set at $p < 0.05$.

RESULTS

To compare incidence of malaria in the sprayed areas and areas that were not sprayed, malaria incidence data from 31 health centres and health posts was collected from HMIS districts database. Figure 2 shows that population where more than 60% of households were protected by Indoor residual spraying had lower incidence of malaria (82/1000 and 400/1000) compared to unsprayed area (398/1000 and 773/1000) both at the beginning and pick of malaria transmission season (p-value at 0.05).

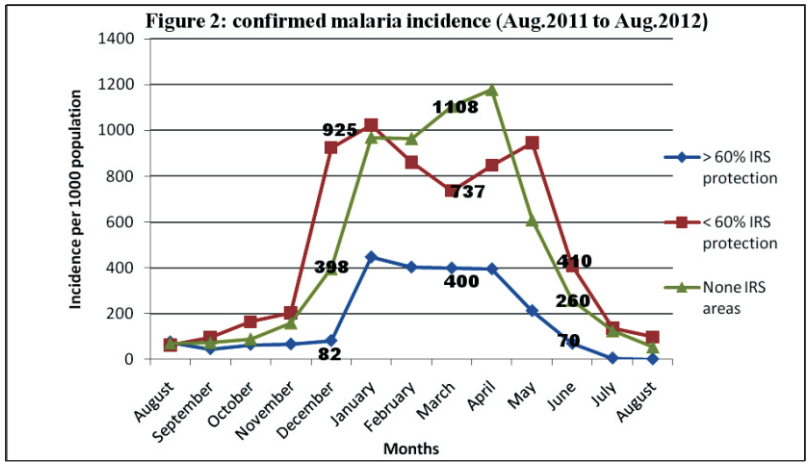


Table 1 shows that there is high level of knowledge of IRS (82%), p-value < 0.001 in those who had been to school than those who had never been (62%). This shows a strong association between having attended school and knowledge of use for IRS.

Table 1: Distribution of Community Knowledge of IRS by school attendance N=252

	Use of indoor residual spraying			
Ever attended School	**killing bugs/roaches**	**killing mosquitoes**	**Didn't know**	**Total**
Never attended school	14(33%)	26 (62%)	2(5%)	42 (17%)
Attended school	22(1%)	173(82%)	15(7%)	210 (83%)
Total	36(14%)	199(79%)	17(7%)	252(100%)

Pearson chi2 (2) = 14.9524 p-value < 0.001

Cross tabulation was done with other variables assumed to have a relationship with household sprayed. The results showed that slightly more than (50.63%) houses sprayed were formal (non porous material) compared to 49.38% informal (porous materials). The chi-square test results of the cross tabulation with type of house, indicated that there is an association between the IRS acceptance (p-value < 0.03) and type of house

The results also show that most (63%) had stayed in the houses for more than 2 years .The length of stay in the house was significantly associated with having the house sprayed (p-value 0.001) .This means that those who stayed longer than 2 years were more likely to have their house sprayed. The study revealed that 51.19% of the household were either self-employed or were famers followed by those in government at 19.84% while 28.97 were unemployed. Occupation was association with the house being sprayed (p-value 0.01).

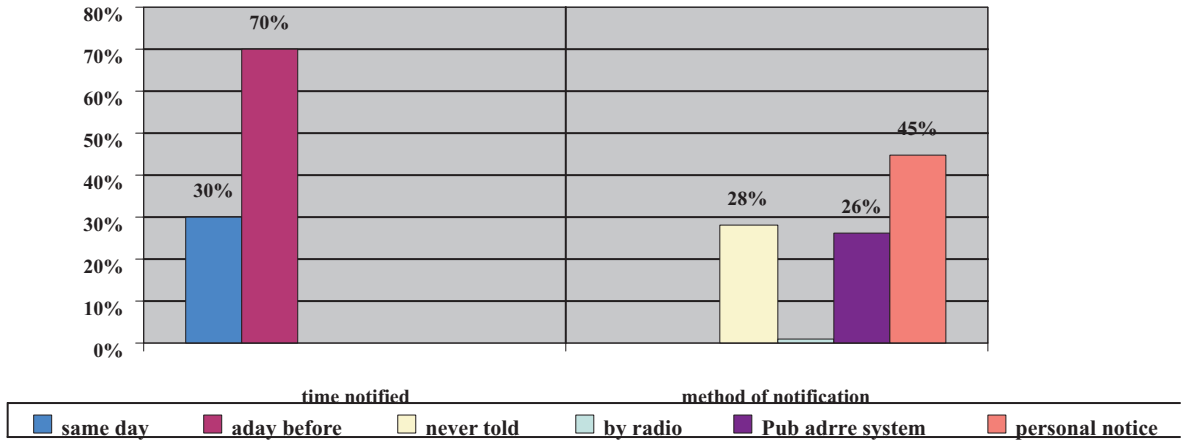
Use of ITN is one of the malaria prevention methods recommended to be used side by side with IRS .The results showed that the majority (57.23 %) of the respondents who reported having their houses sprayed have no ITNs and the converse happens to be true where most (53.26%) of those who did not have their houses sprayed owned at least an ITN. There was no statistical significance (p-value <0.11) of having house sprayed and owning an ITN, therefore, acceptance of spraying the house did not depend on whether one owed an ITN or not.

The IRS status was further tabulated with the number of ITNs owned by the respondents' household and the length one owed an ITN. The results of the cross tabulation of IRS status and the length one owned the ITN indicated that there is an association (p-value<0.04) between the house being sprayed and period one owned and ITN and cross tabulation between the quality of IRS as viewed by the community and the period respondents reported having stayed without mosquitoes showed that there is a relationship (p-value<0.001) between the quality of IRS and the period respondents reported having stayed without mosquitoes. Those who viewed quality of IRS as being good had the longest period without experiencing presence of mosquitoes than those who did not.

Figure 3, shows time and method of notification. About 28% of the respondents indicated receiving no notice; only about 26% were notified through the public address system (Fig.3). In this case poor notification was associated with household acceptance of IRS P < 0.036.

In order to get the views of the quality of management of indoor residual spraying, all the 17 supervisors were interviewed from various spray locations of the district. Despite the ratio of supervisor to operator, being said to be adequate, most (52.94%) of the sprayer operators did not manage to meet the target per day. The main reasons being picked up late to the spray site (41.18%) of the supervisors and high targets as the reason for not meeting the target was not really an issue as shown by the small proportion (5.88%) of the supervisors.

Figure 3 :Time and method of notification for spraying



The majority (76.47%) of the respondents indicated that IRS started in November and (58.82%) indicated the season ended in February and after. About 94%, however, of the supervisors pointed out that the spraying period not being appropriate. In terms of management of commodities, the majority (94.12%) indicated that they did not receive logistics on time. Among these logistics, insecticides, personal protective equipment were pointed out by 29.41% of the supervisors as not having been received on time. Only, about 11.8 % indicated that funds and equipment are not, received on time. Transportation for the exercise was another logistical problem pointed out by 94 % of the supervisors.

DISCUSSION

A comparison of trends in IRS implementing area and non-IRS areas show that IRS implementing areas have less malaria than none-IRS areas. This was evident in the malaria transmission period from November to May. The incidence trend in the more than 60% protection with IRS was lower (81/1000) in December, 2011 when compared with the trend in not sprayed (398/1000) at the beginning of the transmission season. Even at the pick of the malaria transmission season (March 2012) the difference was prominent at 400/1000 to 1108/1000.

The case, however, cannot be said of the malaria incidence in the moderately (less 60% population) protected sprayed areas. The incidence was higher 925/1000 and 945/1000 cases of malaria than in the non-IRS areas 398/1000 and 611/1000 throughout the transmission period except for a brief period after spraying when the incidence was lower (737/1000) than in the non- sprayed areas 1108/1000. The lower incidence of malaria in the moderately protected areas after spraying can be attributed to effect of insecticide on the vector mosquitoes. The effect, however, could not be sustained probably due to the habit of household cleaning walls after 2 weeks of spraying as confirmed by (73.33%) who said that it only took two days for most of the households to clean up after spraying. This could have reduced the effectiveness of the chemical. [3], in his study observed that replastering of walls once or twice led to reduced mortality of anopheles by 27% to 13% respectively. Again only 60% of the houses were sprayed WHO[17] recommends that at least 80% of the structures must be sprayed for the programme to have a significant effect. Andrea, M. R et al [1] supported this in the study who observed that high community coverage of IRS (at 80%) evidently offered the greatest protection from infection. A chi-square test showed that there was a significant difference in the IRS protected area and the non- IRS protected area p-value < 0.05.

In this study, 252 respondents were targeted at household level of which there was 100% response rate. The findings in the study at household levels are that the majority of respondents had attended school (83.33 %) and that there was an association between Knowledge of the use for IRS and school attendance p-value < 0.001. With level of knowledge being high it is expected that the majority fully comprehended the importance of the IRS program. Ministry of Health [11] recommends that high knowledge levels are important in the IRS program as it leads to high acceptance of the program and eventual effectiveness in reducing incidence of malaria in the community.

According to WHO[18], IRS involves application of the internal walls of the house and structure with chemicals (insecticide) that remain poisonous to mosquitoes for several months once they rest on them. This implies that the type of surface where the chemicals are applied matters if the full benefits or effects are to be realized. CDC[2] emphasizes that for IRS to succeed in reducing incidence of malaria, the targeted areas must have high percentage of the structures with adequate sprayable surfaces. The results of this study indicate that about 55.95% of the houses are made of non-porous materials (formal) and 44.05% of porous (informal). Kaoma, therefore, has high percentage of structures with sprayable surfaces and suitable for application of chemicals/IRS. The study showed that there was an association between IRS acceptance and the type of

material the house is built of (p-value < 0.03).Those who stayed in non-porous (formal) houses readily accepted IRS than those informal structures.

Sometimes Spraying was not done due to various reasons among them non-preparedness by occupants. The study revealed that (79%) of those who did not have their houses sprayed pointed out being away from home as the main reason as opposed to staining of walls, chemical smell and irritation as per finding of Mabaso, [7]. The latter reasons, however, did contribute but only to a lesser extent as less than 5 % cited these as reasons for not having their houses sprayed.

Quality of spraying is one indicator that can lead to appreciation of IRS. Among those who rated the quality spraying as good, the longest period without mosquitoes pointed out by the majority was two months and more. An association was found between the quality of spraying and the period stayed by the households without mosquitoes (p-value<0.001).Thus, in cases where respondents rated the quality of spraying as bad, households experienced the absence of mosquitoes only for a short period. Lien[6] showed that In Sao Tome and Principe IRS for malaria control was highly acceptable to the people due to no visible residue remained on the sprayed wall; this underscores the importance of good skills that lead to high acceptance of IRS. It can be concluded, therefore, that the skills of spray operators hence the training was of the right quality.

It must be mentioned that the study revealed that despite high acceptance of IRS, the majority (73.33%) showed that it only took two days for most of the households to clean up the walls following the spraying of houses citing chemical smell as the reason, others cited irritation (41.67%) stained walls (33.33%) and 35.87% other reasons . Cleaning of walls reduces the effectiveness of the chemical against the vector mosquitoes and increases transmission of malaria. Gunasekaran[3], in his study observed that replastering of walls once or twice led to reduced motility of anopheles by 27% to 13% respectively.

Communicating important malaria messages to malaria-vulnerable populations is a key component to improving malaria intervention uptake in the community[10]. It is a requirement that spray operators inform the household on the dos and don'ts as well as the side effects of chemical in use before and after spraying. In the study 90% of the respondents indicated having talked to the sprayer operator before and after the spraying the exercise, an indication that IRS messages were disseminated to the household. MoH[11], however, states that despite the importance of sensitising the community, advocacy and communication activities for behaviour change have not been able to reach all population in need .

Sharp[15] observed that where the program involved the community, achievement was almost 100%; this was attributed to the fact that IEC was done by members of the community prior to the spraying campaign. It should be noted, however, that in this study, 70% of the respondents received notification a day before the spraying exercises while the rest received notification on the same day of spraying. This indicates that households did not receive adequate notice to prepare for IRS. Therefore, indicates poor quality of management of the program. MoH guidelines on IRS implementation requires that notification of households should be done at least a week before implementation[9].

Apart from IRS, other interventions such as ITN program is employed either independently or concurrently with IRS for the programs to complement each other. An evaluation of ITN and IRS revealed that more household (57%) that did not have ITNs were sprayed than (43%) those that did own ITNs. Even though no association was found between acceptance of IRS by household to ITN ownership and the number of ITN owned p-value 0.11 and 0.27, therefore, ITN did not influence household to accept or reject IRS. Those households that owned ITNs were equally as like to have their houses sprayed as those that did not have ITNs.

An association was, however, found between acceptance IRS by households and the length of

time the household owned an ITN (p-value< 0.04). Those households that owned ITNs longer were more likely to have their houses sprayed than those that owned ITNs for a shorter period. Results of further analysis, however, showed that ownership of ITNs is low (46.61%) to have any meaningful impact on incidence of malaria. Like IRS, ITNs can only have a significant impact on malaria incidence if there is 80% or more in the community

Monitoring of spray operators is essential to the great success of the programme, this goes hand in hand with good training. Mamta, [8] In the study of Impact of IRS proved that in spite of the constraints associated with IRS, it still had a major role in the control of malaria if implemented with proper supervision, better coverage and community participation. In this study, majority (94.12%) of the supervisors were trained in IRS supervision and had experience with most (64.71%) of them having more than three years' experience. Sharma[14] in his study observed that application of the correct dosage to have a lethal dose and appropriate residuum effect of the insecticide should be checked by the supervisor. Unsatisfactory results will lead to rejection by the community.

Timing of the spraying period is important as far as implementation of IRS program is concerned. 41.18 % of the supervisor had 11 to 25 sprayer operators under their supervision. This ratio was said to be adequate. The target of houses set for sprayer operator to meet was rated as adequate by 70.59% of the supervisors. It was indicated by 52.94% of the respondents, however, that spray operators failed to meet the target of households per day. Being picked up late to the household was cited as the major reason apart from others.

Ideally, IRS should be done from September to November to avoid the inconvenience brought about by the rains. The results of the study indicate that during the last spraying season (2010/2011), the majority (76.47%) of the respondents indicated that IRS started in November. None, however, reported the activity starting in September. Furthermore, most (58.82%) of the respondents indicated that the spraying season ended in February and after. The majority (94.12%) also stated that the spraying period was not appropriate. The activity went on almost throughout the rain season-the height of the transmission period. This would further explain why some houses were not sprayed, as the owners would have gone to their fields given that most of them are farmers. [14] In his study observed that the refusal rate to have the housing units sprayed, are high if the period is ill timed.

WHO[17] states that IRS is effective in reducing incidence of malaria if the operation is performed correctly, there is existence of infrastructure and programme capacity for implementation .The study reviewed that management of commodities was weak. An overwhelming 94.12% of the supervisors indicated that, commodities such as insecticides, PPEs, funds among others are not received in time. Perhaps what came out strongly was that transport for the exercise is not adequate as indicated by 94.12 % of the respondents, resulting in being picked late for the exercise that contributed to operators not reaching the targets.

It should be noted that WHO recommends that ITNs, IPT and use of appropriate treat be used in addition to other measures in the control of malaria. The role played by these intervention also contribute to reduction in malaria incidence, therefore, these are confounding factors at play in reducing malaria incidence in the community in the study.

STUDY LIMITATIONS

This study had its own limitations mainly to do with the absence of comparative counterfactual elements that could be used to strengthen the argument of lower incidence in the sprayed areas. Testing and positivity rate were not considered to determine the difference in the groups .Lastly limited resources. It is therefore, recommended that for future studies of this nature, testing people at community level, matching people from intervention and control or test people coming to clinics for malaria, ask them about their status and recruit for a period of time would be the best option.

CONCLUSIONS AND RECOMMENDATIONS

Indoor residual spraying was association with reduced malaria incidence in Kaoma district in areas where more than 60% of the population were protected by it .Poor management of the program, however, negatively affected the results. The study clearly demonstrated that IRS activities continued during the rainy season contrary to IRS Zambian guide, activities of spraying should have been completed before the onset of rains. The critical areas the district needs to focus on are management of logistics, intensify sensitisation and improve on the starting time of IRS if it has to have the desired impact in malaria prevention**.**

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