

**SORT IT: MALARIA ELIMINATION SUPPLEMENT****Is there a correlation between malaria incidence and IRS coverage in western Zambezi region, Namibia?**D. R. Mumbengegwi,¹ H. Sturrock,² M. Hsiang,^{2,3,4} K. Roberts,² I. Kleinschmidt,^{5,6} M. Nghipumbwa,⁷ P. Uusiku,⁷ J. Smith,² A. Bennet,² W. Kizito,⁸ K. Takarinda,^{9,10} S. Ade,⁹ R. Gosling²<http://dx.doi.org/10.5588/pha.17.0077>

Setting: A comparison of routine Namibia National Malaria Programme data (reported) vs. household survey data (administrative) on indoor residual spraying (IRS) in western Zambezi region, Namibia, for the 2014–2015 malaria season.

Objectives: To determine 1) IRS coverage (administrative and reported), 2) its effect on malaria incidence, and 3) reasons for non-uptake of IRS in western Zambezi region, Namibia, for the 2014–2015 malaria season.

Design: This was a descriptive study.

Results: IRS coverage in western Zambezi region was low, ranging from 42.3% to 52.2% for administrative coverage vs. 45.9–66.7% for reported coverage. There was no significant correlation between IRS coverage and malaria incidence for this region ($r = -0.45$, $P = 0.22$). The main reasons for households not being sprayed were that residents were not at home during spraying times or that spray operators did not visit the households.

Conclusions: IRS coverage in western Zambezi region, Namibia, was low during the 2014–2015 malaria season because of poor community engagement and awareness of times for spray operations within communities. Higher IRS coverage could be achieved through improved community engagement. Better targeting of the highest risk areas by the use of malaria surveillance will be required to mitigate malaria transmission.

Indoor residual spraying (IRS) is an effective vector control intervention for controlling malaria transmission. IRS and long-lasting insecticidal nets (LLINs) are part of the World Health Organization (WHO) recommended integrated vector management strategy.¹ Adequate coverage and proper use of LLINs and IRS reduce the density of indoor-resting mosquitoes, man-mosquito contact and malaria infection.² IRS kills mosquitoes as they rest within sleeping structures or repels them before they feed. IRS works at community level: the greater the coverage, the more effective it is, as fewer mosquitoes survive long enough to become infective.

Studies have shown IRS to be an effective strategy for preventing malaria infection and mortality across a range of transmission settings.^{3–7} Low coverage and poor quality of IRS can limit the impact on the transmission of malaria, however, as IRS is only effective if vectors are susceptible to the insecticide used.⁸ Modelling studies have suggested that coverage of >80%

in low-transmission areas and >90% in high-transmission areas is sufficient to curtail indoor transmission of malaria.⁹ The WHO also recommends ≥85% coverage in targeted areas for IRS to be effective.¹⁰ To date, however, few reports have shown the relationship between IRS and malaria incidence and parasite infection.^{11,12}

In August 1965, IRS using 75% dichlorodiphenyl-trichloroethane (DDT) wettable powder was introduced to control malaria in Namibia. In the 1990s, deltamethrin was introduced as a secondary insecticide to DDT. The country has sustained IRS using the two insecticides, co-ordinated by the Namibia Ministry of Health and Social Services (MoHSS) through the National Vector-Borne Disease Control Programme (NVDCP), before the rainy season on an annual basis.¹³ All sprayable surfaces of all targeted structures in targeted areas are sprayed between October and December to achieve a minimum coverage of 95% of sprayable structures. The insecticides used are expected to last for the whole transmission period on sprayed walls and ceilings in sleeping structures. Only those insecticides that have been recommended by the WHO Pesticide Evaluation Scheme for IRS and registered in the country are utilised for IRS in Namibia.¹³ Vectors are endophilic and therefore susceptible to IRS. Monitoring and evaluation is a continuous process, with the purpose of correcting and improving actions through planning and re-planning and determining effectiveness.¹³

Namibia has experienced a tremendous decrease in reported malaria cases, from 538 512 cases in 2001 to 4745 in 2013.¹⁴ Ongoing interventions, including IRS, have contributed to this decline. During the same period, malaria deaths decreased by 98%, from 1728 per year to 36, far surpassing the WHO targets to reduce malaria-related deaths by 50%.¹⁴ These achievements are particularly noteworthy, given that 72% of Namibia's population lives in malarious areas. This success, however, has plateaued over the last few years.¹⁴ For Namibia to meet its target of national malaria elimination by 2020, it is essential to focus elimination strategies on health districts with tropical climates and the remote locations reporting the most malaria cases, including the Zambezi region.

In 2013, the Zambezi region reported 2564 malaria cases, and was the second most malarious region in the country, with an annual incidence of approximately 26.2 malaria cases per 1000 residents.¹⁴ As else-

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where in Namibia, IRS is the primary means of malaria vector control. Historically, the predominant malaria vectors in Namibia were *Anopheles arabiensis*, *An. gambiae* and *An. funestus*. Studies in the past 10 years, however, have shown only the presence of *An. arabiensis*.¹⁵ One of the challenges is that the administrative coverage, i.e., the IRS coverage routinely reported by the health districts to the MOHSS, is not always verifiable, and may be lower than the actual proportion of structures sprayed. A complete household enumeration (census) was conducted in western Zambezi region in 2015, and questions were raised about IRS. It is frequently speculated that administrative coverage may be low due to lack of access to structures for spraying and even refusal of access by home owners.¹⁶ The present study aimed to 1) compare reported IRS coverage from the household census with administrative IRS coverage, 2) examine the correlation between administrative IRS and reported malaria cases, and 3) identify reasons for IRS non-uptake in western Zambezi for the 2014–2015 malaria season.

METHODS

Study design

This was a descriptive study.

General settings

Namibia, a country in south-western Africa with a population of 2.2 million, has several ecological zones, with the northern parts of the country conducive to seasonal malaria transmission.

Study settings

Zambezi (formerly known as Caprivi) is one of Namibia's 14 political regions, and is divided into six constituencies. The study was conducted in Kongola, Linyanti, Sibinda and Judea Lyaboloma, constituencies of western Zambezi that are in the catchment areas of Batubaja, Chetto, Chinchimani, Choi, Kanono, Kasheshe, Linyanti, Masokotwane, Sesheke, Sangwali and Sibinda health centres (Figure 1). The semi-tropical Zambezi region comprises one health district out of 34 nationwide, and is situated in the north-east of the country. It is a major transit point that shares borders with Angola, Botswana, Zambia and Zimbabwe.¹⁶ Zambezi is also the wettest region of Namibia, and malaria transmission occurs mostly during the rainy season (December–June), when rainfall ranges from 1100 mm to 1400 mm and temperatures are as high as 40°C. More than 99% of reported malaria cases are caused by *Plasmodium falciparum*. The terrain is heavily vegetated, mostly composed of swamps, floodplains, wetlands and deciduous woodlands. According to the National Population and Housing Census of 2011, the Zambezi region has a total population of 98 000.¹⁷

Study population

The study population comprised the villages in the Kongola, Linyanti, Sibinda and Judea Lyaboloma constituencies and the malaria cases reported at the corresponding clinics in the 2014–2015 malaria seasons.

Data collection tools and methods

The study was a desk review of MoHSS data for administrative IRS coverage (a household survey on reported IRS coverage) and analyses of reported MoHSS malaria cases from the relevant clinics for the 2014–2015 malaria season.

IRS coverage

IRS was carried out annually in the study area, with DDT spraying in rural areas and deltamethrin usage in urban settings.

Administrative coverage

Spray coverage for the study area was obtained from the MoHSS IRS records and was based on the proportion of structures reported to have been sprayed as of September 2014 for each village within each of the four constituencies. These data were compiled in September 2014 (the number of structures sprayed/number of sprayable structures), before the start of the 2014–2015 malaria season (October 2014–May 2015). These IRS coverages are routinely documented by the environmental health office for each village within each constituency of Zambezi region.

Household reported indoor residual spraying coverage

All households in the four selected constituencies were eligible for the survey. If present, a member of the household was approached and asked if he/she would be willing to take part in the survey. If written consent was obtained, a brief questionnaire regarding whether their structures had been sprayed, the last time they were sprayed, and, if not sprayed, the reasons why. Self-reported IRS coverage was determined by visiting all households in the study area between October 2014 and May 2015 using the 2011 census data as a guide. The household global positioning system (GPS) location was also documented. Reported IRS coverage was calculated based on the proportion of sampled and visited households that had been sprayed in the 12 months prior to the 2014–2015 malaria season.

Recording of malaria cases

Data on all malaria cases reported in the 2014–2015 malaria season (October 2014–May 2015) using the weekly surveillance system were collected for each clinic and health facility within the catchment area of each constituency. These data were used to determine the number of cases per constituency and to generate a map to visualise spatiotemporal variation in malaria cases at clinics in the study area using ArcGIS (Esri, Redlands, CA, USA) mapping software.

Analysis and statistics

Numbers and proportions were used to describe the reported and administrative IRS coverage and the reasons for households not being sprayed. Administrative IRS coverage per constituency was calculated as the mean of reported IRS coverage for each village in each constituency in Zambezi region. Reported malaria cases per constituency were used to determine the malaria incidence per 1000 population. All data were entered into Epi Info (v. 7.2, Centers for Disease Control

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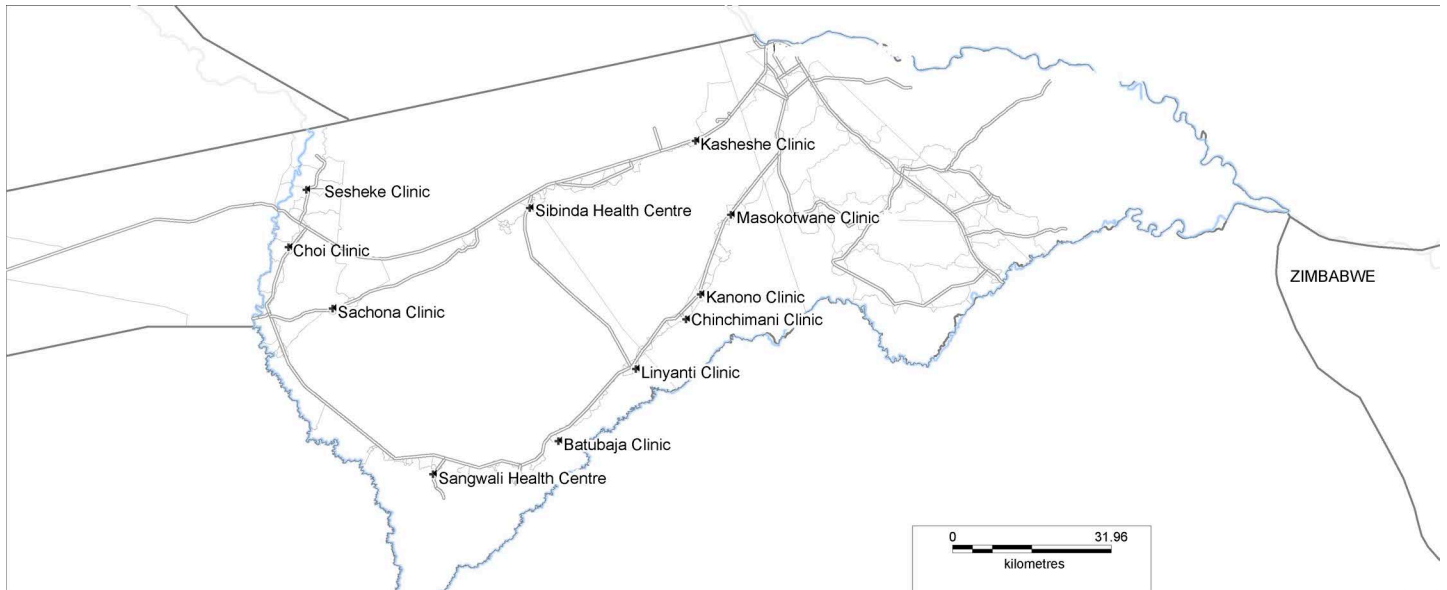


FIGURE 1 Study area in western Zambezi region, Namibia.

and Prevention, Atlanta, GA, USA), checked for entry errors and analysed using Pearson's product-moment correlation coefficient to calculate the strength and direction of the linear relationship between reported malaria incidence and reported IRS coverage. *P* values were set at 5% levels of significance.

Ethical approval

Permission for this study was obtained from the MoHSS Biomedical Research Ethics Committee, the University of Namibia Research Ethics Committee (Windhoek, Namibia) and the Ethics Advisory Group of the International Union Against Tuberculosis and Lung Disease (Paris, France).

RESULTS

Administrative IRS coverage was low in all the constituencies, with coverage ranging from 42.3% to 52.2%. Reported IRS coverage in the four constituencies was low in all the constituencies, ranging from 45.9% to 66.7%, based on household coverage (Table 1). Both administrative and reported IRS coverage fell below the recommended WHO coverage of $\geq 85\%$ in targeted areas for IRS to be effective,¹⁰ as well as the suggested coverage of 80% in low-transmission areas.⁹ A direct comparison cannot be made with administrative coverage for the constituencies, but actual

TABLE 1 Administrative IRS coverage by constituency in western Zambezi region for the 2014–2015 malaria season, based on Namibia MoHSS records

Constituency	Administrative spray coverage* %	Reported spray coverage† %
Sibbinda	52.2	56.8
Linyanti	50.3	45.9
Judea Lyamboloma	45.8	66.7
Kongola	42.3	52.5

*Coverage based on structures sprayed.

†Coverage based on households sprayed.

IRS = indoor residual spraying; MoHSS = Ministry of Health and Social Services.

coverage was more heterogeneous. In addition to whether or not households were sprayed, the survey documented the reasons given for why they had not been sprayed (Table 2).

The two main reasons for households not being sprayed were that the residents were not home at the time of spraying (42.9%) and that spray operators did not visit the households (20.2%). Information from 10% of the households was not available, however.

Figure 2 shows the mapping of malaria cases reported at health facilities in western Zambezi region, as derived from the MOHSS weekly reporting system for the 2014–2015 malaria season, while Table 3 shows malaria incidence for each clinic. The clinics in the north-western parts of the region—Choi, Chetto, Sesheke and Sibbinda clinics—received more malaria cases than those in the eastern and southern parts of the region. The north-western health facilities are geographically nearer to higher malaria transmission areas, including Kavango Region in the west and Angola to the north.

The incidence of malaria in the villages in the health facilities' catchment area did not show a significant correlation with actual IRS coverage ($r = -0.45$, $P = 0.224$), although a trend was observed of lower incidence generally occurring at higher IRS coverage areas (Figure 3).

TABLE 2 Reasons given for no IRS coverage of households in western Zambezi region, Namibia, for the 2014–2015 malaria season

Reason unsprayed	<i>n</i> (%)
Do not like the appearance or smell	22 (1.5)
The sprayers did not come	293 (20.2)
Was away from the house when sprayers came	613 (42.2)
The structure was locked/inaccessible at the time	77 (5.3)
Do not like the attitude of the sprayers	1 (0)
We don't have any malaria in this village/neighbourhood	24 (1.7)
It is not effective against mosquitoes	147 (10.1)
Do not know	29 (2)
Other	248 (17)

IRS = indoor residual spraying.



FIGURE 2 Map of western Zambezi region, Namibia, showing the distribution of malaria cases by health facility for the 2014–2015 malaria season.

DISCUSSION

This study focused on IRS coverage and its effect on malaria incidence in western Zambezi region. It has been established from historical programme data that IRS has an impact on malaria transmission, although the impact has not been quantifiable in different transmission settings.²⁰ IRS coverage in western Zambezi region is low, below the WHO recommended coverage of at least 85%, with the main reasons being that people were away from their homes when the sprayers came or that the sprayers did not visit homes as scheduled through public service announcements broadcast on the radio. This shows a lack of coordination between the spray operators and community members prior to the IRS visits.

The strengths of the study include the thorough representation of household census data, as almost every household in the study area was interviewed. Information could not be collected from 10% of the households due to absences at the time of the

survey. The survey showed that one of the reasons for low IRS coverage was a lack of access to the structures to be sprayed. This may have been due to a low prioritisation of IRS by the communities. The spraying period also corresponds to the period for preparing fields before the rainy season, which may be seen as a greater priority by community members. There may be a need for more education on the importance of malaria interventions, especially IRS. In Zanzibar, a low-transmission country moving towards malaria elimination, it was reported that the purpose of IRS was unclear to both accepting and non-accepting households.²¹ The coordination between communities and spray operators, as well as logistical challenges, are factors in missing the IRS targets. The spray schedule did not have fixed dates for each village, resulting in some household owners being absent when sprayers arrived. Community engagement can raise the awareness of IRS as a malaria intervention as well as provide a platform for coordination of IRS between communities and the MoHSS.

TABLE 3 Malaria incidence in western Zambezi region, Namibia, by health facility, for the 2014–2015 malaria season

Health facility	Malaria incidence per 1000 population <i>n</i>	Self-reported IRS coverage %
Batubaja clinic	1.7	63.0
Chinchimani clinic	4.6	44.4
Choi clinic	21.0	57.2
Kanono clinic	0.6	66.8
Kasheshe clinic	6.6	59.7
Linyanti clinic	0.9	57.8
Masokotwani clinic	3.0	57.8
Sachona clinic	5.7	59.6
Sangwali health centre	2.1	65.9
Sesheke clinic	15.8	41.8
Sibinda health centre	9.7	61.7

IRS = indoor residual spraying.

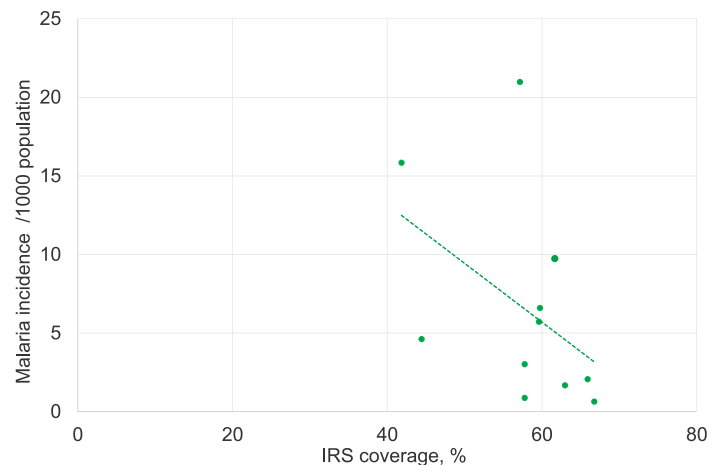


FIGURE 3 Correlation of malaria incidence and IRS coverage in western Zambezi region, Namibia, for the 2014–2015 malaria season. IRS = indoor residual spraying.

IRS is conducted in all areas where there is a risk for malaria, endophilic and endophagic malaria vectors and permanent housing structures. The prioritisation of IRS for villages deemed at higher risk may result in villages around other facilities being considered at lower risk and therefore missed during the spray campaigns. This approach can lead to poorly understood target-area boundaries during field operations, with spray objectives not being achieved.²⁰ The use of health facility data to target IRS may also not always reflect the source of malaria, as these data are aggregated and may miss transmission hotspots.²¹ Furthermore, the health facility data do not take into account the treatment-seeking behaviour of individuals residing further away from the health facilities. The malaria incidence for clinics was based on the assumption that individuals sought treatment from the clinics in whose catchment area they were (usually the nearest) when sick. In Zambia, the decline in the burden of malaria was not associated with IRS coverage at the district level.¹⁷

The MoHSS, however, has now adopted an IRS approach that is guided by geographic information system (GIS) based enumeration and geo-tagging of all IRS activities to improve accuracy. Improved targeting of IRS can also be achieved through the use of risk maps based on household data that highlight entomological risk.¹⁸ The aim of IRS is to eliminate transmission foci by killing the *Anopheles* mosquito species, and targeting transmission hotspots that are likely to have the highest mosquito density and may lead to a greater impact on transmission.²¹ Targeting based on malaria incidence alone does not necessarily target households and populations who would most benefit from IRS. A GIS-based system to identify each targeted household will improve IRS planning, operations, logistics and advocacy, and permit real-time monitoring of spray coverage. It also has the added benefits of being cheaper, faster and requiring fewer human and financial resources.²¹

This study cannot address the impact of IRS because of the effect of other interventions, such as LLINs, and risk factors for malaria transmission such as proximity to Angola and the east Kavango regions (Sesheke and Choi clinics), where malaria transmission is high. Pleuss et al. conducted a review of the impact of IRS trials and reported that there were too few studies to quantify the size of the effect in different transmission settings.⁶ According to the MoHSS, areas are often prioritised for IRS in response to high malaria incidence. This can result in 'reverse causation', leading to high incidence and high IRS being counter-intuitively associated, and can result in an apparent dilution of the protective effect of IRS due to higher baseline incidence in areas given high spray coverage. In this study, the number of units of analysis made it difficult to establish a robust statistical association between high malaria incidence and low IRS coverage.

The limitations of this study are that the data set covers only one malaria season, which is too short to generalise on long-term trends linking IRS and malaria incidence and the requisite statistical power for regression analysis. Malaria cases were diagnosed by rapid diagnostic testing, which has limited sensitivity and may miss individuals with low parasitaemia, a phenomenon that increases in low transmission settings.¹⁷

CONCLUSION

IRS coverage in western Namibia was low during the 2014–2015 malaria season because of poor community engagement

and awareness prior to spray operations as well as poor use of malaria incidence data from health facilities for planning. The use of GIS-based enumeration data to target structures is recommended for scheduling of spraying and community engagement prior to implementation. Geo-tagging of all IRS activities will improve coverage and therefore impact IRS as an intervention to eliminate transmission foci. Furthermore, mapping of malaria cases at household level will allow identification of transmission hotspots so they can be prioritised for IRS. If Namibia is to achieve its goal of eliminating malaria, IRS coverage and surveillance needs to be stepped up considerably.

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Contexte : Une comparaison des données de routine du programme national de lutte contre le paludisme de Namibie (rapportées) et des données d'enquête dans les foyers (administratives) relatives à la pulvérisation d'insecticide à effet rémanent (IRS) dans la région ouest du Zambèze, en Namibie, pour la saison 2014–2015 du paludisme.

Objectifs : Déterminer 1) la couverture de l'IRS (administrative et rapportée), 2) son effet sur l'incidence du paludisme, et 3) les raisons de la non couverture de l'IRS dans la région ouest du Zambèze, Namibie, pendant la saison 2014–2015 du paludisme.

Schéma : Une étude descriptive.

Résultats : La couverture de l'IRS dans la région ouest du Zambèze a été faible, allant de 42,3% à 52,2% pour la couverture administrative contre 45,9% à 66,7% pour la couverture rapportée. Il n'y a pas eu de corrélation significative entre couverture de l'IRS et incidence du

paludisme dans cette région ($r = -0,45$; $P = 0,22$). Les raisons majeures pour lesquelles les foyers n'ont pas bénéficié de pulvérisations ont été l'absence des résidents à leur domicile lors de la pulvérisation ou, inversement, la non-venue des opérateurs de pulvérisation dans les foyers.

Conclusions : La couverture de l'IRS dans la région ouest du Zambèze, Namibie, a été faible pendant la saison 2014–2015 du paludisme en raison de l'engagement médiocre de la communauté et de la méconnaissance des dates d'opérations de pulvérisation dans les communautés. Une couverture plus élevée de l'IRS pourrait être obtenue avec un meilleur engagement de la communauté. Un meilleur ciblage des zones à risque les plus élevés en utilisant la surveillance du paludisme sera requis pour atténuer la transmission du paludisme.

Marco de referencia: Una comparación de los datos corrientes del Programa Nacional contra el Paludismo de Namibia (notificados), con los datos de una encuesta domiciliaria (administrativos) sobre la fumigación de interiores con insecticidas de efecto residual (IRS) en la región occidental de Zambezi en Namibia, durante la temporada de paludismo del 2014–2015.

Objetivos: Determinar 1) la cobertura de la IRS (administrativa y notificada), 2) su efecto sobre la incidencia de paludismo, y 3) las razones de la falta de IRS en la región occidental de Zambezi, en Namibia, durante la temporada de paludismo del 2014–2015.

Método: Un estudio descriptivo.

Resultados: La cobertura de la IRS en la región occidental de Zambezi fue baja, del 42,3% al 52,2% según la cobertura administrativa, en comparación con el 45,9% al 66,7% según la cobertura notificada.

No se observó una correlación entre esta cobertura y la incidencia de paludismo en la región ($r = -0,45$; $P = 0,22$). Las principales razones por las cuales no se fumigaron los domicilios fueron que los residentes no se encontraban presentes en el momento de la fumigación o que los operadores de fumigación no visitaron los hogares.

Conclusiones: La cobertura de la fumigación de interiores con insecticidas de efecto residual en la región occidental de Zambezi, en Namibia, fue baja durante la temporada de paludismo del 2014–2015 por falta de participación comunitaria y de conocimiento de los horarios de fumigación en las comunidades. La cobertura se puede ampliar si se fomenta el compromiso comunitario y es necesario dirigir mejor las campañas a las zonas de mayor riesgo, según lo indiquen los datos de la vigilancia del paludismo, con el propósito de disminuir la transmisión de la enfermedad.