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Ending the Epidemic of Malaria in Nigeria Towards Attaining SDG Target 3.3.3: A Systematic Review of the Progress in Intervention Coverage

Henry Omoregie Egharevba[1], Margaret Idongesit Ekpenyong[2]

[1] Consultancy Service Unit, National Institute for Pharmaceutical Research and Development (NIPRD), Abuja Nigeria. Email: omoregieegharevba@yahoo.com
[2] Research Clinic, National Institute for Pharmaceutical Research and Development (NIPRD), Abuja Nigeria. Email: megprid@yahoo.com

Correspondence: Henry Omoregie Egharevba. Email: omoregieegharevba@yahoo.com; Tel: +234 805 155 9005

Abstract
Background: Meeting SDG 3, 'healthy lives and well-being for all,' is one of the bedeviling challenges of low-/medium income countries like Nigeria whose health index is adversely impacted by the burden of malaria, an epidemic that seems to have defied all interventions aimed at eliminating it and achieving the SDG target. A confounding problem in the efforts so far is the apparent inability to expand and sustain interventions coverage. This review systematically examines available evidence to determine if the current level of malaria intervention coverage in Nigeria could help achieve the SDG target 3.3.3. Methods: Data were systematically extracted through online search of ProQuest databases and BioMed Central website for publication between 1st January 2015 and 3rd February 2024. Of the 26 potential articles that met the inclusion criteria, 12 were selected for quality assessment using the CASP checklist. Seven of the studies reported coverage for seasonal malaria chemoprevention (SMC), while coverage for insecticide-treated nets (ITNs) or long-lasting insecticide-treated nets (LLINs) interventions was reported by 6 of the publications. One study each reported coverage for indoor-residual spraying (IRS) and rapid diagnostic tests (RDTs). The findings were thematically discussed. Findings: The included studies were 1 systematic review (SR), 7 randomized controlled trials (RCTs) and 4 household or community campaigns/surveys. Apart from one study, all the others raised questions of external validity due to the small sample size. The descriptive statistics of the evidence showed that the mean intervention coverages for SMC, ITNs/LLINs, IRS, and RDTs, were 40.31%, 50.02%, 51.1% and 39.67%, respectively. Conclusion: The current intervention coverage is not adequate to meet the National Malaria Elimination Programme (NMEP) vision/goal of 0:10:5:80:80 and the SDG targets 3.3.3 set for the elimination of malaria by 2025 and 2030, respectively. An incremental minimum annual coverage of about 6.3% is needed over the next 6 years to meet 80% coverage for SMC. The same trajectory is estimated for other intervention components.

Keywords: Malaria, Epidemic, SDG Target 3.3.3, Intervention Coverage, Nigerian NMEP

1. Introduction

The Sustainable Development Goals (SDGs) were proclaimed in 2015 by the United Nations General Assembly (UNGA) in a resolve to improve the collective human development index (HDI) within a sustainable environment and climate while promoting equity and equality. Health is a human right and hence Goal 3 of the SDG is targeted at ensuring good health and well-being of all (INGEV, 2019; Pendar *et al.*, 2020). SDG goal 3, "to ensure healthy lives and promote well-being for all at all ages," primarily focuses on improving reproductive, maternal, neonatal and child's health (RMNCH); communicable diseases primarily Malaria, TB and HIV/AIDS; and noncommunicable diseases including cardiovascular diseases and diabetes, through a complex and intricate matrix of healthcare interventions and reducing inequities and inequalities across multiple social sectors which impact healthcare access and delivery (De Neve and Sachs, 2020).

In Nigeria, lower medium-income country, where about 39.1% live in monetary poverty and about 47.3% live in multidimensional poverty, communicable diseases especially malaria, tuberculosis, and HIV/AIDS are responsible for high disease burden, and pose a difficult challenge for SDG goal 3 (Abdulrahman, 2023; IBRD and WB, 2022). Recognizing this high burden, the country's authorities instituted several programmes and interventions toward tackling the problems of communicable diseases and meeting the SDG targets. For instance, the NMEP set up to tackle the epidemic of malaria (OSSAP-SDG and UNICEF, 2022). While there seemed to be a general improvement and decline in the prevalence data for some of these diseases, realizing the SDG target 3.3 – "end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases," remains a mystifying dream due to the protracted challenge of malaria epidemic, giving room for serious concern on the feasibility of meeting the SDG target 3.3.3 aimed at eliminating malaria from endemic countries like Nigeria.

Malaria remains a leading contributor to the global burden of diseases with estimated cases and death toll of 249 million and 608,000 in 2022, and 247 million and 619,000 in 2021 (WHO, 2023a). The SDG target 3.3.3 aims to "reduce malaria case incidence by at least 90%; reduce malaria mortality rates by at least 90%; eliminating malaria in at least 35 countries by 2030; preventing a resurgence of malaria in all countries that are malaria-free" (WHO, 2023a,b; OSSAP-SDG and UNICEF, 2022). Malaria is a hyperepidemic disease in Nigeria, and nearly everyone (97%) is at risk of the infection. The World Malaria Report 2023 showed that Nigeria contributed 27% and 31% to global incidents and deaths, respectively, making her the leading global contributor to the disease burden (WHO, 2023a). The 2018 Nigeria Demographic and Health Survey (NDHS) estimates the prevalence of malaria parasitaemia in children under-five as 23% (a decrease from 27% in 2015), and a mortality rate of 132 per 1000 live birth. Socioeconomic difference in malaria prevalence reveals a prevalence ranging from 16% in the South-South and South-East Zones to 34% in the North-West Zone; and a rural and urban prevalence of 31% and 13%, respectively (PMI, 2022, p. 13). Malaria is mostly responsible for the huge loss of work days and manhours among the country's working population. Evidence suggests that Malaria prevalence runs alongside poverty and underdevelopment (RBM Partnership and UNOPS, 2021).

Eliminating Malaria is a public health priority in Nigeria. Several strategies have been activated in the fight against malaria over the past two decades to varying degrees of success and effectiveness. Some of these strategies include SMC and/or mass administration of medicines including Intermittent Preventive Treatment in Pregnancy (IPTp); and vector control measures such as the use of ITNs and/or LLINs, IRS; and Larva Source Management (LSM) (Omojuyigbe *et al.*, 2023). The Nigerian NMEP with a vision of a malaria-free Nigeria, has a goal to attain a parasite prevalence <10% and malaria-related mortality of <50 deaths per 1,000 live births by 2025. Its primary intervention objectives include to "improve access and utilization of vector control interventions to at least 80% of targeted population by 2025" and to "ensure the provision of chemoprevention, diagnosis and appropriate treatment for 80% of the target populations at risk by 2025" (NMEP, 2024). The vision and goals of NMEP which is zero malaria, <10 parasite prevalence, <50% malaria-related deaths per 1000 live births, 80% vector control intervention access/utilization, and provision of chemoprevention/diagnosis/treatment to 80% of the population, could be summarized as 0:10:5:80:80. This vision/goals have two key intervention coverage targets of 80% of the population. The primary challenges of malaria elimination programmes have been identified as intervention coverage, and adherence to treatment, and sustainability of programme through funding and availability of

materials (Haileselassi *et al.*, 2023). For instance, ITNs ownership in Nigeria seems to have reached its crescendo with households' access to ITNs reduced from 50% in 2016 to 47% in 2018 (Omojuyigbe *et al.*, 2023). Only about two-thirds of the states regularly undertake mass campaigns for ITN use every three years, and only about 13.8% of cases are being tested. The final intervention evaluation report by MEASURE Evaluation, US-President's Malaria Initiative (PMI) in 2017 also indicates palpable gaps in household access to ITNs, IPTp and RDTs and SMC, as well as the availability of all essential commodities at health facilities (PMI, 2017). A 90% reduction on the 2015 baseline data means reducing parasitemia and prevalence to 4.5% and 2.7% respectively in children under-five. Considering this low intervention coverage for ITN, diagnosis and treatment against the set target of 80% by NMEP, there is much ground to cover to meet the SDG target 3.3.3 (Omojuyigbe *et al.*, 2023).

It is against this milieu that the research question, "is there any evidence that the current level of malaria intervention coverage can help reduce malaria case incidence and mortality by 90% each in Nigeria by the year 2030", has become very pertinent. Using the population, exposure and outcome (PEO) model, the research question was framed to carefully attempt to examine the people living in Nigeria's geographic location as the population; malaria control measures directly targeted at parasite and vector elimination as the exposure; and the coverage of intervention or its effect on parasite prevalence as the targeted outcome.

This systematic review aims to evaluate the available evidence on malaria intervention coverage with the view of assessing the possibility of meeting the SDG 3.3.3 targets based on the current trends. The review will attempt to discuss the validity and reliability of evidence and provide evidenced-based interpretations that could guide public health policy and practice in the field of malaria research and interventions, specifically, on the coverage of SMC and vector control measures. Coverage under this context will be taken as the proportion of the participants that completed the treatment regimen or the intervention programme as predetermined by the investigators.

2. Methods

2.1. Search Process

Keywords and phrases relating to the research question were searched in online ProQuest databases (British Nursing database and ProQuest Central databases) and BioMed Central (BMC) journal website. Boolean (OR, AND, NOT), truncation and wildcard searching (*, ?, #), and phrase searching were conducted based on ProQuest databases using keywords and phrase including from malaria interventions coverage in Nigeria and intervention commodities or programmes like "antimalaria drug", SMC, INTs, IRS, RDTs, etc. The phrase used in the BMC journal website search was "Malaria intervention coverage in Nigeria." Initial searches based on titles were screened based on the inclusion/exclusion criteria to arrive at the articles included in the final analysis, as depicted in the PRISMA flow diagram in Figure 1 (Page *et al.*, 2021). The included articles were assessed for quality of evidence using information from the full texts including author, year of publication, title and aim of study, intervention, comparator, main findings, and coverage.

2.2. Inclusion criteria

i. Studies/interventions conducted between 1st January 2015 and 3rd February 2024 in Nigeria.
ii. Systematic reviews and meta-analysis
iii. Randomized controlled trials/study design
iv. household clusters and intervention campaigns
v. Peer-reviewed publications

2.3. Exclusion criteria

i. Studies that were not conducted in Nigeria or on Nigerians as the targeted population.
ii. Studies/interventions conducted before 2015.
iii. Studies that do not contain parasite control or vector control intervention.
iv. Studies that did not report coverage of the intervention.

v. Protocols and scoping reviews.
vi. Publications not in English Language

2.4. Databases and website search:

a) British Nursing Database (BND)
b) ProQuest Central Databases (PQCD)
   i. Health & Medical Collection Database
   ii. Healthcare Administration Database
   iii. Nursing & Allied Health Database
   iv. Public Health Database
c) BioMed Central (BMC) Malaria Journal website.

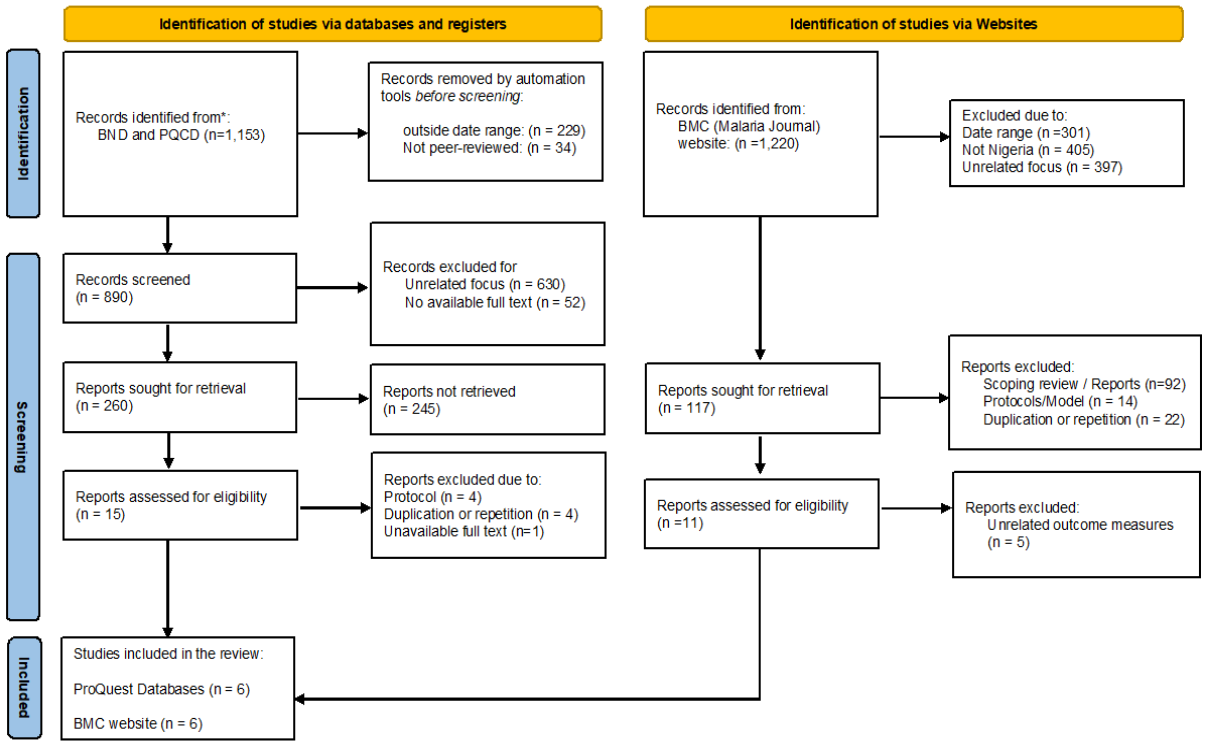

Figure 1: PRISMA flow diagram for the systematic search for evidence. Databases include BND = British Nursing Database (ProQuest), PQCD = ProQuest Central Databases, and BMC = BioMed Central at: https://malariajournal.biomedcentral.com/articles/10.1186/s12936-017-2019-1

2.5. Method of assessment of included evidence

The included articles were critically assessed for quality of evidence using Critical Appraisal Skills Programme checklist (CASP, 2024). Attention was paid to the aims, study design, randomization and blinding, sample size, and power, statistical inclusion of all participants, the similarity of baseline characteristics of participants, equality in groups treatment outside intervention treatment, treatment effect, conformity of outcome and conclusion, and the probable biases (see Table 1). Meta-analysis could not be conducted due to the limited number of evidence. However, descriptive statistics was used to determine mean coverage for each intervention category. An attempt was made to discuss and project the current trend, to determine the level of efforts needed in subsequent interventions to attain the SDG target 3.3.3.

Table 1: Assessment of evidence included in the study

Author and date	**Title of study**	**Aim**	**Intervention**	**Comparator**	**Main finding**	**Outcome of interest to this review (*Coverage)**	**Assessment of evidence using (Critical Appraisal Skills Programme (CASP)**		
							Strength in Evidence	**Weakness/ Biases**	**Limitation /validity**
Falade *et al*. (2023)	"Efficacy and safety of pyronaridine artesunate versus artemether–lumefantrine in the treatment of acute uncomplicated malaria …"	"To compare the safety and efficacy of PA and AL in children aged 3 months to 12 years …"	Pyronaridine–artesunate (PA)	Artemether–lumefantrine (AL)	PA and AL were well-tolerated. PA was significantly more efficacious than AL	95.9%	Randomized, controlled clinical trial Outcome supported conclusion. Defined population, and inclusion/ exclusion criteria Clearly defined endpoint. Balances population baseline characteristics Sample size powered at 90%. Appropriate statistical analysis.	Open-labeled RCT study design, Small sample size. Reporting bias.	Small sample size Imbalance in age group enrolment Low external validity
Hetzel *et al*. (2023)	"Pre-referral rectal artesunate: no cure for unhealthy systems"	"To understand the challenges involved in the successful real-world implementation of pre-referral rectal Artesunate…"	Pre-referrer Rectal artesunate suppositories	none	Pre-referral rectal artesunate did not increase the chance of child survival in routine clinical practice	52%	Large sample size. Observational study design.	Not RCT study design. Methodical limitation in diagnosis or ailment. Internal and External validity may be poor due to influence of access to case management.	Confounding ailments were not be properly diagnosed or defined. Influence of quality of and access to case management and health workers adherence to guideline may have affected outcomes.
Okoro *et al*. (2023)	"Superiority trial of intermittent treatment with dihydroartemisinin–piperaquine versus sulfadoxine–pyrimethamine for the prevention of malaria during pregnancy"	To assess the efficacy and safety of IPTp with DP as an alternative to IPTp with SP	dihydroartemisinin–piperaquine (DP)	sulfadoxine–pyrimethamine (SP)	The risk of adverse birth outcome was not significantly different (No superiority)	33.6%	Double-blind experimental RCT study design. Defined Population, inclusion and exclusion criteria. Appropriate statistical analysis	Small sample size. Low adherence to treatment	External validity is poor due to the proportion completed treatment

							with Cofounders adjusted for. Statistical power 80% Outcome supported conclusion		
Balami *et al.* (2021)	"Improving malaria preventive practices and pregnancy outcomes through a health education intervention…."	"To determine the effects of a malaria health educational intervention based on the information-motivation behavioural skills (IMB) model…"	A four-hour health education intervention on malaria intervention in Hausa language.	Similarly designed health education on breastfeeding	intervention was effective in improving ITN use, IPTp uptake, and haematocrit levels.	71.77% completed the study. *ITN = 22% (almost always use) *IPTp = 14.65% (Completed three doses)	Double blinded randomized controlled parallel-group study Sample size determined at 80% statistical power Clearly defined inclusion/ exclusion criteria	Small sample size Unclear and undetailed statistics Self-reporting questionnaire method prone to reporting bias. Not clear if outcome certainly reflect conclusion	Low external validity due to small sample size. Confounding not clearly identified
Noguchi *et al.* (2020)	"Effect of group versus individual antenatal care on uptake of intermittent prophylactic treatment of malaria in pregnancy…"	"To determine whether women randomized to group-antenatal care (G-ANC) versus standard antenatal care (ANC) differed in IPTp uptake and insecticide-treated nets (ITN) use"	Group antenatal care (G-ANC) IPTp uptake	Standard ANC insecticide-treated nets (ITN) use	G-ANC may support IPTp uptake.	*Mothers that received ITN = 94.3 Mothers that slept under ITN previous night = 70.4% Infants that slept under ITN previous night = 79.25%	A pragmatic, cluster-randomized, controlled trial. Good sample size and Statistical power 80% Clearly defined inclusion/ exclusion criteria	Confounders were not identified. Some data prone to reporting bias.	Availability of essential commodities for the intervention may have affected attrition and coverage.
Ameh *et al.* (2016)	"Barriers to and determinants of the use of intermittent preventive treatment of malaria in pregnancy in Cross River State, Nigeria…."	"To identify the barriers to and determinants of the use of SP-IPTp among pregnant women attending ANC in PHC facilities…"	SP-IPTp use	none	SP-IPTp	*SP-IPTp use prevalence = 41%	Define population	Non-RCT cross-sectional questionnaire surveys. Prone to reporting bias and Hawthorne effect.	Facility-based study Prone to selection bias.
Iwuafor *et al.* (2016)	"Malaria Parasitaemia and the use of insecticide-treated nets (INTs) for malaria control amongst under-5 year old children in Calabar, Nigeria"	"To investigate the prevalence of malaria infection and use of insecticide treated nets (ITNs) for malaria control among…"	Malaria testing with RDT and microscopy	none	Mosquito net utilization among the under-fives was low despite high net ownership rate by households	*ITN use = 51.5 % *IRS use = 51.1%	Cross-sectional descriptive study design. Ethical approval obtained Defined population	Not RCT study Small sample size Questionnaire-based study is prone to reporting bias from self-reported data.	Low external validity due to small sample size and being facility-based
Zegers de Beyl *et al.* (2016)	"Multi-country comparison of delivery strategies for mass	"To assess whether the choice of campaign strategy had	ITN campaign	none	proportion of households that received at	Proportion of population within household	Community-household campaign with large	Cross-sectional questionnaire surveys, and prone to	Selection of household was not systematic or random

	campaigns to achieve universal coverage with insecticide-treated nets: what works best?"	any effect on distribution outcomes and whether any other factors can be identified as determinants of successful campaigns"			least one ITN from the campaign (also referred to as reach), and the proportion of households with enough nets (defined as having at least one ITN for every two people)	with access to ITN = 44.45%	sample size.	reporting bias and Hawthorne effect.	but opportunistic, hence prone to selection bias.
Orobaton *et al.* (2016)	"Scaling-up the use of sulfadoxine-pyrimethamine for the preventive treatment of malaria in pregnancy…"	1. "Examine scale-up mechanisms that enable increased SP coverage.." . 2. "Examine community acceptance of SP..." 3. "Document associations, if any, between increased SP3 coverage and improved intrauterine conditions for newborn,…" 4. "Estimate the costs of delivering SP at scale per woman for a three doses or higher regimen"	Free IPTp-SP	No free IPTp-SP	IPTp-SP coverage and MCH indices (head circumference and stillbirth)	IPTp-SP3+ coverage = 45%	RCT study design Large sample size, and better external validity.	Prone to measurements bias from head circumference Error from misclassification of primary endpoints could result in information bias.	Prone to low Internal validity due to non-stratification of socioeconomic status
Koenker *et al.* (2015)	"Impact of a behaviour change intervention on long-lasting insecticidal net care and repair behaviour and net condition…"	"To determine whether behavioural change interventions (BCC) could substantially impact on the average useful life of the net"	LLIN and behavioural change interventions (BCC) messages	none	Access and durability of LLIN	Population having access to LLIN = 39.85%	Cluster cross-sectional household survey RCT (before and after study)	Prone to Effect modification and interaction, and Hawthorn effect Low adherence No clearly stated aims of study	Limited internal and external validity
Onwujekwe *et al.* (2015)	"Effectiveness of provider and community interventions to improve treatment of uncomplicated malaria in Nigeria…."	"To evaluate the effectiveness of the interventions in the context of existing drug supply channels"	RDTs with provider training RDTs with provider training plus a school-based community intervention	Rapid Diagnostic Tests (RDTs) with basic instruction	There was no evidence of a difference in uptake of testing due to the interventions.	*39.67% (control = 34%; provider arm = 48%; provider-school arm = 37%)	A Cluster Randomized Controlled Trial Clearly defined inclusion /exclusion criteria, and outcome measures Comparable baseline characteristics	High attrition rate Systematic bias due to variation of cluster size. Effect modification and interaction due to variation in cluster size Possibility of Hawthorn effect	Low internal and external validity due to high attrition rate and variation in cluster size

							Good statistical analysis with sample size powered at 80%		
Wollum *et al.* (2015)	"Benchmarking health system performance across states in Nigeria…"	"To provide the first-ever analysis of state-level trends for a range of Nigeria's key maternal and child health (MCH) outcomes and interventions from 2000 to 2013"	none	none	Nigeria is making notable gains through intervention. Interventions should be more regular to improve coverage	*ITN = 48% *SMC = 29% (IPTp = 20% plus ACTs = 9%)	Systematic review	Prone to statistical or Systematic and interpretation error. Few publications included in the review. No clearly stated aim of study	Broad scope of review.

*Coverage is defined as completed treatment or intervention at final endpoint. **Sources of evidence:** BND and ProQuest Central: Okoro *et al.* (2023), Hetzel *et al.* (2023), Falade *et al.* (2023), Balami *et al.* (2021), Noguchi *et al.* (2020), and Onwujekwe *et al.* (2015); BMC Malaria Journal website: Koenker *et al.* (2015), Wollum *et al.* (2015), Iwuafor *et al.* (2016), Zegers de Beyl *et al.* (2016), Ameh *et al.* (2016), and Orobaton *et al.* (2016).

3. Findings / Results

The search for evidence was done on ProQuest databases and the BMC website, between 1st and 3rd February 2024, respectively. The combined search identified 2,373 publications that were screened for inclusion eligibility. The abstracts of 26 potentially eligible articles were assessed, and 12 met the inclusion criteria (Figure 1).

Table 2: Summary of data from included evidence

Interventions category	SMC	ITN or LLIN	IRS	RDT
Reported Coverage (%)	33.60	22.00	51.1	39.67
	52.00	94.30	-	-
	95.90	51.50	-	-
	14.65	44.45	-	-
	41.00	39.85	-	-
	45.00	48.00	-	-
	29.00	-	-	-
Mean Coverage (%)	40.31	50.02	51.1	39.67

3.1. SMC coverage

The highest coverage of SMC intervention (95.9%) was that by Falade *et al.* (2023) with an intervention and comparator of Pyronaridine–artesunate and Artemether–lumefantrine, respectively (Table 1). The lowest coverage (14.65%) was by Balami et al (2021) with a health education intervention to promote the uptake of ITN and IPTp. The strength of evidence from the two studies based on hierarchy-of-evidence is strong because they were both randomized controlled trials (RCTs) (Turner, 2014). However, while that of Falade *et al.* was open-label, Balami *et al.* were blinded. Blinded RCTs are less prone to systematic and investigator biases. A major weakness of the RCTs was the small sample size which can limit its external validity. The same challenge was apparent in the evidence by Okoro *et al.* (2023) which reported 33.6% coverage for an intervention involving dihydroartemisinin–piperaquine and sulfadoxine–pyrimethamine, and Orobaton *et al.* (2016) which reported 45% coverage for IPTp-SP intervention. Hetzel et al (2023) studied the effectiveness of pre-referrer rectal artesunate suppositories on child's survival and recorded a coverage of 52%. The large sample size contributed to the strength of evidence but the study design was observational and non-RCT, which contributed to its weakness. A non-RCT study is more prone to biases than RCT studies because it is more dispose to systematic errors and selection bias which cannot be readily adjusted for statistically. The study by Ameh *et al.* (2016) in Cross River State in Nigeria was

questionnaire-based. The authors reported a SP-IPTp use prevalence of 41%. The study was facility-based. The facilities were also not randomized, which made the study prone to selection bias. Wollum *et al.* (2015) systematic review gave a combined coverage of 29% for IPTp (20%) and ACTs (9%) use. Systematic reviews are rated high in hierarchy-of-evidence for evidence-based practice (Turner, 2014).

3.2. ITN and LLIN Coverage

Balami *et al.* (2021) achieved ITN coverage of 22%. The strengths and weaknesses of the evidence were as discussed under SMC coverage. The study has limited external validity because of the small sample size, unclear statistical analysis, and use of a self-reporting questionnaire which is prone to reporting bias. Noguchi *et al.* (2020) compared the effect of group-antenatal care (G-ANC) against standard antenatal care (ANC) in the uptake and use of ITNs (94.3%), in a RCT study design. The design was appropriate but confounding such as socioeconomic status and the effect of health systems were not discussed, contributing to the weakness of the study (LaMorte and Sullivan, 2016). Iwuafor *et al.* (2016) reported a coverage of 51.5% using a non-RCT self-reporting cross-sectional study design. In addition, the sample size was small, limiting its external validity. Non-RCT studies are not rated very high in the hierarchy-of-evidence and self-reporting methods are prone to reporting or information bias (Turner, 2014). Zegers de Beyl *et al.* (2016) also conducted a cross-sectional household-based study with an ITN use of 44.45% using a self-reporting survey questionnaire. However, the validity of the evidence may be impeded by information or reporting and selection bias since the households were not randomly selected. Koenker *et al.* (2015) behavioural change campaign achieved a coverage of 39.85% long-lasting insecticide nets (LLINs) usage. The study used a repeated cross-sectional household survey and before and after study design, which is prone to Hawthrone effect (McCambridge *et al.*, 2014). Wollum *et al.* (2015) also reported 48% ITN use. The strength and weakness of the evidence have been discussed in the preceding SMC section.

3.3. IRS and RDT Coverage

Onwujekwe *et al.* (2015) studied the "effectiveness of provider and community interventions to improve treatment of uncomplicated malaria" with RDTs using a cluster-RCT study design. The intervention attained a coverage of 39.67%. Though the strength of evidence appears strong due to the RCT study design, it was however prone to statistical bias due to variation in cluster sizes. Iwuafor *et al.* (2016) reported IRS coverage of 51.1%. The strengths and weaknesses of the study discussed in the preceding ITN section also applies.

4. Discussion

The evidence from this review showed that the average intervention coverage for SMC, ITNs/LLINs, IRS and RDT interventions, were 40.31%, 50.02%, 51.1% and 39.67% of targeted population, respectively. The review indicates that recent peer-reviewed publications on malaria intervention coverage in Nigeria are few. More so, it included only one systematic review by Wollum *et al.* (2015), and seven RCTs viz; Balami *et al.*, (2021), Falade *et al.* (2023), Koenker *et al.* (2015), Noguchi *et al.* (2020), Okoro *et al.* (2023) and Orobaton *et al.* (2016). Only the RCTs by Orobaton *et al.* could be considered to have had an adequate sample size to strengthen external validity. However, its internal validity was in question due to the non-stratification of the participants' socioeconomic status. The sample sizes of the other RCTs raised questions about the external validity of the studies.

The implication of the seemingly persistent low level of coverage is far-reaching on the malaria eradication and elimination targets by WHO and NMEP, respectively. It is estimated that over 97% of Nigerians are at risk of malaria population (PMI, 2022). With an average intervention coverage of about 50.56% (mean of ITN and IRS) for vector control, and 40% (SMC and RDTs) for diagnosis and treatment, there exists a huge gap to be met. Of all the SMC interventions, only 28.6% (2) attained a coverage of over 50%, and only 14.3% (1) had a coverage of 95% but with a limitation of small sample size. A similar challenging profile could be seen for the vector control interventions (Tables 1 and 2). The upward trajectory of malaria elimination interventions is a slow-gradient slope, and much progress seemed not to have been achieved over the last 9 years. The SMC during antenatal in 2015 was 37% (Noguchi *et al.*, 2020), and this is not significantly different from the average of 40% reported for the 9 years

after with only 3% marginal increase in coverage. This amounts to about 0.33% change annually or a 2% in the next 6 years going by the current momentum. This will translate to an average coverage of about 42.% by 2030. To meet the target set by NMEP (80%) and SDG, a minimum annual incremental coverage of about 6.3% is needed. This means multiplying the current effort by about 20 folds. A similar trajectory is estimated for the other intervention components. The implication of this is that the country needs to review its framework of intervention and mobilize adequate resources if it is to make reasonable progress toward the set targets.

The challenge of intervention coverage has been identified as multifaceted by many authors (Noguchi *et al.*, 2020). The enrolment and attrition of participants from interventions could be traced to many factors related to inequities, inequalities, and operational and logistics gaps including the availability of commodities, as well as knowledge and proficiency of health workers and caregivers. For instance, multidimensional poverty makes it difficult for some participants to adhere to treatment or programme regimens since time spent on participation may translate to lost man-hours and revenue. Gender-related inequality in health behaviours and cultural beliefs and practices, for instance, the nomadic culture, also play roles in treatment access and adherence (Haileselassi *et al.*, 2023; Ricci, 2012). Another growing challenge is the rising number of internally displaced persons who live in suboptimal vector-prone shelters due to political instability, insecurity from terrorism, natural disasters and environmental pollution (Solanke *et al.*, 2023). A contextual framework that could promote health-seeking behaviours and hygiene, reduce the level and impact of poverty and internal displacement, and increase knowledge and awareness to correct misleading harmful or health-hindering cultural practices could help improve and sustain adherence to programme and intervention coverage (Ibinaiye *et al.*, 2024; Solanke *et al.*, 2023). Such a framework needs proper planning and adequate resource mobilsation for year-round and multiyear intervention.

4.1. Limitation of study

This study was limited by the small number of articles that met the inclusion criteria. Hence, a meta-analysis could not be undertaken. Only one article each was available for IRS and RDT, and their "mean coverage" was not a statistical calculation. Hence, this may be a source of interpretation bias (Gutbezahl, 2021). In addition, the computed means may not be a true representation of the current trends which ought to be computed on an annual basis but for the inadequate publications. It is recommended that more peer-reviewed studies on coverage and the matrix of all intrinsic and extrinsic factors interloping between intervention coverage, vector control, and parasite prevalence be conducted to establish the true trend to adequately project and estimate the feasible date for meeting the SDG target 3.3.3. Furthermore, the review was undertaken by two authors only which makes it prone to selection, reporting, and interpretation bias, as some studies that were excluded could have been included from the perspective of a third or fourth reviewing author, and vice-versa.

5. Conclusion

The SDG goal that is focused directly on promoting healthcare is Goal 3, 'ensuring healthy lives and well-being for everyone through all ages'. Attaining this goal, depends on the attainment of a number of targets to address global burden of diseases. For instance, target 3 is focused on addressing infectious diseases including malaria, TB, and HIV/AIDs which greatly affect low- and medium-income countries like Nigeria. Nigeria is the leading contributor to the global burden of malaria. Malaria is largely responsible for Nigeria's poor health and socioeconomic indices resulting in huge economic losses annually. The fight against malaria in the country is led by the Federal Ministry of Health through NMEP. The parasite prevalence and mortality target set by the NMEP for 2025 is <10%, and <50 deaths per 1,000 live births, respectively. The intervention commodities coverage targets include ≥80% utilization of vector control interventions (ITNs/LLINs and IRS), and ≥80% access to chemopreventives and diagnostics for appropriate treatment. Recent evidence indicates that the trend in malaria prevalence in Nigeria is a very slow decline if at all there is any decline despite several interventions by government and development partners (Omojuyigbe *et al.*, 2023). This challenge has been hinged on un-sustained programmes and limited coverage determined by several factors. The attainment of target 3.3.3 of the SDG and the vision of NMEP to eliminate malaria from Nigeria is dependent on achieving ≥80% coverage for vector control and parasite elimination interventions. This systematic review considered available evidence in the literature to answer the research question "is there any evidence that the current level of malaria intervention coverage can

help reduce malaria case incidence and mortality by 90% each in Nigeria by the year 2030". Of the 2,373 articles systematically searched on ProQuest databases and BMC Malaria journal website (Figure 1), only few peer-reviewed publications (twelve) met the inclusion criteria for the review, and the quality of each evidence (validity and reliability) was assessed and discussed using the CASP assessment tool. The review indicated that the average coverage of malaria intervention remained low over the past nine years at about 40.31%, 50.02%, 51.1% and 39.67% for SMCs, ITNs/LLINs, IRS and RDTs, respectively. Improving the coverage of interventions to ≥80%, and sustaining it is imperative to achieving malaria elimination targets and SDG 3 for Nigeria, specifically, SDG targets 3.3.3 and the NMEP target 0:10:5:80:80. A multiyear context-specific multiplicity of effort should be adopted and sustained over the next 6 years to meet the targets. Resolving the challenge of improved coverage is mediated by many factors including funding, commodities logistics, culture and lifestyle, and socioeconomic status of the targeted population, etc. The strategy and framework for improving malaria intervention coverage have to be multisectoral to address multidimensional poverty, hygiene, wrong perspectives, health-hindering cultural practices, and limited knowledge about the disease in the targeted population (Ibinaiye *et al.*, 2024).

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