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Prevalence and Diagnostic Detection of Asymptomatic Malaria Parasitaemia among Apparently Healthy Community Dwellers in Benue South, Nigeria

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ABSTRACT

Background: Malaria control programmes have traditionally focused on symptomatic infections, yet individuals who harbour parasites without current symptoms may sustain transmission while remaining outside routine case-detection pathways. The epidemiology of asymptomatic malaria in Benue South, North-Central Nigeria, remains insufficiently characterized.

Objectives: This study assessed the prevalence of asymptomatic malaria parasitaemia among apparently healthy community dwellers and compared parasite detection by rapid diagnostic testing (RDT) and light microscopy.

Methods: A community-based cross-sectional study was conducted between August and October 2024 among apparently healthy residents aged ≥15 years in selected rural and semi-urban communities of Otukpo and Okpokwu Local Government Areas (LGAs), Benue State, Nigeria. Participants were selected using a multistage sampling approach. Information on socio-demographic characteristics, malaria prevention practices, healthcare access and selected environmental exposures was obtained using a structured questionnaire. Venous blood samples were examined using malaria RDTs and Giemsa-stained thick and thin blood films. Parasite density was estimated using the standard white-cell-count assumption. Descriptive statistics were used to summarize the study population and diagnostic findings.

Results: A total of 275 participants were studied; 123 (44.73%) were male and 152 (55.27%) females. The largest age group was 15–29 years (107; 38.91%). Microscopy detected malaria parasitaemia in 88 participants, corresponding to a prevalence of 32.0% (95% CI 26.5–37.5%), whereas RDT detected infection in 55 participants, corresponding to 20.0% (95% CI 15.3–24.7%). Thus, microscopy identified 12 percentage points more positive participants than RDT, with a descriptive prevalence ratio of 1.60. Among microscopy-positive participants, 74/88 (84.09%) had parasite densities below 1,000 parasites/µL, while 14/88 (15.91%) had densities ≥1,000 parasites/µL. Malaria prevention information had reached 72.0% of participants, while 53.82% reported always using insecticide-treated nets. Stagnant water was reported near the homes of 64.0% of participants.

Conclusion: A substantial proportion of apparently healthy residents of Otukpo and Okpokwu LGAs harboured microscopically detectable malaria parasites. The higher proportion detected by microscopy than RDT highlights the importance of maintaining quality-assured microscopy capacity for community surveillance, particularly where parasite densities may be low. The findings

support continued investment in vector control, community-level prevention and surveillance approaches that recognize asymptomatic infection as part of the malaria reservoir.

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INTRODUCTION

Malaria remains one of the most persistent infectious diseases in sub-Saharan Africa. Despite substantial progress in prevention, diagnosis and treatment, transmission continues in many endemic settings, and progress towards elimination has increasingly depended on identifying infections that remain outside conventional clinical surveillance systems. The most recent global malaria assessments continue to identify Africa as the region carrying the greatest share of the global malaria burden, with Nigeria remaining one of the countries requiring sustained and locally tailored malaria-control efforts (World Health Organization, 2025a; World Health Organization, 2025b; Greenwood, 2008a; Greenwood, 2008b).

The clinical expression of malaria is only one part of the epidemiological picture. In endemic populations, individuals may carry *Plasmodium* parasites without fever or other malaria-related symptoms. These infections may persist for variable periods and are often associated with relatively low parasite densities. The asymptomatic reservoir is epidemiologically important because individuals who do not feel ill generally have little reason to seek testing or treatment, allowing infections to remain outside routine facility-based surveillance (Bousema et al., 2014; Lindblade et al., 2013).

Asymptomatic parasitaemia is also closely linked to the development of naturally acquired immunity. Repeated exposure to malaria can reduce the likelihood that infection will result in overt clinical disease, although this protection does not necessarily eliminate parasite carriage. Consequently, apparently healthy individuals in endemic communities should not automatically be regarded as free of malaria infection (Staalsoe & Hviid, 1998; Hviid, 1998). Furthermore, asymptomatic parasitaemia may have subsequent clinical implications, as individuals carrying parasites without symptoms may remain at risk of developing symptomatic malaria (Njama-Meya et al., 2004).

The epidemiological importance of asymptomatic infection extends beyond the individual. Asymptomatic carriers can harbour transmissible parasites, including infections at densities below the detection threshold of routine microscopy or RDTs. Evidence from endemic African settings demonstrates that low-density and asymptomatic infections can contribute to the human infectious reservoir, although their relative contribution varies with transmission intensity, age structure, parasite density and season (Bousema et al., 2014; Lindblade et al., 2013; Ouédraogo et al., 2016; Gonçalves et al., 2017). The recognition of this infectious reservoir has important implications for malaria control and elimination strategies (Drakeley et al., 2017; Greenwood, 2008b).

The choice of diagnostic method is therefore particularly relevant in community surveys. WHO recognizes microscopy and malaria rapid diagnostic tests as important parasite-based diagnostic approaches within malaria diagnosis and case management (World Health Organization, 2025b; World Health Organization, 2024). Microscopy has the additional advantages of allowing parasite quantification and species identification, but its performance depends heavily on the competence of microscopists, slide quality, staining and quality-assurance systems (Research Malaria Microscopy Standards Working Group, 2015; World Health Organization, 2016a; World Health Organization, 2016b). RDTs are comparatively simple and rapid and can extend diagnostic capacity to settings where reliable microscopy is unavailable (Bastiaens et al., 2014; World Health Organization, 2025b).

The distinction becomes particularly important in asymptomatic infection. Molecular methods can detect infections at parasite densities below the detection threshold of conventional microscopy and RDTs, and systematic evidence has demonstrated that microscopy can substantially underestimate the prevalence of *P. falciparum* infection when compared with PCR-based methods (Okell et al., 2009; Okell et al., 2012; Wu et al., 2015). Previous methodological work has also demonstrated the importance of appropriate blood sampling and storage for PCR-based malaria detection (Färnert et al., 1999). Nevertheless, microscopy remains an important field and research method because it can directly visualize parasites, identify species and estimate parasite density when performed appropriately (Research Malaria Microscopy Standards Working Group, 2015; World Health Organization, 2016a; World Health Organization, 2016b; World Health Organization, 2016c).

Nigeria has a substantial body of malaria research, but important geographical gaps remain. Studies from southwestern Nigeria have documented asymptomatic infection in apparently healthy adults, while previous work in Benue State has also identified asymptomatic malaria among community residents (Ibrahim et al., 2023; Aju-Ameh et al., 2017). Evidence from other Nigerian populations further demonstrates the persistence of malaria infection and the influence of socio-demographic characteristics on malaria epidemiology (Nwaneli et al., 2020). More recent studies from neighbouring West African settings similarly demonstrate that asymptomatic microscopic and submicroscopic infections remain epidemiologically relevant (Telfils et al., 2024).

Evidence from other African settings also demonstrates substantial asymptomatic infection. A study from Cameroon reported a high prevalence of asymptomatic malaria and identified associated risk factors among children in Nkwen village (Kaghou *et al*., 2024). In South Benin, longitudinal evidence has further demonstrated the persistence and dynamics of both microscopic and

submicroscopic asymptomatic malaria infection (Telfils *et al*., 2024). Such findings reinforce the importance of considering asymptomatic infection in malaria surveillance beyond individual clinical presentation.

However, data specifically describing asymptomatic malaria among apparently healthy residents of Benue South remain limited. The present study therefore examined the prevalence of asymptomatic malaria parasitaemia among apparently healthy community dwellers in selected communities of Otukpo and Okpokwu LGAs, while comparing detection by RDT and microscopy and describing the parasite-density profile.

Study objectives

The study aimed to determine the prevalence of asymptomatic malaria parasitaemia among apparently healthy community dwellers in Benue South, Nigeria.

Specifically, the study sought to:

1. determine the prevalence of malaria parasitaemia among apparently healthy participants using RDT;
2. determine the prevalence using light microscopy;
3. compare the observed detection rates obtained by the two diagnostic approaches;
4. describe the parasite-density distribution among microscopy-positive participants; and
5. characterize the socio-demographic and selected malaria-prevention profile of the study population.

MATERIALS AND METHODS

Study design and setting

A community-based cross-sectional study was conducted between August and October 2024 in selected rural and semi-urban communities of Otukpo and Okpokwu LGAs in Benue State, North-Central Nigeria. The study formed part of a community-based assessment of malaria transmission among apparently healthy residents of Benue South.

The selected communities in Otukpo LGA were Otukpo town, Otada, Akpachi, Otukpo Nobi, Ogobia, Odaubi II and Efeyi-Ipole. In Okpokwu LGA, the selected communities were Omadewu, Ichakwu, Odessassa, Ugwu and Okpudu. The study area has a tropical environment favourable to malaria transmission.

Study population

Participants were community residents aged ≥15 years who were apparently healthy and did not have malaria-related symptoms at the time of recruitment. Individuals who were unwell at recruitment, including those with headache or fever with a temperature of ≥38°C, were excluded.

Participants who met the eligibility criteria and provided informed consent were enrolled.

For this paper, asymptomatic infection refers specifically to parasitaemia detected in participants who were apparently asymptomatic at the time of recruitment. A history of previous malaria symptoms was not used to exclude participants if they were clinically asymptomatic at the time of study enrolment.

Sampling

A multistage sampling procedure was used. Local government areas within Benue South were considered for selection, followed by selection of districts and wards and subsequently households within selected communities. Eligible residents within selected households were invited to participate. A total of 275 participants were recruited and included in the study.

Data collection

A structured questionnaire was used to collect information on:

- socio-demographic characteristics;
- malaria-prevention information;
- use of insecticide-treated nets (ITNs);
- use of insect repellents;
- recent antimalarial drug use;
- access to healthcare;
- previous malaria symptoms or diagnosis; and
- selected environmental exposures, including stagnant water around the home and environmental insecticide spraying.

Blood collection and malaria diagnosis

Venous blood samples were collected from participants for malaria testing.

Malaria infection was assessed using an RDT and light microscopy. Thick and thin blood films were prepared and stained with Giemsa before microscopic examination. WHO recommends appropriately performed thick- and thin-film microscopy for malaria parasite detection and species identification, while parasite counting can be used to estimate parasite density.

Microscopy-positive samples were used to estimate parasite density using the standard white blood cell-count assumption documented in the original study protocol. Parasite density was subsequently categorized as:

- ≤200 parasites/µL;
- 200–999 parasites/µL; and
- ≥1,000 parasites/µL.

Statistical analysis

Data were originally analysed using IBM SPSS Statistics version 25. Categorical variables were summarized using frequencies and percentages. Chi-square tests were used in the original study to assess associations between categorical variables, while logistic regression was used to investigate predictors of asymptomatic malaria infection.

Confidence intervals around the two reported prevalence estimates were calculated from their published numerators and denominators using the binomial approximation. The difference between microscopy and RDT prevalence was calculated as an absolute percentage-point difference, while the ratio of the two observed prevalence estimates was presented descriptively.

Importantly, the two diagnostic positivity totals do not permit reconstruction of the four cells of a paired RDT-by-microscopy contingency table. Consequently, diagnostic sensitivity, specificity, predictive values, Cohen's kappa and McNemar's test were not calculated.

Ethical considerations

Ethical approval was obtained from the Federal University of Health Sciences Otukpo Ethical Review Committee. Written informed consent was obtained from participants before enrolment. The study was conducted in accordance with accepted ethical principles for research involving human participants.

RESULTS

Socio-demographic characteristics

A total of 275 apparently healthy community residents were included. Females constituted a modest majority of the study population, accounting for 152 (55.27%), while 123 (44.73%) were male.

Participants aged 15–29 years represented the largest age group, with 107 (38.91%), followed by those aged 30–44 years (72; 26.18%), 45–64 years (63; 22.91%) and ≥65 years (33; 12.00%).

Regarding educational attainment, 32 (11.64%) had no formal education, 58 (21.09%) had primary education, 104 (37.82%) had secondary education and 81 (29.45%) had tertiary education.

Farmers constituted the largest occupational group (112; 40.73%), followed by students (69; 25.09%) and traders (55; 20.00%).

Table 1. Socio-demographic characteristics of participants

Characteristic	Category	n (%)
Sex	Male	123 (44.73)
	Female	152 (55.27)
Age (years)	15–29	107 (38.91)
	30–44	72 (26.18)
	45–64	63 (22.91)
	≥65	33 (12.00)
Education	No formal education	32 (11.64)
	Primary	58 (21.09)
	Secondary	104 (37.82)
	Tertiary	81 (29.45)
Occupation	Farmer	112 (40.73)
	Trader	55 (20.00)
	Civil servant	27 (9.82)
	Student	69 (25.09)
	Unemployed	12 (4.36)

Malaria prevention practices and healthcare access

Most participants (198; 72.00%) reported having received information on malaria prevention.

Regular ITN use was reported by 148 (53.82%) participants, while 72 (26.18%) reported using ITNs sometimes and 55 (20.00%) reported never using them. In addition, 110 (40.00%) reported using insect repellents.

A history of antimalarial drug use during the preceding six months was reported by 156 (56.73%) participants.

Most respondents (218; 79.27%) reported easy access to healthcare.

Stagnant water was reported around the homes of 176 (64.00%) participants, while 110 (40.00%) reported regular environmental insecticide spraying.

Table 2. Selected malaria-prevention, healthcare and environmental characteristics

Variable	Response	n (%)
Received malaria-prevention information	Yes	198 (72.00)
ITN use	Always	148 (53.82)
	Sometimes	72 (26.18)
	Never	55 (20.00)
Use of insect repellent	Yes	110 (40.00)
Antimalarial use in previous 6 months	Yes	156 (56.73)
Easy access to healthcare	Yes	218 (79.27)
Stagnant water near home	Yes	176 (64.00)
Environment regularly sprayed	Yes	110 (40.00)

Prevalence of asymptomatic malaria by diagnostic method

Microscopy detected malaria parasites in 88 of 275 participants, giving an observed prevalence of 32.00% (95% CI 26.5–37.5%).
RDT detected malaria infection in 55 of 275 participants, giving an observed prevalence of 20.00% (95% CI 15.3–24.7%).
Thus, microscopy identified 12.0 percentage points more positive participants than RDT.
The ratio of the observed microscopy prevalence to the RDT prevalence was 1.60, indicating that the proportion detected by microscopy was approximately 60% higher than that detected by RDT in this study.

Table 3. Detection of asymptomatic malaria parasitaemia by diagnostic method

Diagnostic method	Positive/Total	Prevalence (%)	Approximate 95% CI
RDT	55/275	20.0	15.3–24.7
Microscopy	88/275	32.0	26.5–37.5

Parasite-density profile among microscopy-positive participants

Among the 88 microscopy-positive participants, 32 (36.36%) had parasite densities ≤200 parasites/μL, 42 (47.73%) had densities between 200 and 999 parasites/μL, and 14 (15.91%) had densities ≥1,000 parasites/μL.
Thus, 74 of the 88 microscopy-positive participants (84.09%) had parasite densities below 1,000 parasites/μL, while approximately one in six microscopy-positive participants had densities ≥1,000 parasites/μL.

Table 4. Parasite-density distribution among microscopy-positive participants

Parasite density (parasites/μL)	n	%
≤200	32	36.36
200–999	42	47.73
≥1,000	14	15.91
Total	**88**	**100.00**

DISCUSSION

This community-based study found a substantial burden of malaria parasitaemia among individuals who were apparently healthy at the time of recruitment. Using microscopy, 32% of participants were parasite-positive, compared with 20% using RDT. The finding is important because routine facility-based malaria surveillance is naturally weighted towards people who develop symptoms and seek care, whereas community surveys can reveal a less visible component of the infection reservoir (Bousema et al., 2014; Lindblade et al., 2013).

The observed microscopy prevalence is within the broad range reported in other African settings, although direct comparisons must be interpreted cautiously because prevalence varies considerably with age structure, transmission intensity, season, diagnostic method, sampling strategy and definition of asymptomatic infection (Bousema et al., 2014; Lindblade et al., 2013). The present finding is also broadly consistent with evidence from other endemic African populations in which substantial proportions of apparently healthy individuals have been found to harbour malaria parasites (Kaghou et al., 2024; Telfils et al., 2024).

The result is also comparable with findings from other Nigerian community studies. Ibrahim and colleagues reported a 19% prevalence of microscopy-confirmed asymptomatic *P. falciparum* infection among apparently healthy adults in Ido-Ekiti, Southwestern Nigeria (Ibrahim et al., 2023). An earlier study conducted in selected communities of Benue State reported asymptomatic malaria using RDT, microscopy and PCR, demonstrating that apparently healthy residents can constitute an important reservoir of infection in the same broad geographical region (Aju-Ameh et al., 2017). Differences between these studies and the present findings may reflect differences in age composition, geography, transmission intensity, season and diagnostic methodology.

The 32% microscopy positivity observed in this study should not be interpreted simply as evidence that one-third of participants had clinically significant malaria. The participants were selected because they were apparently asymptomatic at recruitment. The finding instead demonstrates that parasite carriage can occur in the absence of overt illness. This distinction matters for malaria surveillance because individuals who do not perceive themselves to be ill are unlikely to present for routine diagnostic testing (Bousema et al., 2014; Lindblade et al., 2013).

The biological basis of asymptomatic carriage is complex. Repeated malaria exposure can result in partial clinical immunity, reducing the likelihood that infection produces fever and other symptoms without necessarily preventing parasite persistence. Consequently, asymptomatic parasitaemia can represent an interaction between parasite burden, host immunity, parasite characteristics and the epidemiological context in which infection occurs (Staalsoe & Hviid, 1998; Hviid, 1998).

An important finding in the present study was the difference between microscopy and RDT detection. Microscopy identified 32% of participants as positive compared with 20% by RDT. The 12-percentage-point difference is epidemiologically meaningful, particularly in a community-surveillance setting where many infections are likely to be of relatively low density.

However, the observed difference should be interpreted carefully. The available study record does not provide the paired RDT/microscopy results for each participant. It is therefore impossible to determine how many participants were positive by both methods, how many were RDT-positive but microscopy-negative, or how many were microscopy-positive but RDT-negative. Consequently, the present study cannot establish the sensitivity or specificity of either method, nor can it formally measure diagnostic agreement.

The higher detection rate by microscopy is nevertheless biologically plausible. WHO guidance recognizes microscopy as an important malaria diagnostic approach and emphasizes standardized procedures for examination of thick and thin blood films (World Health Organization, 2025b; Research Malaria Microscopy Standards Working Group, 2015; World Health Organization, 2016a). Microscopy also permits parasite counting, which provides an estimate of parasite density (World Health Organization, 2016c). RDTs provide a rapid alternative, but their performance can vary according to parasite density, the diagnostic antigen targeted and other parasite-related factors (Wu et al., 2015; Bastiaens et al., 2014).

The issue of low-density infection is particularly relevant to the present findings. More than four-fifths of microscopy-positive participants had parasite densities below 1,000 parasites/µL. This distribution is consistent with the broader observation that many asymptomatic infections in endemic populations are low-density. Low-density infection is also one reason why conventional diagnostic methods do not capture the entire infection reservoir (Okell et al., 2009; Okell et al., 2012; Wu et al., 2015).

At the same time, the present study should not be interpreted as demonstrating that all microscopy-negative or RDT-negative participants were malaria-free. PCR and other nucleic-acid amplification methods can detect infections below the analytical threshold of microscopy and many RDTs (Okell et al., 2009; Okell et al., 2012; Wu et al., 2015). Previous work has also established that appropriate blood sampling and storage are important for reliable PCR detection (Färnert et al., 1999). The true prevalence of infection in this population may therefore be higher than the 32% detected by microscopy.

This has practical implications. If community malaria surveillance relies exclusively on symptomatic case detection, a substantial component of parasite carriage may remain invisible. The significance of this reservoir is not simply theoretical. Studies using molecular diagnostics and mosquito-feeding approaches have demonstrated that asymptomatic and low-density infections can contribute to human-to-mosquito transmission (Ouédraogo et al., 2016; Gonçalves et al., 2017). The recognition of the human infectious reservoir has consequently become an important consideration in malaria elimination strategies (Drakeley et al., 2017).

More recent evidence from The Gambia has similarly highlighted the importance of asymptomatic schoolchildren and adults in the human infectious reservoir for *P. falciparum* malaria, particularly in settings of relatively low endemicity (Soumaré et al., 2025). This supports the broader observation that the epidemiological importance of asymptomatic infection is not restricted to areas of very high malaria transmission.

The study population also provides useful contextual information for interpreting the findings. More than half of participants reported always using ITNs, and nearly three-quarters had received malaria-prevention information. Nevertheless, 20% reported never using an ITN, and nearly two-thirds reported stagnant water near their homes. These findings suggest that exposure to malaria risk may persist despite substantial community awareness and uptake of some preventive measures.

The study also demonstrates why malaria prevention cannot depend on a single intervention. WHO's current malaria guidance emphasizes integrated approaches involving effective vector control, appropriate diagnosis and treatment, and interventions tailored to local epidemiology (World Health Organization, 2025b; World Health Organization, 2024). The continued presence of asymptomatic infection in a population where preventive measures are already being used suggests that improving coverage, consistency and targeting remains important.

The present findings also have particular relevance for Benue State. A previous study from selected Benue communities identified asymptomatic malaria as a potential threat to malaria elimination, while the present study extends the evidence to additional communities in Otukpo and Okpokwu LGAs (Aju-Ameh et al., 2017). The geographical proximity of these studies makes the persistence of asymptomatic malaria in Benue especially noteworthy and supports continued local surveillance rather than reliance solely on national or regional prevalence estimates.

Strengths

Several features strengthen the study.

First, participants were recruited directly from communities rather than solely from health facilities. This reduces the likelihood that the sample would be restricted to people already seeking care.

Second, the study included both RDT and microscopy, providing complementary information on malaria detection.

Third, microscopy allowed estimation of parasite density, which provides information beyond a simple positive/negative classification.

Fourth, participants were recruited across multiple rural and semi-urban communities in two LGAs, providing a broader community perspective than a single-facility survey.

Limitations

The findings should also be interpreted in light of several limitations.

First, the cross-sectional design provides a snapshot of malaria carriage during the August–October 2024 study period and cannot establish persistence, duration of infection or temporal relationships.

Second, the study relied on conventional microscopy and RDTs. Molecular methods such as PCR were not used. Consequently, submicroscopic infections below the detection threshold of the employed methods may have been missed.

Third, the available study record does not contain the paired participant-level RDT and microscopy results. Therefore, formal diagnostic agreement and accuracy measures cannot be calculated.

Fourth, the study was conducted in selected communities of two LGAs and should not be assumed to represent all of Benue State or Nigeria.

CONCLUSION

A substantial burden of asymptomatic malaria parasitaemia was identified among apparently healthy community residents of Otukpo and Okpokwu LGAs, Benue State. Microscopy detected parasitaemia in 32% of participants, compared with 20% by RDT. Most microscopy-positive participants had parasite densities below 1,000 parasites/μL.

The findings reinforce the epidemiological importance of infections that remain clinically silent. Community members without symptoms can carry malaria parasites and may therefore remain outside routine facility-based surveillance.

Microscopy detected a greater proportion of positive participants than RDT in this study; however, the available data do not permit formal assessment of diagnostic sensitivity or specificity. The findings instead support the complementary role of quality-assured microscopy and RDTs according to the epidemiological and health-system context.

Public Health Implications

The findings support five practical priorities.

1. Maintain community-level malaria surveillance that does not rely exclusively on symptomatic case presentation.
2. Strengthen quality-assured microscopy capacity, particularly in laboratories serving malaria-endemic rural and semi-urban communities.
3. Sustain and improve ITN coverage and consistent use, rather than treating possession of a net as equivalent to effective protection.
4. Address environmental mosquito-breeding risks, including stagnant water around households.
5. Consider molecular surveillance in future research, particularly where the objective is to quantify the submicroscopic reservoir that cannot be adequately characterized by microscopy or RDTs.

Future studies in Benue South should ideally combine microscopy, RDT and molecular testing and should retain participant-level paired results so that diagnostic agreement, submicroscopic infection and temporal changes in parasite carriage can be assessed directly.

Ethics Approval and Consent to Participate

Ethical approval was obtained from the Federal University of Health Sciences Otukpo Ethical Review Committee. Written informed consent was obtained from all participants before enrolment.

Consent for Publication

Not applicable. No individually identifiable participant information is reported.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

Author TA Onoja has the original concept. She designed, collected samples, analysed and drafted the study. All the other co-authors participated in full, reviewed and approved the final manuscript for publication.

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