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Cabirou Mounchili Shintouo [a,b,c], Robert Adamu Shey [c,d], Bernis Neneyoh Yengo [c], Ntang Emmaculate Yaah [c], Rene Ning Teh [e], Roland Akwelle Ngwese [c], Lawrence Ayong [f], Luc Vanhamme [d,1], Jacob Souopgui [d,1,*], Stephen Mbigha Ghogomu [c,1,*], Rose Njemini [a,b,1,*]

[a] Department of Gerontology, Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel, Laarbeeklaan 103, B-1090 Brussels, Belgium
[b] Frailty in Ageing Research Group, Vrije Universiteit Brussel, Laarbeeklaan 103, B-1090 Brussels, Belgium
[c] Department of Biochemistry and Molecular Biology, Faculty of Science, University of Buea, P.O. Box 63 Buea, Cameroon
[d] Department of Molecular Biology, Institute of Biology and Molecular Medicine, IBMM, Université Libre de Bruxelles, Gosselies Campus, 126040 Gosselies, Belgium
[e] Department of Zoology and Animal Physiology, University of Buea, Buea, Cameroon
[f] Malaria Research Unit, Centre Pasteur Cameroon, Yaoundé, Cameroon

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ABSTRACT

Onchocerciasis is an infectious disease of public health and socio-economic importance in most parts of Sub-Saharan Africa. The objective of this study was to evaluate the effects of the suspension of implementation activities towards combating onchocerciasis in the Bandjoun and Massangam health districts in the West Region of Cameroon as a consequence of the COVID-19 pandemic. Data on socio-demographic and clinical characteristics were obtained using a structured questionnaire. All participants in both health districts were examined for the presence of clinical manifestations of onchocerciasis. In addition, two skin snips were obtained from the knee of each participant and examined for the presence of microfilaria. All data were categorized, coded, entered in a database, and analysed using SPSS version 23.0. A total of 229 participants in the Bandjoun health district and 378 in the Massangam health district were recruited for the study. In both health districts, there was no significant difference between male and female participants in terms of the clinical manifestations of onchocerciasis. The prevalence of nodules was 8.7% in the Bandjoun health district and 20.6% in the Massangam health district while the prevalence of microfilaria carriers in Bandjoun and Massangam health districts was 3.5% and 3.7%, respectively. Except for the Tsesse and Lemgo communities in the Bandjoun health district, there was a reduction in the prevalence of microfilaria in the communities that were studied when compared to previous data obtained before the disruption of control programmes activities. Overall, in both health districts, elderly individuals bear the largest burden of onchocerciasis. Based on the results obtained, we conclude that the temporary suspension of Neglected Tropical Disease control programme activities by the World Head Organization as a result of COVID-19 may have resulted to recrudescence of *O. volvulus* transmission in hypoendemic communities in the Bandjoun health district.

1. Introduction

Infection with the filaria nematode *Onchocerca volvulus* causes onchocerciasis, which is one of the leading causes of infectious blindness in humans (Cheke et al., 2021). The parasite is transmitted to humans by black flies (*Simulium*), and the disease is confined to communities around rapidly flowing rivers or streams where the black fly vectors breed (Brattig et al., 2021). Currently, close to 22 million people are estimated to be infected with *O. volvulus,* 1.15 million of whom suffer from visual impairment and 14.6 million suffer from skin disease. More than 99% of these infected individuals and a minimum of 220 million individuals requiring preventive chemotherapy against onchocerciasis

* Corresponding authors.
E-mail addresses: jacob.souopgui@ulb.be (J. Souopgui), stephen.ghogomu@ubuea.cm (S.M. Ghogomu), Rose.Njemini@vub.be (R. Njemini).
[1] These authors are last authors on this work.

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live in 31 countries in sub-Saharan Africa (World Health Organisation 2022). The disease has a significant economic impact on Sub-Saharan Africa because it not only disables a sizable portion of the adult working population and hinders them from working to their best ability, but can also cause entire communities to abandon fertile farm lands near rivers and valleys in favour of less fertile areas in order to escape the devastating effects of the disease (Turner et al., 2019).

To fight against the disease, the World Health Organization (WHO) recommends mass drug administration of ivermectin (IVM) to both infected and at-risk individuals. IVM kills the juvenile stage of the worm, and temporarily blocks the release of microfilaria by adult worms (Ehrens et al., 2022). However, it is unable to kill the adult worms. Thus, treatment with IVM must be taken for about 15 years, which corresponds to the life span of the adult worm in humans (Mounchili et al., 2018, Stolk et al., 2021). By the same token, the success of IVM in disrupting *O. volvulus* transmission and protecting individuals in an endemic community from further infection is dependent on all eligible members of that community taking IVM for at least 15 years (Dissak-Delon et al., 2019, Endale et al., 2015). Non-compliance to IVM treatment can lead to sub-optimal response of *O. volvulus* adult worms which may be demonstrated by the release of microfilaria at a faster rate than expected (Basáñez et al., 2008).

In Cameroon, treatment of the disease was initiated in 1996 in the West Region of the country using the community-based approach with a yearly dose of IVM after the region was declared as one of the most hyperendemic using Rapid Epidemiological Mapping of Onchocerciasis surveys (Katabarwa et al., 2013, Mace et al., 1997). After 15 years of IVM administration, an evaluation study was carried out in this region in 2011. The yearly administration of IVM led to a reduction in microfilaria and nodule prevalence in all the sentinel communities of this region compared with the baseline data obtained in 1996. However, only 3 out of 11 (Foumban, Bafang, and Kekem) health districts were close to disrupting the transmission of the parasite, and thus, no recommendation was provided to stop IVM administration in the West Region of Cameroon (Katabarwa et al., 2013). In 2015, another survey was conducted, and the authors reported that there was progress towards the elimination of the disease in this Region in all the surveyed health districts except for the Massangam health district, which had a significant level of parasite transmission (Kamga et al., 2017).

The persistent transmission of the parasite in the Massangam health district was reported to be due to the existence of an area where there was perennial transmission (in a radius of about 12 km around the Makouopsap community) within the wider transmission zone (Bakajika et al., 2018). In such cases, the WHO recommends the use of alternative intervention strategies to accelerate disease elimination (World Health Organization, 2015). Thus, from 2017 to 2019, the Cameroon National Neglected Tropical Diseases (NTDs) Programme together with Sightsavers implemented alternative strategies to fight the disease. These strategies include testing individuals for *O. volvulus* infection and treating positive individuals with doxycycline, biannual mass drug administration of IVM, and ground larviciding of blackfly breeding sites. The authors reported a significant reduction in the prevalence of microfilaria carriers in the Massangam health district from 35.7% to 12.3% after the intervention (Atekem et al., 2022).

However, in March 2020 after the first case of COVID-19 was identified in Cameroon, several preventive measures were adopted (in addition to recommendations by the WHO) to limit the spread of the SARS-CoV-2 virus. These measures ranged from the closure of schools, limiting outdoor gatherings to a maximum of 50 persons, and the closure of bars and restaurants after 18:00 h (Siewe Fodjo et al., 2021, Esso et al., 2021). In addition, the WHO suspended health care services and programs directed towards combating NTDs (Toor et al., 2021, Sanyaolu et al., 2021). It was therefore necessary to evaluate the status of *O. volvulus* transmission in the Massangam health district to determine the effects which the suspension may have had on previous efforts that were implemented to disrupt the spread of the parasite. Similarly, it is also important to evaluate the effects of the disruption due to COVID-19 in hypoendemic regions. Thus, the Bandjoun health district which was previously reported to be hypoendemic for onchocerciasis in 2017 (Kamga et al., 2017) with a decline in the transmission rate of *Onchocerca* species in 2020 (Shintouo et al., 2020) was included in the study. A prevalence study was conducted to determine gender-age related distribution of onchocerciasis and establish the magnitude of onchocerciasis skin disease in both health districts.

2. Materials and methods

2.1. Ethical consideration

Ethical approval for the study was obtained from the Cameroon Bioethics Initiative (CAMBIN) Ethics Review and Consultancy Committee (ERCC) (approval number: CBI/470/ERCC/CAMBIN). All individuals who voluntarily accepted to take part in the study signed informed consent forms after clear explanations of the pertinence of the study. The privacy of participants was safeguarded during data collection, processing, and reporting.

2.2. Study area

The study was conducted from May to June 2021 in the Bandjoun and Massangam health districts in the West Region of Cameroon. Three communities were chosen in the Bandjoun health district (Tsesse, Lemgo, and Se-Dembom) as well as in the Massangam health district (Makouopsap, Mankakoun, and Mansouen) (Fig. 1). The West Region (5°30′0″N, 10°30′0″E) is 13,892 km^2 and is bordered by the North West Region to the northwest, the South West Region to the west, the Centre Region to the southeast, the Littoral Region to the southwest, and the Adamawa Region to the northeast (Kamga et al., 2017). The West Region is one of the most mountainous areas in Cameroon, with mountain peaks extending up to 3000 metres above sea level. This supports the existence of many continuously fast-flowing rivers that enable the breeding of black flies (Busari et al., 2022).

2.3. Study design

The study was a cross-sectional study where advocacy to invite participants for the study was made by community health workers. The study included all volunteers over the age of 5 who provided written informed consent or an assent form.

2.4. Clinical examination of the study participants

Each study participant was subjected to a clinical evaluation for manifestations of onchocerciasis like palpable nodules, pruritus, tiger skin, craw-craw, ocular lesions, and skin pigmentation. This clinical evaluation was carried out by a trained medical practitioner in a private room for the sake of respect of the participants' privacy.

2.5. Data, specimen collection and analysis

Information on socio-demographic variables like age, gender, marital status, occupation, length of time spent in the community, and previous treatments received for *O. volvulus* infection was obtained using a structured questionnaire. Two skin snips were obtained from the left and right knees of each participant, using a sterilised razor blade, and transferred to separate wells of a microtiter plate containing 100 μL of physiological saline. The plates were incubated at room temperature for 24 hrs to ensure the complete emergence of microfilariae from the skin biopsies. Microfilariae were counted under the microscope, and the microfilaria load was recorded as the number of microfilariae/skin snip.

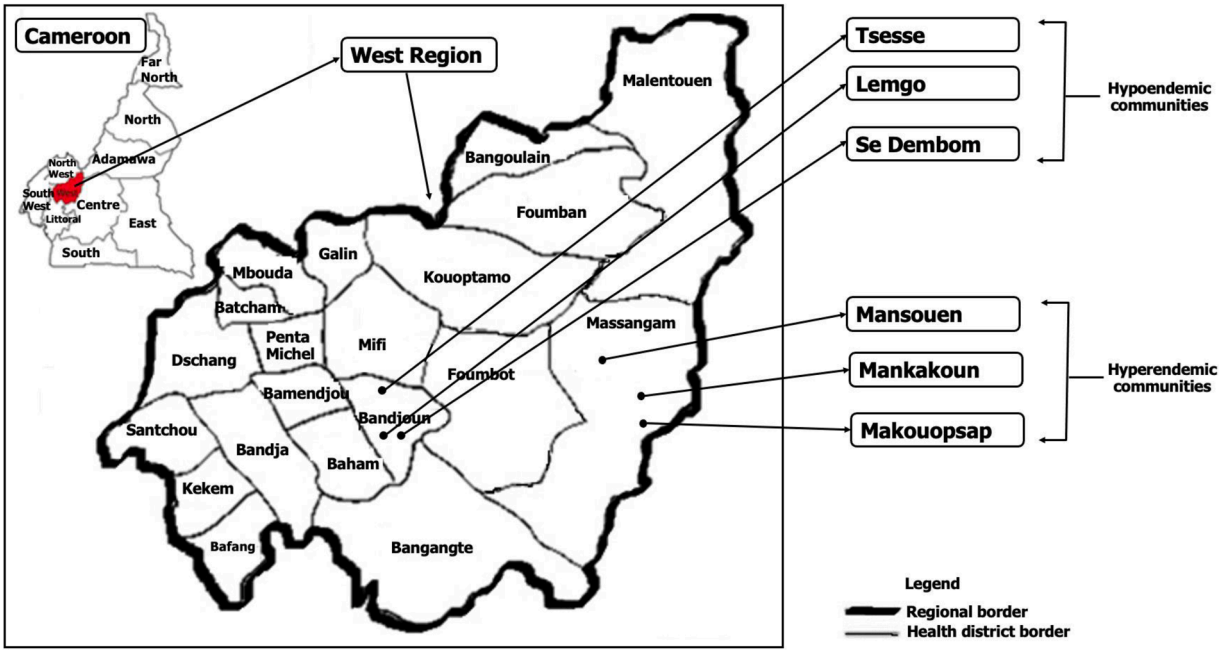

Fig. 1. Map of the West Region of Cameroon showing the surveyed communities. The figure is reproduced from Shintouo et al. (Shintouo et al., 2020) with slight modifications under Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).

2.6. Statistical analysis

The data was cleaned and analysed with the IBM Statistical Package for Social Sciences (IBM-SPSS) version 23.0. Continuous variables (parasite density) were summarised into geometric means and Standard Deviations. Categorical variables (demographic data, clinical examination, and onchocercal parasite status) were reported as frequencies and percentages. The difference in proportions was evaluated using Pearson's Chi-Square and Fisher exact Test. Group means of *O. volvulus* parasites were compared using the Mann-Whitney and Kruskal-Wallis tests. Significant levels were measured at 95% CI with the level of significance set at $P < 0.05$.

3. Results

3.1. Socio-demographic characteristics of study participants

A total of 229 participants in the Bandjoun health district and 378 in the Massangam health district were enrolled in the study. The ages of the study participants in both health districts ranged from 5 to 86 years, with a mean age of 35.85. A majority of the study participants were females in both health districts (Bandjoun – 54.1% and Massangam – 51.1%). For the Bandjoun health district, a majority of the participant were students (42.8%) while most of the participants from the Massangam health district were farmers (64.3%) (Table 1).

Table 1
Socio-demographic characteristics of study participants.

Characteristics	Bandjoun health district (n=229)	Massangam health district (n=378)
Gender, n (%)		
Male	105 (45.9)	185 (48.9)
Female	124 (54.1)	193 (51.1)
Age in years, n (%)		
5-20 (children)	101 (44.1)	95 (25.1)
21-49 (adults)	66 (28.8)	159 (42.1)
≥50 (elderly)	62 (27.1)	124 (32.8)
Level of Education, n (%)	9 (3.9)	67 (17.7)
No formal Education		
Primary	134 (58.5)	229 (60.6)
Secondary	77 (33.6)	77 (20.4)
Tertiary	9 (3.9)	5 (1.3)
Occupation, n (%)		
Student	98 (42.8)	77 (20.4)
Farmer	63 (27.5)	243 (64.3)
Artisans	57 (7.4)	47 (2.9)
Civil servant	11 (4.8)	11 (2.9)

n = number of participants.

3.2. Clinical examinations results

All participants were examined for onchocerciasis-related clinical manifestations. Overall, the commonly diagnosed signs of onchocerciasis (pruritus, tiger skin, craw-craw, skin pigmentation, nodules, and ocular lesions) were not significantly different between female and male participants in the Bandjoun and Massangam health districts. The overall prevalence of *Onchocercal* nodule carriers - the clinical manifestation used to determine the community-wide prevalence of *O. volvulus* infection - was 8.7% in the Bandjoun health district and 20.6% in the Massangam health district. In both health districts, there was no difference in the prevalence of nodule carriers with respect to gender (Table 2).

Furthermore, tiger skin, one of the signs of chronic infection with *O. volvulus*, was higher in elderly individuals (≥ 50 years) in the Bandjoun health district (21.0%) as well as in the Massangam health district (35.5%) when compared with the younger age groups, $P < 0.01$. Similarly, ocular lesion, which is also indicative of an individual's long-standing infection with *O. volvulus* was more prevalent among the elderly individuals as opposed to the younger individuals in Bandjoun and Massangam health districts (72.6% and 75.8% respectively), $P < 0.001$ (Table 3). In addition, as seen in Fig. 2, the preponderance of tiger skin and ocular lesion was correlated with the age of participants ($R^2 = 0.42$, $P < 0.001$).

Table 2
Frequency of the clinical manifestations of onchocerciasis with respect to gender in the study communities.

Clinical manifestation	Bandjoun health district				Massangam health district			
	Total (n = 229)	Males (n = 105)	Females (n = 124)	*P*-value[a]	Total (n = 378)	Males (n = 185)	Females (n = 193)	*P*-value[a]
Pruritus, n (%)	98 (42.8)	45 (42.9)	53 (42.7)	0.986	218 (57.7)	111 (60.0)	107 (55.4)	0.370
Tiger skin, n (%)	22 (9.6)	6 (5.7)	16 (12.9)	0.075	97 (25.7)	58 (31.4)	39 (20.2)	**0.013**
Craw-craw, n (%)	71 (31.0)	28 (26.7)	43 (34.7)	0.192	189 (50.0)	95 (51.4)	94 (48.7)	0.607
Skin pigmentation, n (%)	20 (8.7)	7 (6.7)	13 (10.5)	0.308	61 (16.1)	23 (12.4)	38 (19.7)	0.055
Nodules, n (%)	20 (8.7)	8 (7.6)	12 (9.7)	0.583	78 (20.6)	43 (23.2)	35 (18.1)	0.220
Ocular lesion, n (%)	102 (44.5)	40 (38.1)	62 (50.0)	0.071	170 (45.0)	89 (48.1)	81 (42.0)	0.230

n = number of participants.
[a] Results of Chi-Square test between male and female participants.

Table 3
Frequency of clinical manifestation of Onchocerciasis amongst the different age groups in the two health districts.

Clinical manifestation	Bandjoun health district				Massangam health district			
	5-20[a] (n = 101)	21-49[a] (n = 66)	≥ 50[a] (n = 62)	*P*-value[b]	5-20[a] (n = 95)	21-49[a] (n = 159)	≥ 50[a] (n = 124)	*P*-value[b]
Pruritus, n (%)	39 (38.6)	30 (45.5)	29 (46.8)	0.519	49 (41.6)	93 (58.5)	76 (61.3)	0.341
Tiger skin, n (%)	4 (4.0)	5 (7.6)	13 (21.0)	**0.001**	21 (22.1)	32 (20.1)	44 (35.5)	**0.009**
Craw-craw, n (%)	35 (34.7)	22 (33.3)	14 (22.6)	0.240	55 (57.9)	80 (50.3)	54 (43.5)	0.109
Skin Pigmentation, n (%)	7 (6.9)	8 (12.1)	5 (8.1)	0.497	23 (24.2)	19 (11.9)	19 (15.3)	**0.035**
Nodules, n (%)	4 (4.0)	5 (7.6)	11 (17.7)	**0.010**	26 (27.4)	22 (13.8)	30 (24.2)	**0.018**
Ocular lesion, n (%)	28 (27.7)	29 (43.9)	45 (72.6)	**<0.001**	14 (14.7)	62 (39.0)	94 (75.8)	**<0.001**

n = number of participants.
[a] age in years
[b] Results of Kruskal-Wallis test

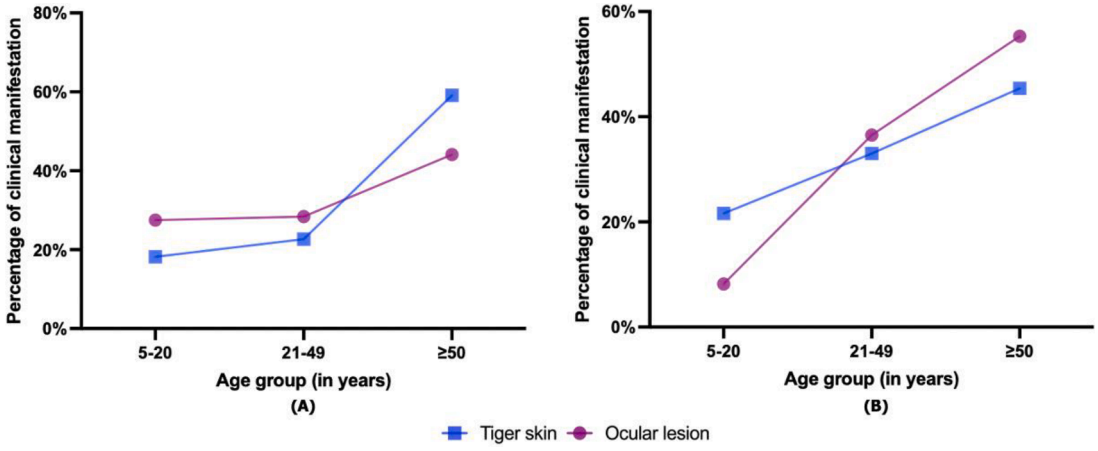

Fig. 2. Correlation between tiger skin and ocular lesion with age of participants in **(A)** Bandjoun and **(B)** Massangam health districts.

3.3. Parasitological data

The overall *O. volvulus* microfilaria prevalence in Bandjoun and Massangam health districts was 3.5% and 3.7%, respectively. In the Bandjoun health district, microfilaria prevalence was comparable between the different genders and age groups. Also, the geometric mean parasite density (GMPD) of males (4.9 microfilariae per skin snip) was comparable to that of females (4.7 microfilariae per skin snip). Furthermore, the older age group recorded the highest GMPD (8.2 microfilariae per skin snip) when compared with the age group of 5-20 years (2.9 microfilariae per skin snip) and the age group of 21-49 years (4.5 microfilariae per skin snip).

In the Massangam health district, *O. volvulus* prevalence was comparable between the genders and age groups. Also, the GMPD was comparable between the different age groups. However, the GMPD of males (1.4 microfilariae per skin snip) was significantly lower (P = 0.001) than that of females (19.2 microfilariae per skin snip). Furthermore, the group which consisted of adults (21-49 years) recorded the highest GMPD (10.0 microfilariae per skin snip) when compared with the younger age group (5-20 years) (1.0 microfilariae per skin snip) (Table 4).

The infection rate was not significantly different among participants involved in different occupations (Table 5). In the Bandjoun health district, the highest prevalence of microfilaria carriers was observed among participants from the Se-Dembom community (4.8%) while the lowest prevalence was found among study participants from the Tsesse community (2.6%). In the Massangam health district, the highest prevalence of microfilaria carriers was observed among participants from the Mankakoun community (6.5%) while the lowest prevalence was found among study participants from the Mansouen community (0.0%). In contrast to Tsesse and Lemgo communities, there was reduction in the prevalence of microfilaria in the study communities when compared to previous data obtained before the disruption of NTD programmes activities (Fig. 3).

Similarly, the prevalence of microfilaria carriers increased with the duration of stay in both health districts (Fig. 4). On the other hand,

Table 4
O. volvulus prevalence and density with respect to gender and age among participants in Bandjoun and Massangam health districts.

Parameter	Bandjoun health district Weighted mf Prevalence, n (%)	*P*-value	Parasite density, GMPD (range)	*P*-value	Massangam health district Weighted mf Prevalence, n (%)	*P*-value	Parasite density, GMPD (range)	*P*-value
Gender								
Male	2 (1.9)	0.294[a]	4.9 (4.0 – 6.0)	1.000[b]	7 (3.8)	1.000[c]	1.4 (1.0 – 3.0)	**0.001**[b]
Female	6 (4.8)		4.7 (1.0 – 20.0)		7 (3.6)		19.2 (3.0 – 85.0)	
Age in years								
5 – 20	3 (3.0)	0.813[d]	2.9 (1.0 – 6.0)	0.371[e]	1 (1.1)	0.255[d]	1.0 (1.0 – 1.0)	0.161[e]
21 - 49	2 (3.0)		4.5 (4.0 – 5.0)		8 (5.0)		10.0 (1.0 – 85.0)	
≥ 50	3 (4.8)		8.2 (4.0 – 20.0)		5 (4.0)		2.6 (1.0 – 20.0)	

n = number infected. GMPD = Parasite density is in microfilariae per skin snip.
[a] Difference in prevalence in the gender group determined by Fisher exact Tests.
[b] Difference in GMPD in the gender group determined by Mann-Whitney.
[c] Difference in prevalence in the gender group determined by Chi-Square test.
[d] Difference in prevalence in the different age groups determined by Chi-Square test.
[e] Difference in GMPD in the different age groups determined by Kruskal–Wallis test.

Table 5
Prevalence of infection vs. occupation of participants.

Occupation	Prevalence in health district	
	Bandjoun	Massangam
Students, n (%)	2 (2.0)	3 (3.8)
Farmers, n (%)	4 (6.3)	10 (4.1)
Artisans, n (%)	2 (3.5)	1 (2.1)
Civil servants, n (%)	0 (0.0)	0 (0.0)
P-value	0.4689	0.8317

n = number infected.

microfilaria carrier rate was not significantly different among participants who had never been treated with IVM in the Bandjoun and Massangam health districts (4.0% and 6.1% respectively), compared to infection rate amongst participants who complied with treatment (3.2% and 3.1% respectively) ($P = 0.473$, $P = 0.172$).

4. Discussion

Treatment for onchocerciasis in the West Region of Cameroon has been ongoing for over 20 years. However, the emergence of the COVID-19 pandemic interrupted regular public health services, including the implementation of mass drug administration activities (Sakho et al., 2021, Amanyi-Enegela et al., 2021). Without compliance and adherence to mass drug administration of IVM in a community, the treatment

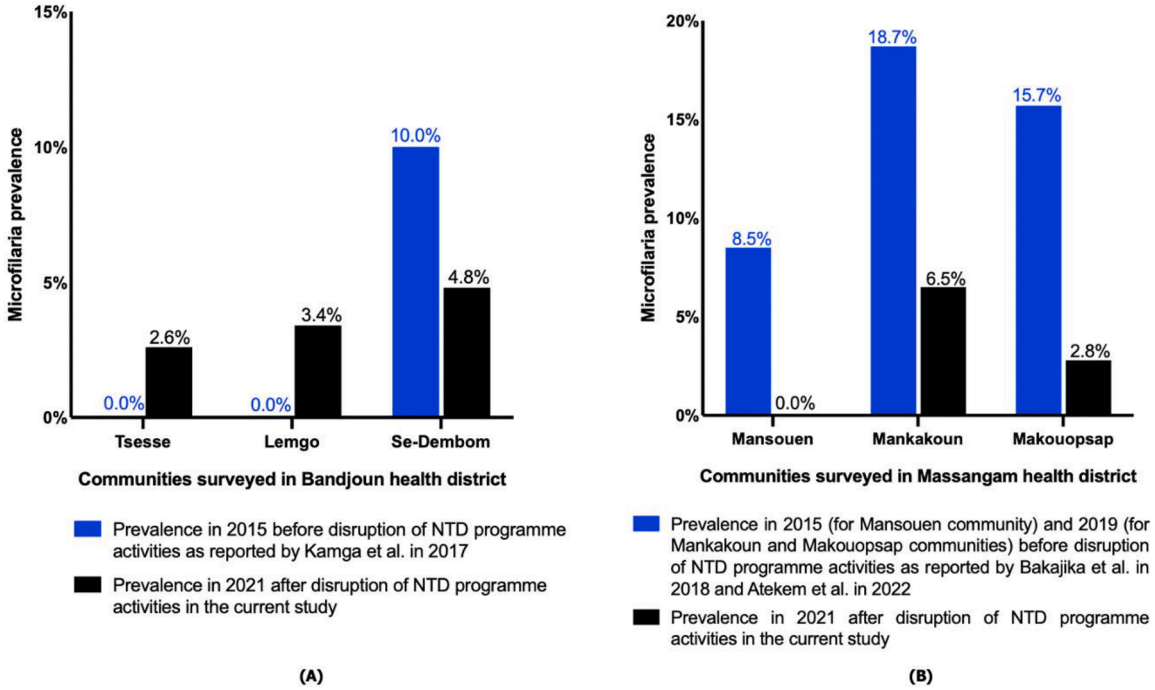

Fig. 3. Comparison of the prevalence of microfilaria before and after the disruption of NTD programme activities by WHO. The current data was compared with that of **(A)** Kamga et al. (Kamga et al., 2017) for the Bandjoun health district and **(B)** Bakajika et al. (Bakajika et al., 2018) in the Mansouen community and Atekem et al. (Atekem et al., 2022) in the Mankakoun and Makouopsap communities for the Massangam health district.

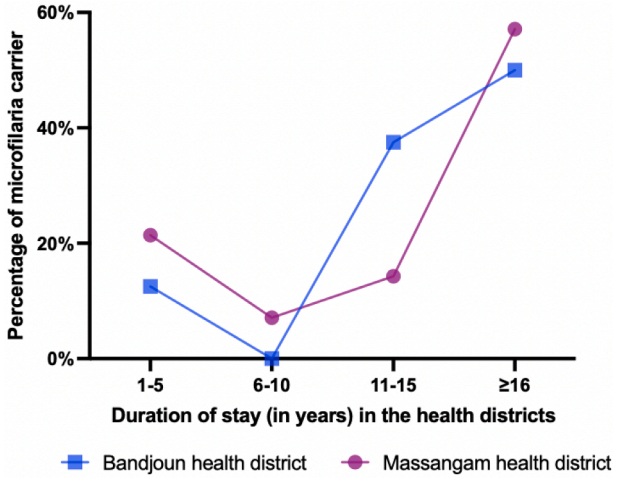

Fig. 4. Prevalence of microfilaria carriers and duration of stay in the health districts.

strategy might not be effective due to the possibility of resurgence and/or resistance to IVM (World Health Organisation 2016, Senyonjo et al., 2016). To investigate this hypothesis and in particular attempt to evaluate the consequences of the recent world health crisis related to the SARS-CoV2 epidemic, we conducted a prevalence study of *O. volvulus* infection to determine the microfilaridermia status and also establish the magnitude of onchocerciasis skin lesions in the Massangam and Bandjoun health districts, which were previously reported to be hyperendemic and hypoendemic for onchocerciasis respectively (Kamga et al., 2017, Bakajika et al., 2018).

Overall, the prevalence of the clinical manifestations of onchocerciasis was not significantly different among male and female participants in both health districts. This observation may be attributed to the fact that in our study population, both males and females are involved in activities that may have equal rate of exposure to black fly vectors. Ocular impairment was the main clinical manifestation of onchocerciasis in the Bandjoun health district, while in the Massangam health district, pruritus was the main clinical manifestation. Ocular lesion has been reported to be a sign of longstanding infection with *O. volvulus* while pruritus is usually the first visible symptom of onchocerciasis (Ramaiah et al., 1999). This suggest that the infection present in these districts is due to a combination of chronic and recent infections.

Additionally, tiger skins and ocular lesion, which are signs of longstanding infection with *O. volvulus,* were more prevalent among elderly individuals in both health districts. This is in line with similar reports that revealed that the elderly population bears the greatest burden of onchocerciasis (Shintouo et al., 2021, Okoro et al., 2014). This could be due to a continuous build-up of *O. volvulus* infection acquired early in life, as adult worms can live in humans for up to 15 years (Dozie et al., 2004, Kamalu & Uwakwe, 2014, Kifle et al., 2019). The prevalence of nodules was 8.7% in the Bandjoun health district and 20.6% in the Massangam health district. This prevalence agrees with previous reports that have been conducted in the various health districts before the suspension of NTDs activities (Kamga et al., 2017, Bakajika et al., 2018). It should be noted that some clinical manifestations of onchocerciasis, like skin lesions, are irreversible when an individual is free from the disease, while other manifestations like blindness, may take many years to develop when an individual is infected (Vinkeles Melchers et al., 2021). Thus, the effects of the temporal suspension of NTDs activities due to COVID-19 were difficult to evaluate in terms of these clinical manifestations.

In the Bandjoun health district, there was an increase in the prevalence of microfilaria in the Tsesse and Lemgo communities and a reduction in the Se-Dembom community when compared to previous data obtained before the disruption of NTD programmes activities. Therefore, although Kamga et al. (Kamga et al., 2017) reported 0% prevalence of microfilaria in the Tsesse and Lemgo communities, adult worms were still present in the communities. This implies that the ability of these adult worms to release microfilaria was repressed by IVM. Thus, the increase in the prevalence of microfilaria in both communities may be as a result of the production of microfilaria by adult worms in the absence of IVM during the disruption of NTD programme activities. Indeed, it is estimated that the development of an oocyte into a mature microfilaria takes between three to four weeks (Schulz-key & Soboslay, 1994). This increase in the prevalence of microfilaria may delay the elimination of onchocerciasis in these communities. Mathematical modelling predicts a mean delay of 2–3 years for a 1-year interruption of onchocerciasis elimination programme activities (Borlase et al., 2022).

As compared to earlier data, (Kamga et al., 2017, Bakajika et al., 2018, Atekem et al., 2022) there was a decrease in the prevalence of microfilaria in all the surveyed communities in the Massangam health district. Skin snip microscopy test was used to get the prevalence of microfilaria in the communities before the disruption of NTD programme activities as well as in the present study. Thus, technical differences between previous studies and this one and in particular the low sensitivity of skin snip microscopy, (Eberhard et al., 2017) do not account for the decrease in the prevalence of microfilaria reported in the present study. However, tests which are more sensitive and specific are needed to get a better picture of the transmission pattern of the parasite in these communities as well as in other endemic communities (Yengo et al., 2022, Shintouo et al., 2021, Shey et al., 2018). The decrease in the prevalence of microfilaria may be associated to the use of alternative intervention strategies that were implemented from 2017 to 2019 by Sightsavers and the National NTDs Programme in the health districts (Atekem et al., 2022). Indeed, doxycycline, which was used in the intervention, kills adult *O. volvulus* worms, (Hoerauf et al., 2009) and this may result in a decrease in the prevalence of microfilaria even in the absence of IVM. This is similar to reports observed in previous studies in some parts of Cameroon (Turner et al., 2010, Wanji et al., 2009) as well as in other parts of Africa (Hoerauf et al., 2003). Hence, the use of alternative tools to disrupt the spread of the parasite should continue in this health district as the use of IVM alone may not be sufficient to eliminate the disease (Atekem et al., 2022, Boussinesq et al., 2018, Ndjonka et al., 2018, Shey et al., 2021).

The geometric mean parasite density was higher in the elderly population in both health districts. This may be due to the fact that *O. volvulus* supresses the host immune system, and this may have a greater devasting effect on the elderly individuals who already have a compromised immune system (Bajaj et al., 2020, Wilson, 2023). Also, there was no significant difference between the prevalence of microfilarial infection with respect to occupation in both health districts. However, the length of stay in both health districts was associated with contracting the disease. This could be explained by previous reports, which revealed that persons who lived in an onchocerciasis endemic region for more than 60 years were at least 6 times more at risk of *O. volvulus* infection than persons who lived in the region for less than 10 years (Dana et al., 2015). Furthermore, the infection rate was not significantly different between participants who had different IVM treatment histories in both health districts. This suggests that treatment using IVM alone may reduce the burden of onchocerciasis in an endemic zone, but it may not be sufficient to eliminate onchocerciasis, as some individuals who have been receiving IVM for close to two decades were still microfilaria positive.

5. Conclusions

The temporary suspension of Onchocerciasis National Programme activities in Cameroon because of COVID-19 led to an increase in the prevalence of microfilaria carriers in the Tsesse and Lemgo hypoendemic communities in the Bandjoun health district while a decrease was

noted in the other surveyed communities. This decrease in the prevalence of microfilaria may be associated to the use of alternative intervention strategies to disrupt the transmission of *O. volvulus* between 2017 to 2019 (Atekem et al., 2022). Hence, there is a need for alternative strategies to eliminate onchocerciasis in both health districts as well as to intensify surveillance studies in other regions of Africa where the COVID-19 pandemic also disrupted Onchocerciasis Programmes activities.

Author Contributions

Conceptualization, project administration, validation, and supervision: R.N., S.M.G., J.S., L.V., L.A. and R.A.S.; methodology, C.M.S., R.A.S., B.N.Y., N.E.Y., R.N.T., and R.A.N.; software, data curation and formal analysis, C.M.S., B.N.Y., N.E.Y., and R.N.T.; funding acquisition, R.N.; J.S., S.M.G., L.V. and R.A.S.; writing—original draft preparation, C.M.S.; writing—review and editing, all authors. All authors have read and agreed to the published version of the manuscript.

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Ethical approval

The study was conducted in accordance with the Declaration of Helsinki and approved by the Cameroon Bioethics Initiative (CAMBIN) Ethics Review and Consultancy Committee (ERCC) (approval number: CBI/470/ERCC/CAMBIN).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Author statement

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by the authors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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