First evidence of lymphatic filariasis transmission interruption in Cameroon: Progress towards elimination

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Abstract

Background

Lymphatic filariasis (LF) is among the 10 neglected tropical diseases targeted for control or elimination by 2020. For LF elimination, the World Health Organization (WHO) has proposed a comprehensive strategy including (i) interruption of LF transmission through large-scale annual treatment (or mass drug administration (MDA)) of all eligible individuals in endemic areas, and (ii) alleviation of LF-associated suffering through morbidity management and disability prevention. In Cameroon, once-yearly mass administration of ivermectin and albendazole has been implemented since 2008. The aim of this study was to assess progress towards the elimination goal, looking specifically at the impact of six rounds of MDA on LF transmission in northern Cameroon.

Methodology

The study was conducted in the North and Far North Regions of Cameroon. Five health districts that successfully completed six rounds of MDA (defined as achieving a treatment coverage ≥ 65% each year) and reported no positive results for Wuchereria bancrofti microfilariaemia during routine surveys following the fifth MDA were grouped into three evaluation units (EU) according to WHO criteria. LF transmission was assessed through a community-based transmission assessment survey (TAS) using an immunochromatographic test (ICT) for the detection of circulating filarial antigen (CFA) in children aged 5–8 years old.

Principal findings

A total of 5292 children (male/female ratio 1.04) aged 5–8 years old were examined in 97 communities. Positive CFA results were observed in 2, 8 and 11 cases, with a CFA
prevalence of 0.13% (95% CI: 0.04–0.46) in EU#1, 0.57% (95% CI: 0.32–1.02) in EU#2, and 0.45% (95% CI: 0.23–0.89) in EU#3.

Conclusion/Significance
The positive CFA cases were below WHO defined critical cut-off thresholds for stopping treatment and suggest that transmission can no longer be sustained. Post-MDA surveillance activities should be organized to evaluate whether recrudescence can occur.

Introduction
Lymphatic filariasis (LF) is among the most widespread neglected tropical diseases. In the mid-1990s, it was reported that about 1.4 billion people were exposed to the disease worldwide, of whom 120 million were infected and more than 40 million disfigured by the disease [1].

One of the core resolutions of the 50th World Health Assembly held in 1997 was to eliminate LF as a public health problem through annual preventive chemotherapy (PC), repeated for at least six years, and reaching at least 65% of the population at risk. To date, about 5.63 billion cumulative treatments have been delivered since 2000, and more than 300 million people no longer require PC thanks to successful implementation of the WHO strategy. In Cameroon, PC for LF has been implemented since 2008. The aim of this study was to assess whether the transmission of LF has been interrupted. Cross-sectional surveys were conducted in three evaluation units (EU) in northern Cameroon. The LF prevalence observed in each of these EU was lower than the threshold of infection below which transmission is likely no longer sustainable, suggesting that the transmission of LF has been interrupted in the study area.
infection in the community will be reduced to levels below which transmission cannot be sustained, even after MDA has been stopped [5]. Recent estimates of the impact of MDA during the past 13 years revealed that more than 96 million LF cases were prevented or cured, although as many as 36 million cases of hydrocele and lymphedema remain [1]. However, data reporting interruption of LF transmission are scanty, especially in Sub Saharan Africa where the disease represents one-third of the global burden [6].

Cameroon is known to be endemic to onchocerciasis [7,8] and bancroftian filariasis [9,10], and MDA against LF have been implemented since 2008. Indeed, ivermectin and albendazole have been distributed by community drug distributors (CDDs) following the community directed treatment with ivermectin (CDTI) approach. This strategy has already been implemented 15–20 years earlier to fight against onchocerciasis. As such, the strategy was already well mastered by CDDs and was ongoing smoothly at the time MDAs against LF were implemented, following a door-to-door approach. This study aimed at assessing whether the transmission of LF has been successfully halted in areas where six MDA rounds have already been delivered.

Methods

Survey areas and populations

This study was carried out in 2014 in the North and Far North Regions of Cameroon, situated between latitudes 7˚ and 12˚N, and longitudes 12˚ and 16˚E. Five health districts or implementation units (Ngong, Poli, Tcholliré, Rey-Bouba in the North Region and Mokolo in the Far-North Region), with rural to semi-urban settings, were included in this study. These implementation units (IU) were organized into three evaluation units (EU) (Fig 1) according to the criteria described in the WHO monitoring and evaluation manual [2]. In 2014, the population of each of these two Regions was estimated to two millions, children aged 6–7 years old representing about 10% of the general population [11].

Study design

A cross sectional study was carried out following the recommendations described in the WHO manual for national elimination programs [2].

Pre-requisites and eligibility of implementation / evaluation units

The flow chart below (Fig 2) describes the different steps taken in the LF elimination process, thus conferring the eligibility of the targeted implementation units to the transmission assessment survey step.

Existing data and mapping. LF was known to be endemic in Cameroon since the 1900s thanks to some informative but parcel data from point microfilariaemia surveys (Fig 2). These data had shown that LF was mostly endemic in the northern (North and Far North Regions) Cameroon, with prevalence up to 22% [10]. In 2007, *W. bancrofti* circulating filarial antigen (CFA) was detected in 2.7% and 6.9% of individuals tested in four health districts in the Far North using ICT and ELISA, respectively [12], and mf prevalence ranging from 1% to 2% were found during night blood surveys for sentinel site identification in the North and Far North Regions (Ntep, personal communication). In 2009–2010, a nationwide mapping of lymphatic filariasis was organized following WHO recommendations [2], and prevalences ranging from 0 to 20% were found [9].

MDA. Since 1987, mass ivermectin distributions, either by mobile teams or through community directed interventions, have been organized over the country in the framework of river blindness control. From 2008 onwards, control efforts are ongoing through once-yearly
preventive chemotherapy based on ivermectin and albendazole combination. Due to logistical constraints, health districts (implementation unit, IU) are gradually included in the treatment plan. In 2013, five health districts of the North (Ngong, Poli, Tchollire and Rey-Bouba) and Far North (Mokolo) Regions completed their fifth MDA round, and were therefore eligible to post fifth MDA survey aiming at assessing the impact of MDA on LF infection.

Coverage survey. Each of the eligible IU had already completed at least five rounds of annual MDA. After each treatment campaign, drugs’ (ivermectin + albendazole) coverage was reported by the health system at the district level, via the compilation of treatment data from CDDs registers. Indeed, these data showed that reported treatment coverage were in general greater than 65% of the total population (S1 Table), and treatment coverage surveys conducted in 2013 in some of these IU to check whether these reported treatment coverages were accurate confirmed that drug coverages generally exceeded 65% [13].

Post 5th MDA survey. A cross sectional survey was conducted in sentinel sites, selected before MDA, where baseline microfilariaemia prevalence was collected for further follow-up of impact of mass treatments on LF endemicity. A comprehensive description of the basic
Characteristics of sentinel sites are provided in the WHO LF TAS manual [2]. Although no strict rule on the number of sentinel site per IU was edited, it is recommended that a minimum of one sentinel site will be chosen for each 1,000,000 population in the IU. Since the population of the IU considered in this study were relatively small (all between 200,000 and 400,000), it was accepted that one community will be chosen to service as sentinel site in each of the IUs. In these sentinel sites where the likelihood of transmission based on previous surveys were among the highest, a convenient sample of at least 300 individuals, aged 5 years and over, was constituted in each of the five eligible IU, following the WHO recommendations [2]. During this assessment of the impact of five years MDAs in sentinel sites, a total of 1497 individuals (Median age: 16 years old) were examined among which 48% were males. Although 33 hydrocele cases (1.8%; 95% CI: 1.3–2.5) and 2 elephantiasis of lower limb cases (0.1%; 95% CI: 0.0–0.4) were detected during the survey, none of the individuals examined was tested positive for W. bancrofti microfilariae in night blood smears [14]. Therefore these five IUs were qualified for transmission assessment survey (TAS).

Transmission assessment survey (TAS)

Survey type, target population and sample size. The sampling method used in the evaluation units (EU) was intended to be based on lot quality assurance sampling (LQAS), depending upon factors such as the net primary school enrolment rate in each EU, the target population size, the number of clusters (schools or enumeration areas), and the vector and parasite species. The general design of the TAS was performed using the Survey Sample Builder (SSB), a Microsoft Office Excel based-tool developed by the NTDs Support Centre (http://www.ntdsupport.org/resources/transmission-assessment-survey-sample-builder). Since the net primary-school enrolment ratio was <75% (~60% according to the National Institute of Statistics [15]) in the study area, a community-based cluster survey of children aged 6–7 years old was used. Children from this age group were chosen since they had lived most of their life during the course of MDA, and a positive CFA would likely indicate an ongoing transmission.
In addition to the survey design, the SSB was also helpful by calculating automatically the sample size of each EU based on information provided (primary vector species, population of children aged 6–7 years old, total number of EAs, and anticipated non response rate) (S2 Table). The SSB then generated a minimum sample size of 1552 in the EU#1, 1556 in the EU#2 and 1556 in the EU#3, to be collected in 30, 34 and 33 enumeration areas (EAs), respectively. It is worth to mention that, according to WHO guidelines [2], an EA is the smallest area for which census population results are available, and in Cameroon, EAs are equivalent of communities. To randomize household selection in each community or EA, the SSB calculated the sampling interval by dividing the total population of the EU by the number of clusters. Random numbers were then generated by the SSB to be used for the selection of EAs or communities from a list of all communities in each EU beforehand numbered according to geographical proximity. Finally, the sampling fraction (inverse of the sampling interval) was also computed automatically by the SSB to provide the proportion of children to be surveyed per household in each EA to reach the sample size.

**Diagnostic tools and data collection.** *Wuchereria bancrofti* circulating antigen was searched using a rapid-format card test, the immunochromatographic test (ICT) (Alere Inc., Scarborough, USA) [16,17], adhering to the manufacturer’s instructions. The survey was carried out during holidays, thus facilitating the enrollment of children in the communities. Sampling was carried out by skilled laboratory technicians, and training in the use of the ICT cards to detect *W. bancrofti* antigen as well as data recording was done for standardization purpose. Besides the antigenaemia data, socio-demographic data (age, sex, community of residence, health area and health district) of each enrollee was also collected.

**Critical cut-off threshold.** This is the threshold of infection prevalence below which transmission is likely no longer sustainable, even in the absence of control interventions. The WHO estimates this threshold by the number of antigen-positive or antibody-positive cases. In the design of the present survey, the critical cut-off value generated by the SSB was 18 for each of the three EUs evaluated.

**Data entry and analysis**

All relevant data for this study were recorded into a purpose-built Microsoft Access database and subsequently exported into PASW Statistics version 18 (SPSS Inc., Chicago, IL, USA) for statistical analyses. The prevalences of infection were expressed as the percentage of infected children (harboring CFA) among the total number of children examined; the 95% confidence interval (CI) was calculated using the Wilson method not corrected for continuity [18]. Chi-square tests were used to compare LF prevalence between sexes and age groups, as well as the computed threshold of infection prevalence below which transmission is likely no longer sustainable, so-called critical cut-off threshold, against the observed proportion of ICT positive cases.

**Ethical considerations**

This study was conducted as part of the action plan of the national program to eliminate lymphatic filariasis in Cameroon. Ethical clearance was granted by the Cameroon National Ethics Committee for Human Health Research (N’2014/09/491/CE/CNERSH/SP). Before enrolment, the objectives and schedule of the study were explained to the eligible population and individuals willing to participate signed two informed consent forms, and kept a copy. The second copy was stored at the Centre for Research on Filariasis and other Tropical Diseases. Even after minors assenting, the approval of their parents or legal guardians was necessary before any procedure. Each enrollee was assigned a unique identifier and his data analyzed anonymously. Positive cases were referred to CDDs and health officers for a close follow-up during
next treatments, and their parents or legal guardians warned about the situation to further insure a better compliance. Although no guidelines are given in the TAS manual [2], the number of positive cases– that can be up to 18 as was the case in the present study –, appears as a real concern in a context where MDA has to be halted if the EU passes TAS. In this context, we have recommended to treat these rare positive cases with ivermectin during the MDA campaign plan just after the survey, then by a long course of doxycycline (4–6 weeks) when they get above 8 years and MDA no longer available.

Results

Demographic data

A total of 97 communities (EAs) were surveyed in the three EUs, and 5292 children (48.9% females) examined. These children were aged 5–8 (median age: 6) years old. Among the 5292 enrollees, 4171 (78.8%) were aged 6–7 years old (initial target), a small proportion being aged 5 (11.8%) or 8 (9.4%) years old. A total of 1595 children were examined in EU#1, 1919 in EU#2 and 1778 in EU#3, the expected sample size being reached in all the three EUs (Table 1).

CFA prevalence

Prevalence of *W. bancrofti* circulating antigens, assessed using ICT card test, was equal to 0.13% (95% CI: 0.04–0.46) in EU#1, 0.57% (95% CI: 0.32–1.02) in EU#2, and 0.45% (95% CI: 0.23–0.89) in EU#3 (Table 1). The overall prevalence was 0.40% (95% CI: 0.26–0.61), with 80.95% positive cases aged 6–7 years old. The prevalence of LF was similar, both between age groups and sexes (*p* > 0.7408). The spatial distribution of positive cases was in general over-dispersed (both among health districts and EAs), except in the EU#2 where 8 children (1.07%; 95% CI: 0.54–2.10) with *W. bancrofti* circulating antigens were found in the Ngong health district, 6 of them belonging to two EAs.

Critical cut-off values

The total number of LF positive cases was 2 in EU#1, 11 in EU#2 and 8 in EU#3, all below the critical cut-off threshold (18 in each EU) generated by the Survey Sample Builder. As compared to the threshold of infection prevalence below which transmission is likely no longer sustainable, the proportion of positive cases was significantly lower in the EU#1 (Chi-square = 12.68; *p* = 0.0004) and EU#3 (Chi-square = 5.27; *p* = 0.02), but not significantly lower in EU#2 (Chi-square = 3.48; *p* = 0.06).

Discussion

In Cameroon, MDA against LF, using the combination of ivermectin and albendazole, started in 2008 in the North and Far North Regions. In 2014, five health districts (Mokolo, Ngong, Poli, Rey-Bouba and Tcholliré) completed six MDA rounds, and successfully passed the assessment of impact of MDA on LF infection after the fifth round of MDA (post 5 th MDA survey).
The objective of the present study was thus to check whether the transmission of the disease has been successfully halted.

Based on historical data [10], sentinel sites’ survey data and/or kriging data [9,12], the North and Far North Regions were previously highly endemic for LF, and were reported among the most prevalent over the country. In 2014, LF prevalence observed in each of the three EUs investigated—in average equal to 0.40% (95% CI: 0.26–0.61)—was significantly lower than the threshold below which the transmission of the disease can no longer be sustained. Indeed, it was accepted that in areas where *W. bancrofti* is endemic and *Anopheles* or *Culex* is the principal vector, this target threshold must be < 2% antigenaemia prevalence [2]. In Cameroon, LF entomological data are very scanty but malaria data can be informative. Although *Anopheles gambiae* and *Anopheles funestus* have been found naturally infected with *W. bancrofti* [10], malaria entomological data have shown that the most abundant vectors in the Northern Cameroon are from genera *Anopheles* and *Culex* (Nwane, personal communication).

The number of positive antigenaemia cases observed in each of the three EUs surveyed was below the critical cut-off generated by the SSB (18 CFA positive cases), indicating that the area successfully "passed" TAS, and a cessation of MDA in the constituting communities should be envisioned. Indeed, the sample sizes and critical cut-off values were chosen so that an EU has (i) at least a 75% chance of passing TAS if the true prevalence of antigenaemia is 1.0% (half the target level if the vector is *Anopheles* or *Culex*), and (ii) no more than about a 5% chance of passing (incorrectly) TAS if the true prevalence of antigenaemia is ≥2.0% [19,20]. The importance of transmission assessment surveys as an evaluation tool for stopping MDA have been previously demonstrated in a multicenter evaluation using different approaches or study designs [21]. Moreover, the validity of TAS was also proven in long term post-MDA surveillance, although complementary test (antibody and xenomonitoring) appear of interest to ascertain the interruption of transmission during post-MDA surveillance [22–24].

It is important to notice that the interruption of transmission was achieved despite the fact that in some health districts, the effective treatment coverage was not reached for one or two rounds, although globally higher than 65% (S1 Table). TAS was considered for these health districts for three main reasons: (i) long lasting insecticidal nets (LLINs) have been distributed in the study area in the framework of malaria control program activities. Indeed, between 2003 and 2010, more than two millions LLINs have been distributed to pregnant women and children under 5 years old. In the framework of LLINs universal coverage for the control of malaria, a total of 21,028,770 LLINs have been distributed in the entire country in 2011 and 2016 (with 73% coverage in 2011 and 88% coverage in 2016), on the basis of one LLIN for every 2.2 households [25]. The impact of LLINs on prevalence and intensity of LF infection is now widely accepted [26,27], and it was shown that a sustained reduction in LF prevalence can be reached in spite of missed rounds of MDA [28]. In addition to these efforts related to the known usefulness of LLINs, the relatively poor compliance observed at the beginning of this large scale control strategy against malaria, and to some extent against LF, was improved over time thanks to communication and sensitization of populations [29]. It seems worth to mention that although insecticide resistance has been reported in several foci in Cameroon, it was demonstrated that LLINs might still offer some protection against the resistant *Anopheles gambiae* s.l. populations in northern Cameroon [30]. (ii) Ivermectin has been widely distributed in the study area since 1987 (Fig 2). Indeed, in 1987–1989, limited MDA campaigns were organized in the framework of a phase IV trial of ivermectin conducted in the Vina Valley located in the North Region of Cameroon [31]. In 1992, the Ministry of Health (MoH) and the River Blindness Foundation (RBF) began to broaden distribution of ivermectin, with the assistance of non-governmental developmental organizations (NGDOs), through mobile teams/outreach approach [32]. Since 1997–1998, the African Program for Onchocerciasis Control (APOC)
joined the coalition to support annual delivery of ivermectin through community-directed
treatment with ivermectin (CDTI) [33]. Although ivermectin is not macrofilaricidal, it is
highly microfilaricidal and repeated treatments might have significantly contributed to the
interruption of LF transmission [34,35]. Moreover, it was demonstrated that the transmission
can be interrupted earlier than expected in areas previously treated for onchocerciasis [36].
(iii) Last but not the least, the prevalences in the study areas were relatively low when MDAs
against LF began, suggesting that in such context, LF endemicity can be quickly lowered to
level under which transmission cannot be sustained.

After six years of MDA (ivermectin in combination with albendazole), the transmission of
LF was interrupted in five IUs (Mokolo, Ngong, Poli, Tchollire and Rey-Bouba heath districts)
of the North and Far North Regions. These results support the cessation of MDA in these IUs,
but this decision needs further thinking. It was demonstrated that MDA can be safely stopped
in some but not all local government areas of Plateau and Nasarawa States in Nigeria [37], sug-
gesting that the cessation of MDA can be feasible in the IUs investigated in northern Camer-
on, even if the transmission of LF might be ongoing in the neighboring IUs. This is likely in
accordance with the focal LF transmission that might be occurring in Cameroon. Also, the
LF prevalences were relatively low at the beginning of MDAs, and the neighboring EUs has
already completed at least four effective rounds of MDA when mass treatments can be halted
as a consequence of transmission interruption.

However, epidemiological surveys conducted in northern Cameroon in 2008–2010 showed
that mass ivermectin distributions had significantly lowered prevalence and intensity of on-
chocerciasis, but the transmission of the disease was yet to be interrupted [33]. In such circum-
stances where onchocerciasis transmission is still ongoing in these (and the neighboring) IUs,
the interruption of treatments (IVM + ALB) might need further thinking. It is accepted that in
areas where onchocerciasis is endemic, ivermectin can be used solely after interruption of LF
transmission but this might be challenging while conducting surveillance activities to investi-
gate potential recrudescence of LF. Another important challenge to take into account is the
endemicity of soil transmitted helminthiasis (STH) since both IVM and ALB are effective
against the parasites responsible of these diseases, especially in areas where STH control is not
performing well. In such circumstances, it appears useful to investigate the situation of oncho-
cerciasis and STH, especially now rapid diagnostic tests are being releasing for these diseases.
This will help taking the decision about stopping MDA not only according to the evidence
of LF transmission interruption, but also to the situation of STH and onchocerciasis in the
selected EU. These additional data, collected in an integrated manner during TAS surveys, will
be really cost effective and provide more insights in decision making.

Supporting information
S1 Checklist. STROBE checklist.
(DOCX)

S1 Dataset. Database for lymphatic filariasis transmission assessment survey in three eval-
uation units in northern Cameroon. EU: evaluation unit; IDN: identification number; ICT:
immunochromatographic test; TAS: transmission assessment survey; Neg: negative; Pos: posi-
tive; M: Male; F: female.
(XLSX)

S1 Table. Population and therapeutic coverage reported in the target implementation
units (IUs) between 2008 and 2013.
(DOCX)
S2 Table. Population description of the targeted evaluation units.

(nocx)

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References
1. WHO (2016) Lymphatic filariasis. World Health Organ Fact Sheet 104.
2. WHO (2011) Monitoring and epidemiological assessment of mass drug administration in the global programme to eliminate lymphatic filariasis: a manual for national elimination programmes. World Health Organization, Geneva WHO/HTM/NTD/PCT/2011.4.
3. Plaisier AP, Stolk WA, van Oortmarssen GJ, Habberma JD (2000) Effectiveness of annual ivermectin treatment for Wuchereria bancrofti infection. Parasitol Today 16: 298–302. PMID: 10858649
4. Michael E, Malecela-Lazaro MN, Simonsen PE, Pedersen EM, Barker G, et al. (2004) Mathematical modelling and the control of lymphatic filariasis. Lancet Infect Dis 4: 223–234. https://doi.org/10.1016/S1473-3099(04)00973-9 PMID: 15050941
5. Stolk WA, Swaminathan S, van Oortmarssen GJ, Das PK, Habberma JD (2003) Prospects for elimination of bancroftian filariasis by mass drug treatment in Pondicherry, India: a simulation study. J Infect Dis 188: 1371–1381. https://doi.org/10.1086/378354 PMID: 14593597
6. Sodahlon Y, Malecela M, Gyapong JO (2016). Lymphatic filariasis (elephantiasis). In: Gyapong JO, Boatin B, editors. Neglected Tropical Diseases—Sub-Saharan Africa. pp. 159–186.
7. Noma M, Zoure HG, Tekie AH, Enyong PA, Nwoke BE, et al. (2014) The geographic distribution of onchocerciasis in the 20 participating countries of the African Programme for Onchocerciasis Control.
(1) priority areas for ivermectin treatment. Parasit Vectors 7: 325. https://doi.org/10.1186/1756-3305-7-325 PMID: 25053266

8. Zoure HG, Noma M, Tekle AH, Amazigo UV, Diggle PJ, et al. (2014) The geographic distribution of onchocerciasis in the 20 participating countries of the African Programme for Onchocerciasis Control: (2) pre-control endemicity levels and estimated number infected. Parasit Vectors 7: 326. https://doi.org/10.1186/1756-3305-7-326 PMID: 25053392

9. Nana-Djeunga HC, Tchatchueng-Mbogua JB, Bopda J, Mbickmen-Tchana S,elong-Kana N, et al. (2015) Mapping of Bancroftian Filariasis in Cameroon: Prospects for Elimination. PLoS Negl Trop Dis 9: e0004001. https://doi.org/10.1371/journal.pntd.0004001 PMID: 26353087

10. Boussinesq M (1999) La filariosè lymphatique au Cameroun: état des connaissances. Bull liais doc OCEAC 32: 7–12.

11. BUCREP (2010) Population du Cameroun en 2010. Available: http://bucrep.cm/index.php/fr/component/phodownload/category/20-presentation-des-resultats. Accessed 26 February 2017. Rapport du Troisième Recensement de la Population et de l’Habitat (RGPH).

12. Gounoue-Kamkumo R, Nana-Djeunga HC, Bopda J, Akame J, Tarini A, et al. (2015) Loss of sensitivity of immunochromatographic test (ICT) for lymphatic filariasis diagnosis in low prevalence settings: consequence in the monitoring and evaluation procedures. BMC Infect Dis 15: 579. https://doi.org/10.1186/s12879-015-1317-x PMID: 26700472

13. Nana-Djeunga HC, Njitchouang GR, Tchatchueng-Mbougua JB, Ndjomo-Andjembe JE, Wabo-Tala Y, et al. (2014) Therapeutic coverage survey following mass drug administration against lymphatic filariasis in the Far North Region of Cameroon: consequences in the elimination process. African Journal of Epidemiology 2 (Suppl 1).

14. Nana-Djeunga HC, Njitchouang GR, Tchatchueng-Mbougua JB, Ndjomo-Andjembe JE, Wabo-Tala Y, et al. (2015) Progress towards lymphatic filariasis elimination in Cameroon: impact of six rounds of mass drug administration on infection and transmission. 4th Congress of the Cameroon Society of Parasitology.

15. INS (2011) Deuxième enquête sur l’emploi et le secteur informel au Cameroun (EESI 2). 155.

16. Weil GJ, Ramzy RM (2007) Diagnostic tools for filariasis elimination programs. Trends Parasitol 23: 78–82. https://doi.org/10.1016/j.pt.2006.12.001 PMID: 17174604

17. Rebollo MP, Bockarie MJ (2014) Shrinking the lymphatic filariasis map: update on diagnostic tools for mapping and transmission monitoring. Parasitology 141: 1912–1917. https://doi.org/10.1017/S0031182014001231 PMID: 25225828

18. Wilson EB (1927) Probable inference, the law of succession, and statistical inference. J Amer Stat Assoc 22: 209–212.

19. WHO (2010) Global Programme to Eliminate Lymphatic Filariasis progress report 2000–2009 and strategic plan 2010–2020. World Health Organization, Geneva WHO/HTM/NTD/PCT/2010.6.

20. WHO (2010) Global programme to eliminate lymphatic filariasis: progress report on mass drug administration in 2009. wkly Epidemiol Rec 83: 365–372.

21. Chu BK, Deming M, Brittwum NK, Bougma WR, Dorkenoo AM, et al. (2013) Transmission assessment surveys (TAS) to define endpoints for lymphatic filariasis mass drug administration: a multicenter evaluation. PLoS Negl Trop Dis 7: e2584. https://doi.org/10.1371/journal.pntd.0002584 PMID: 24340120

22. Ramaiah KD, Vanamail P (2013) Surveillance of lymphatic filariasis after stopping ten years of mass drug administration in rural communities in south India. Trans R Soc Trop Med Hyg 107: 293–300. https://doi.org/10.1093/trstmh/trt011 PMID: 23442572

23. Rao RU, Nagodavithana KC, Samarasekera SD, Wijegunawardana AD, Premakumara WD, et al. (2014) A comprehensive assessment of lymphatic filariasis in Sri Lanka six years after cessation of mass drug administration. PLoS Negl Trop Dis 8: e3281. https://doi.org/10.1371/journal.pntd.0003281 PMID: 25393404

24. Noland GS, Blount S, Gonzalez M (2015) Post-Mass Drug Administration Transmission Assessment Survey for Elimination of Lymphatic Filariasis in La Cienega, Dominican Republic. Am J Trop Med Hyg 93: 1292–1294. https://doi.org/10.4269/ajtmh.15-0204 PMID: 26503279

25. AMP (2015) The Alliance for Malaria Prevention: expanding the ownership and use of mosquito nets. Country profile: Cameroon. Available: http://allianceformalariaprevention.com/wp-content/uploads/2015/08/Cameroon-AMP-country-profile.pdf. Accessed 26 February 2017. Report.

26. Kelly-Hope LA, Molyneux DH, Bockarie MJ (2013) Can malaria vector control accelerate the interruption of lymphatic filariasis transmission in Africa; capturing a window of opportunity? Parasit Vectors 6: 39. https://doi.org/10.1186/1756-3305-6-39 PMID: 23433078
27. Richards FO, Emukah E, Graves PM, Nkwocha O, Nwankwo L, et al. (2013) Community-wide distribution of long-lasting insecticidal nets can halt transmission of lymphatic filariasis in southeastern Nigeria. Am J Trop Med Hyg 89: 578–587. https://doi.org/10.4269/ajtmh.12-0775 PMID: 23939708

28. Njenga SM, Mwandawiro CS, Wamae CN, Mukoko DA, Omar AA, et al. (2011) Sustained reduction in prevalence of lymphatic filariasis infection in spite of missed rounds of mass drug administration in an area under mosquito nets for malaria control. Parasit Vectors 4: 90. https://doi.org/10.1186/1756-3305-4-90 PMID: 21612649

29. FIS (2016) Shadow Report. Independent monitoring of the Global Funds Grants in Cameroon (CMR-MoH). Available: http://www.fiscameroon.org/sites/default/files/Rapports_E/Shadow%20anglais%20version%20finale.pdf. Accessed 26 February 2017. Report.

30. Etang J, Pennetier C, Piameu M, Bouraima A, Chandre F, et al. (2016). When intensity of deltamethrin resistance in Anopheles gambiae s.l. leads to loss of Long Lasting Insecticidal Nets bio-efficacy: a case study in north Cameroon. Parasit Vectors 9: 132. https://doi.org/10.1186/s13071-016-1420-x PMID: 26951758

31. Prod'hom J, Boussinesq M, Fobi G, Prud'hom JM, P. E, et al. (1991) Lutte contre l'onchocercose par ivermectine: résultats d’une campagne de masse au Nord-Cameroun. Bull World Health Organ 69: 443–450. PMID: 1934238

32. Meredith SEO, Cross C, Amazigo UV (2012) Empowering communities in combating river blindness and the role of NGOs: case studies from Cameroon, Mali, Nigeria, and Uganda. Health Res Policy Syst 10: 16. https://doi.org/10.1186/1478-4505-10-16 PMID: 22574885

33. Katabarwa MN, Eyamba A, Nwane P, Enyong P, Yaya S, et al. (2011) Seventeen years of annual distribution of ivermectin has not interrupted onchocerciasis transmission in North Region, Cameroon. Am J Trop Med Hyg 85: 1041–1049. https://doi.org/10.4269/ajtmh.2011-0333 PMID: 22144441

34. Cao WC, Van der Ploeg CP, Plaisier AP, van der Sluijs IJ, Habbema JD (1997) Ivermectin for the chemotherapy of bancroftian filariasis: a meta-analysis of the effect of single treatment. Trop Med Int Health 2: 393–403. PMID: 9171850

35. Eberhard ML, Hightower AW, Addiss DG, Lammie PJ (1997) Clearance of Wuchereria bancrofti antigen after treatment with diethylcarbamazine or ivermectin. Am J Trop Med Hyg 57: 483–486. PMID: 9347968

36. Koroma JB, Sesay S, Sonnie M, Hodges MH, Sahr F, et al. (2013) Impact of three rounds of mass drug administration on lymphatic filariasis in areas previously treated for onchocerciasis in Sierra Leone. PLoS Negl Trop Dis 7: e2273. https://doi.org/10.1371/journal.pntd.0002273 PMID: 23785535

37. King JD, Eigege A, Umaru J, Jip N, Miri E, et al. (2012) Evidence for stopping mass drug administration for lymphatic filariasis in some, but not all local government areas of Plateau and Nasarawa States, Nigeria. Am J Trop Med Hyg 87: 272–280. https://doi.org/10.4269/ajtmh.2012.11-0718 PMID: 22858758