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Onchocerciasis control in the Democratic Republic of Congo (DRC): challenges in a post-war environment

J.-C. Makenga Bof[1], V. Maketa[2], D. K. Bakajika[3], F. Ntumba[3], D. Mpunga[4], M. E. Murdoch[5], A. Hopkins[6], M. M. Noma[7], H. Zouré[7], A. H. Tekle[7], M. N. Katabarwa[8] and P. Lutumba[2,9,10]

1 *Faculty of Public Health, Université Catholique de Louvain, Brussels, Belgium*
2 *Department of Tropical Medicine, Faculty of Medicine, Kinshasa University, Kinshasa, Democratic Republic of Congo*
3 *Programme National de Lutte contre l'Onchocercose, Kinshasa, Democratic Republic of Congo*
4 *School of Public Health, Kinshasa University, Kinshasa, Democratic Republic of Congo*
5 *Department of Dermatology, Watford General Hospital, Watford, UK*
6 *Mectizan Donation Program, Task Force for Global Health, Decatur, GA, USA*
7 *African Programme for Onchocerciasis Control, Ouagadougou, Burkina Faso*
8 *Emory University/The Carter Centre, Atlanta, GA, USA*
9 *Prince Leopold Institute of Tropical Medicine, Antwerp, Belgium*
10 *National Institute of Biomedical Research, Kinshasa, Democratic Republic of Congo*

Abstract

OBJECTIVE To evaluate onchocerciasis control activities in the Democratic Republic of Congo (DRC) in the first 12 years of community-directed treatment with ivermectin (CDTI).

METHODS Data from the National Programme for Onchocerciasis (NPO) provided by the National Onchocerciasis Task Force (NOTF) through the annual reports of the 21 CDTI projects for the years 2001–2012 were reviewed retrospectively. A hypothetical–inputs-process-outputs-outcomes table was constructed.

RESULTS Community-directed treatment with ivermectin expanded from 1968 communities in 2001 to 39 100 communities by 2012 while the number of community-directed distributors (CDD) and health workers (HW) multiplied. By 2012, there were ratios of 1 CDD per 262 persons and 1 HW per 2318 persons at risk. More than 80% of the funding came from the fiduciary funds of the African Programme for Onchocerciasis Control. The cost of treatment per person treated fell from US $ 1.1 in 2001 to US$ 0.1 in 2012. The therapeutic coverage increased from 2.7% (2001) to 74.2% (2012); the geographical coverage, from 4.7% (2001) to 93.9% (2012). Geographical coverage fell in 2005 due to deaths in loiasis co-endemic areas, and the therapeutic coverage fell in 2008 due to insecurity.

CONCLUSIONS Challenges to CDTI in DRC have been serious adverse reactions to ivermectin in loiasis co-endemic areas and political conflict. Targets for personnel or therapeutic and geographical coverages were not met. Longer term funding and renewed efforts are required to achieve control and elimination of onchocerciasis in DRC.

keywords onchocerciasis, Democratic Republic of Congo, community-directed treatment with ivermectin

Introduction

A major strategy for achieving Africa's Millennium Development Goals for poverty reduction is the control and elimination of the neglected tropical diseases (NTDs) (Hotez & Kamath 2009). Onchocerciasis, one of the most common NTDs, is the world's second leading cause of infectious blindness (WHO 2010a). It also causes pruritus and a variety of cutaneous changes (Murdoch *et al.* 1993). Typically coexisting with extreme poverty in 'end-of-the-road' communities, this infection is a significant public health problem (De Sole *et al.* 1991; Murdoch *et al.* 2002) with high socio-economic impact (Oladepo *et al.* 1997; Benton 1998; Brieger *et al.* 1998; Vlassoff *et al.* 2000; Tchounkeu *et al.* 2012) and increased mortality (Walker *et al.* 2012). Most cases occur in sub-Saharan Africa, where 89 million people are at risk of infection (WHO/APOC 2005).

Onchocerciasis has been known in the Democratic Republic of Congo (DRC) since 1903 (Maertens 1990).

The first observation of ocular onchocerciasis in Africa was reported by Hissette in Zaïre in 1931; a detailed clinical survey in Oriental province by Browne in 1959 revealed a prevalence of onchocerciasis of 17.3% (Hissette 1931; Browne 1959). The national burden of onchocercal disease in 1990 was estimated at 4.57 million people infected and 37 500 persons blind due to onchocerciasis, within a total population at risk of 35.6 million (Remme 2004). A more recent estimate suggested that approximately 23.6 million persons in DRC are exposed to onchocerciasis, among whom more than a half (14 million) are infected (Ministère du Plan, DRC 2006).

Community-directed treatment with ivermectin

The first community-based treatments in DRC began in 1991 in Dimbelenge, Kasai-Occidental Province, where a cluster-based population survey using skin snips was performed to determine prevalence. It was followed by treatment for all eligible persons in the community. Various other community-based programmes also began in the early 1990s in Kasai-Oriental Province.

In 1995, the African Programme for Onchocerciasis Control (APOC) was launched with the goal of controlling onchocerciasis as a public health problem in the African countries where the disease remained endemic (Amazigo 2008). A single dose of ivermectin (Mectizan®) donated by Merck and Co. Inc. via the Mectizan Donation Program is given annually to all eligible residents of endemic areas (Thylefors 2008). Community-directed treatment lets the communities be actively involved and choose their own ivermectin distributor. This strategy is feasible, sustainable and achieves higher treatment coverage than traditional health system strategies (Amazigo 2008).

In 1996, with support from WHO/APOC, DRC's Ministry of Health created firstly, the National Programme for Onchocerciasis (NPO) and secondly, a National Onchocerciasis Task Force (NOTF) using the community-directed treatment with ivermectin (CDTI) approach. The provinces had relative autonomy in the management of CDTI projects and storage facilities and warehouses in the provinces were successfully used to stock up ivermectin for use in the projects. The first CDTI project was launched in 2001 in Occidental and Oriental areas of Kasai Province, followed by Uélé (Oriental Province) in 2002. In 2003, four new projects were implemented, Bandundu (Bandundu Province), Tshopo (Oriental Province), Bas-Congo/Kinshasa (Kinshasa and Bas-Congo Province) and Sankuru (Oriental Kasai Province). Three projects in Katanga (North Katanga, South Katanga and Lualaba) and five in the province of Equateur (Tshuapa, North Ubangi, South Ubangi, Mongala and Equateur-Kiri) were added in March 2004.

From June 2004 to 2005, however, the Bas-Congo/Kinshasa, Tshopo and Uélé projects and new projects launched over the previous few months were suspended temporarily because of deaths associated with ivermectin use in populations where onchocerciasis and loiasis coexisted. The combined use of loiasis mapping using 'Rapid Assessment Procedure for Loiasis' (RAPLOA) and onchocerciasis mapping using Rapid Epidemiological Assessment (REA) was therefore launched to identify onchocerciasis treatment areas and to exclude areas of onchocerciasis and loiasis co-endemicity. In 2005, only populations from the projects of Bandundu, Kasai and Sankuru were treated with ivermectin. In 2006, the projects of Bandundu, Bas-Congo/Kinshasa, Equateur-Kiri, Kasai, North and South Katanga, Lualaba, Mongala, Rutshuru-Goma (North Kivu Province), Sankuru, Tshopo, Tshuapa, North Ubangi, South Ubangi and Uélé organised ivermectin treatment. In 2007, Kasongo (Maniema Province) was added. In 2008, the Butembo-Beni (North Kivu Province), Lubutu (Maniema Province), Masisi-Walikale (North Kivu Province) and North Ituri (Oriental Province) projects were launched. In 2012, the last project, South Ituri, was launched (Table 7). In addition to CDTI, larviciding and other vector control activities were initiated on a small-scale in a few health zones.

Although the original aim of APOC was to control onchocerciasis as a public health problem, more recently the objective has shifted from control towards elimination of the disease. Mindful of this wider perspective, in this article, we evaluate the progress and costs of onchocerciasis control activities and the therapeutic and geographical coverages of ivermectin distribution achieved during the first 12 years of CDTI in DRC.

Methods

Context and population

Democratic Republic of Congo has an area of 2.3 million km² and an estimated population in 2010 of 67.8 million people, 70% of whom live in rural areas (Ministère du Plan, DRC 2011). Since 1990, the country has been devastated by political unrest and two wars (1996–1997 and 1998–2003). In 2011, the human development index classification of the United Nations Development Programme (UNDP) placed DRC in 187th position of 187 countries (UNDP 2011). The populations affected by onchocerciasis typically live in remote areas alongside rivers and are mainly subsistence farmers. Administratively, DRC is

subdivided into 11 provinces, and onchocerciasis affects all the provinces in varying degrees.

Rapid epidemiological mapping of onchocerciasis

During the late 1990s, the Congolese Government began Rapid Epidemiological Mapping of Onchocerciasis (REMO) to determine the nation-wide prevalence of onchocerciasis and decide which geographical areas should be treated with ivermectin (Ngoumou & Walsh 1993; Noma *et al.* 2002). REMO is a tool developed by WHO (TDR) to quickly assess onchocerciasis endemicity. The method uses geographical information, in particular river systems, to identify the communities likely to be at high risk of onchocerciasis infection. A sample representing 2–4% of the villages in the area is assessed for possible presence of onchocerciasis. Palpation for subcutaneous nodules (which contain adult worms) is performed in 30–50 adults per village (Rapid Epidemiological Assessment or REA). Adults must be at least 20 years old and have lived in the community for at least 10 years. The levels of endemicity for onchocerciasis are defined as sporadic (nodule prevalence <10%), hypoendemic (10–19.9%), mesoendemic (20%–39.9%) and hyperendemic (≥40%). If more than 20% of adults have nodules, mass treatment is required and this figure is extrapolated to the entire area. In communities where the rate of nodules is below 20%, treatment is given via

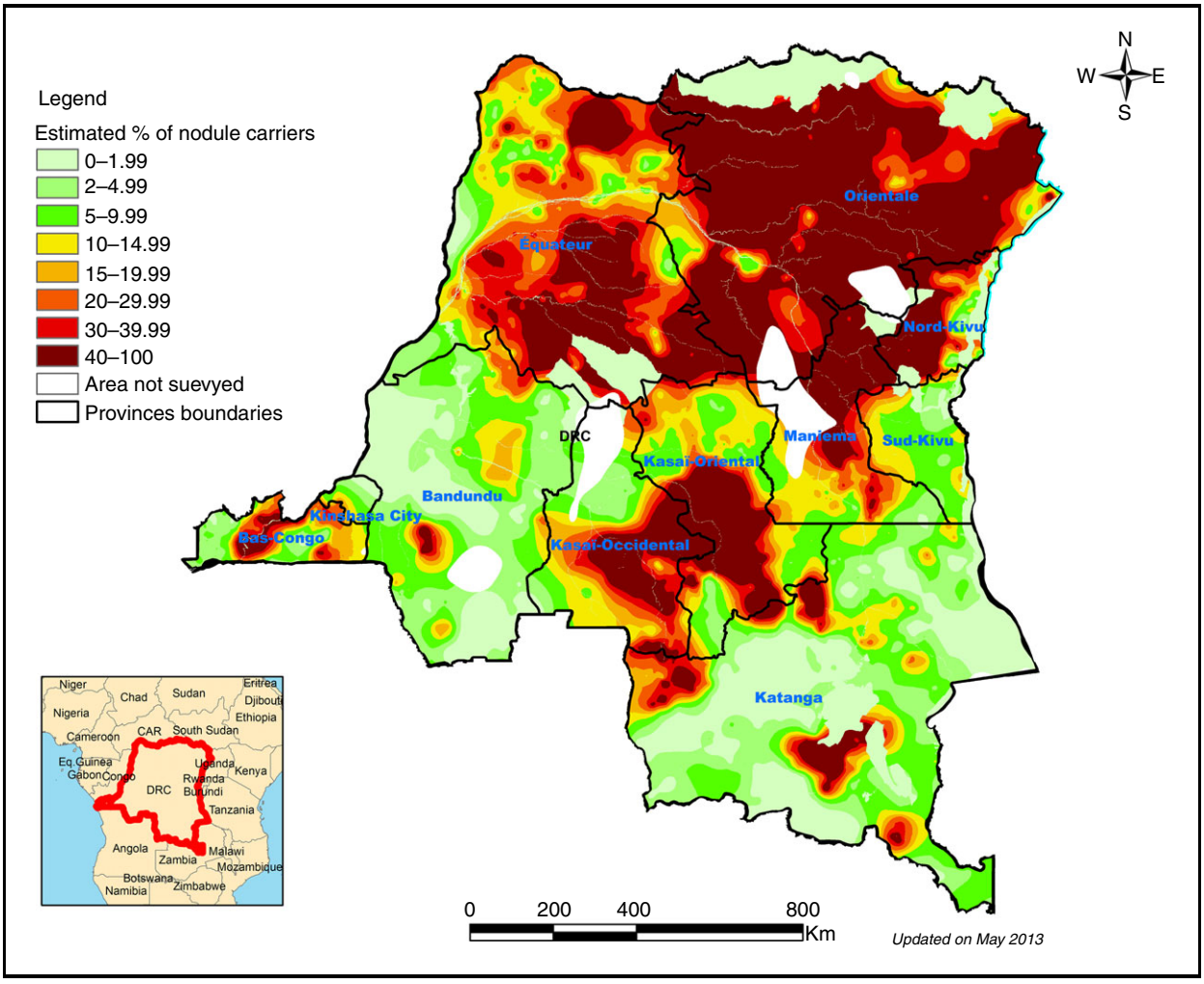

Figure 1 Rapid epidemiological mapping of onchocerciasis in Democratic Republic of Congo, showing meso-/hyperendemic areas (in orange/red/brown).

clinics. Palpation of nodules has low sensitivity and specificity in communities with a low prevalence.

Rapid epidemiological mapping of onchocerciasis surveys began in DRC in 1997 in the disease foci of Sankuru and Kasai, progressed to Uélé and continued throughout the rest of the country until 2008. Once the data had been collected throughout the country, they were integrated into a geographical information system (GIS). A demographic map was overlaid on the onchocerciasis map. The distribution of disease endemicity (hypo-, meso- and hyperendemic areas) throughout the mapped regions in DRC is detailed in Figure 1.

Data sources

Two data sources were examined retrospectively. Data on ivermectin distribution were obtained from NOTF. They comprised the number of implemented projects, and for each project, the number of years of CDTI, geographical coverage, total population, treated persons, therapeutic coverage, absent individuals or refusals, and distributed or unused tablets.

The numbers of new, retained and total number of community-directed distributors (CDD) and health workers (HW) were also reviewed. For the years 2001–2008, only approximations of the numbers of CDD were available, but from 2009 to 2012 more accurate data on the total numbers of CDD were available. Funding information was obtained from NOTF reports to the donors and APOC's Financial Office, Ouagadougou, Burkina Faso.

The second data source was national technical reports of CDTI projects, compiled annually from 2001 until 2012. We also reviewed individual project data on funding and expenditure, population involvement at village level, stakeholders' intervention, treatments and side effects in these reports.

Definitions

Therapeutic coverage is the number of people treated in a given year, divided by the total population (expressed as a percentage). Geographical coverage refers to the number of communities treated in a given year, divided by the total number of meso-/hyperendemic communities as identified by REMO (expressed as a percentage).

Evaluation method

We structured our evaluation of the onchocerciasis CDTI control programme in the form of a hypothetical–inputs–process–outputs–outcomes (HIPPOPOC) table (Tellier *et al.* 1991) and according to the method of

Table 1 Indicators for evaluating onchocerciasis control by community-directed treatment with ivermectin (CDTI) in Democratic Republic of Congo (DRC)

Onchocerciasis control activities	Inputs	Process*	Outputs	Outcomes
Mapping	Human resources Financial resources Material resources – stocks of ivermectin tablets	Rapid epidemiological mapping of onchocerciasis Rapid Epidemiological Assessment	Onchocerciasis map of DRC available	CDTI areas decrease Onchocerciasis prevalence decreases
Implementation		Training: Health workers recruitment Community-directed distributors recruitment Community awareness HSAM (health education sensitisation, advocacy and mobilisation) Mass drug distribution	Therapeutic and geographical coverage increases	
Monitoring		Evaluation of annual therapeutic and geographical coverages and trends	Empowerment of the communities is effective. Sustainability of drug delivery after African Programme for Onchocerciasis Control funding is withdrawn is known	

*Process indicators were not assessed in this study.

Bouchet *et al.* (1998). The inputs considered were the three types of resources needed – human, financial and material resources; process (not assessed in this paper) referred to all control programme activities that transformed inputs into outputs; outputs were the products of the activities such as increases in therapeutic and geographical coverage of ivermectin distribution; and the outcomes were the ultimate changes in health status such as reduction in onchocerciasis prevalence (Table 1).

Results

Inputs

Cost of delivering onchocerciasis control activities. Total funding was below US$ 700 000 in 2001 and 2002, but had increased more than threefold compared to baseline by 2012 (Table 2). Conversely, the cost of treatment per person treated decreased from US$ 1.1 in 2001 to US$ 0.1 from 2009 onwards (Table 3). (N.B. The cost of ivermectin was not included in this financial analysis. All ivermectin was donated via the Mectizan Donation Program, and during the years from 2001 till 2009, the amount of donated ivermectin reached a value of US $69 366 426).

Between 2001 and 2012, 84.1% of funding came from the fiduciary funds of the APOC and was aimed at ivermectin-distribution activities and office and transport materials (Table 2). Another 9.7% of funds were provided by Non-Governmental Development Organizations (NGDOs): Christian Blind Mission (CBM), Lion's Club International Foundation (LCIF), United Front Against River Blindness (UFAR), Catholic Relief Service (CRS) and Interchurch Medical Assistance (IMA). CBM intervened in 11 projects of 21 and the UFAR in 1 project. These were the only NGDOs providing support after 2007. The financial contribution of the government was mainly directed at paying the salaries and bonuses of staff.

The annual funding gaps (the difference between APOC funding and real funding needs) remained fairly consistent over the study period (Table 4). The costs per CDTI project per year fluctuated from year to year, ending in 2012 with an average cost per project of approximately US$94 000 (Table 5).

Trained community-directed distributors and health workers. In 2001, approximately 3431 CDD and 268 HW were available for the first CDTI implemented project, which covered 1968 communities. By 2012, 119 340 CDD and 13 493 HW were established in a total of 39 100 communities (Table 6). The CDD were poorly mobilised and trained during the first 5 years, but

Table 2 Funding sources for control of onchocerciasis in Democratic Republic of Congo, 2001–2012 (US$)

	Funding (US$)										
Year	Ministry of Health/Central Government	Provincial Ministry of Heath	NGDO partners of the PNLO (CBM, lCIF, UFAR, CRS and IMA)	UNICEF	Medicus Mundis	SICOTRA	Methodist Church	Catholic Church	Communities	African Programme for Onchocerciasis Control	Total
2001	17856.00	0.00	71424.00							597520.00	686800.00
2002	14901.00	0.00	59605.00							591660.00	666166.00
2003	23733.00	0.00	94933.00							1336902.00	1455568.00
2004	33275.00	0.00	133100.00							553375.00	719750.00
2005	40676.00	0.00	162706.00				500.00	200.00	250.00	1209955.00	1414287.00
2006	70606.00	0.00	282423.00	8250.00	266.00		200.00	1450.00	260.00	2026766.00	2390221.00
2007	77178.00	278.00	308713.00			3000.00	500.00	1550.00		1738625.00	2129844.00
2008	71086.00	8453.00	284345.00			2500.00		2400.00		1661433.00	2030217.00
2009	119066.00	0.00	238066.00							1657244.00	2014376.00
2010	304415.00	0.00	105404.00							2144363.00	2554182.00
2011	308508.00	0.00	109955.19							2516976.00	2933439.19
2012	226266.08	0.00	226115.00							2067798.00	2520179.08
Total	1307566.10	8731.00	2076789.19	8250.00	266.00	5500.00	1200.00	5600.00	510.00	18102617.00	21517029.27

Table 3 Average expenditures of community-directed treatment with ivermectin per treated person and treated community in Democratic Republic of Congo, 2001–2012

Year	Funds received (US$)	Treated persons	Treated communities	Cost per treated person (US$)	Cost per treated community (US$)
2001	686800.00	606 420	1968	1.1	349.0
2002	666166.00	1 630 344	4413	0.4	151.0
2003	1455568.00	4 117 035	10 402	0.4	139.9
2004	719750.00	5 051 770	14 016	0.1	51.4
2005	1414287.00	4 876 791	10 631	0.3	133.0
2006	2390221.00	8 310 318	22 782	0.3	104.9
2007	2129844.00	9 343 606	21 793	0.2	97.7
2008	2030217.00	9 534 666	22 905	0.2	88.6
2009	2014376.00	17 704 257	34 799	0.1	57.9
2010	2554182.00	20 290 244	37 669	0.1	67.8
2011	2935439.19	22 403 957	38 976	0.1	75.3
2012	2520179.08	23 126 855	39 100	0.1	64.5
Cumulative total	21517029.27	126 996 263	259 454	0.2	82.9

Table 4 Annual funding gaps for community-directed treatment with ivermectin in Democratic Republic of Congo, 2001–2012

Year	African Programme for Onchocerciasis Control Contribution (US$)	Population	Cost per treated person (US$)	Desired cost (US$)	Real annual need (US$)	Annual gap (US$)
2001	597 520	22 598 584	0.03	0.2	3796562.1	3199042.1
2002	591 660	23 276 542	0.03	0.2	3910459.1	3318799.1
2003	1 336 902	23 974 838	0.06	0.2	4027772.8	2690870.8
2004	553 375	24 694 083	0.02	0.2	4148605.9	3595230.9
2005	1 209 955	25 434 906	0.05	0.2	4273064.2	3063109.2
2006	2 026 766	26 197 953	0.08	0.2	4401256.1	2374490.1
2007	1 738 625	26 983 891	0.06	0.2	4533293.7	2794668.7
2008	1 661 433	27 793 408	0.06	0.2	4669292.5	3007859.5
2009	1 657 244	28 627 211	0.06	0.2	4809371.4	3152127.4
2010	2 144 363	29 486 027	0.07	0.2	4953652.5	2809289.5
2011	2 516 976	30 370 608	0.08	0.2	5102262.1	2585286.1
2012	2 067 798	31 281 726	0.07	0.2	5255330.0	3187532.0
Total	18 102 617		0.05	0.2	53880922.5	35778305.5

their number more than tripled between 2005 and 2006. By 2012, there were ratios of 1 CDD per 262 head of population and 1 HW per 2318 individuals. Personnel ratios per head of population varied widely between projects and the values in 2012 are shown per project in Figure 2. Although the APOC standard is one CDD per maximum of 100 people, only Lubutu and South Ubangi projects achieved this target in 2009 (data not shown), and no projects achieved this in 2012. Furthermore, whereas ideally one HW should take care of between 2500 and 5000 people, by 2009, the HW were still responsible for greater numbers than this in 7 out of 20 (35%) of projects (data not shown). By 2012, the situation had improved somewhat but this scenario still pertained in 4 out of 21 (19%) of projects (Figure 2).

Although from 2009 to 2012 more accurate data on the total numbers of CDDs were available, the number of new and retained CDDs could not be ascertained, and hence the CDD attrition rate could be not be determined.

Process

Implementation of CDTI in target areas and uptake by target populations. During the years 2001–2012, 21 operational projects were implemented (Table 7). As a result of the annual sensitisation campaigns in the projects, the target populations adopted CDTI. By 2009, 20 projects had organised such campaigns, with 80% of decision-makers (2892), 90% of village leaders (35 930) and their people annually mobilised and sensitised about

Table 5 Costs per community-directed treatment with ivermectin project in Democratic Republic of Congo, 2001–2012

Year	Number of projects	African Programme for Onchocerciasis Control Funds (US$)	Amount by project (US$)
2001	2	597 520	298760.0
2002	3	591 660	197220.0
2003	7	1 336 902	190986.0
2004	4	553 375	138343.8
2005	4	1 209 955	302488.8
2006	16	2 026 766	126672.9
2007	17	1 738 625	102272.1
2008	21	1 661 433	79115.9
2009	21	1 657 244	78916.4
2010	21	2 144 363	102112.5
2011	21	2 516 976	119856.0
2012	22 (includes PNLO National Office as 22nd project)	2 067 798	93990.8

onchocerciasis, ivermectin uptake and the implementation of their responsibilities within CDTI.

Outputs

Mass treatment. Democratic Republic of Congo has an annual population growth rate estimated at 3.1% (Ministère du Plan, DRC 2011). The total population at risk living in meso- and hyperendemic areas increased from 22.6 million in 2001 to 31.3 million in 2012 (Table 8). The total number of communities at risk remained unchanged at 41 618.

There were general trends for increases in the annual therapeutic and geographical coverages (Figure 3). The annual therapeutic coverage ranged from 2.7% (2001) to 74.2% (2012) and the geographical coverage from 4.7% (2001) to 93.9% (2012) (Table 8). In November 2003, however, the Bas-Congo/Kinshasa CDTI project experienced serious adverse events (SAEs) post CDTI, with a few deaths in the Bas-fleuve region. In early 2004, a field investigation conducted by APOC and stakeholders' experts (CBM/IMA-SANRU) revealed that onchocerciasis was hypo-endemic in the Bas-fleuve region where ivermectin had been distributed the previous year. CDTI was then stopped in the entire project in 2004, and the Tshopo and Uélé projects were also suspended temporarily. The Rapid Assessment Procedure for Loasis (RAPLOA) combined with REA was performed in every community. The results of these RAPLOA/REA activities in 2005 confirmed that a large area in Bas-Congo/Kinshasa was

Table 6 Evolution of the number of community-directed distributors (CDD) and health workers (HW) trained by the National Onchocerciasis Task Force by year*

Indicators	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of trained CDD	3431	8276	19 138	17 193	21 012	65 254	63 769	90 078	112 254	115 194	125 043	119 340
Number of trained HW	268	974	1671	1924	2291	4975	3258	5965	6546	6740	7925	13 493
Total population of meso-/hyperendemic areas	22 598 584	23 276 542	23 974 838	24 694 083	25 434 906	26 197 953	26 983 891	27 793 408	28 627 211	29 486 027	30 370 608	31 281 726
Number of persons at risk/number of CDD	6587	2813	1253	1436	1210	401	423	309	255	256	243	262
Number of persons at risk/number of HW	84 323	23 898	14 348	12 835	11 102	5266	8282	4659	4373	4375	3832	2318

*N.B. The numbers of CDDs for the years 2001–2008 are approximations only and may underestimate the true number. Accurate data was available for the numbers of CDDs for 2009–2012.

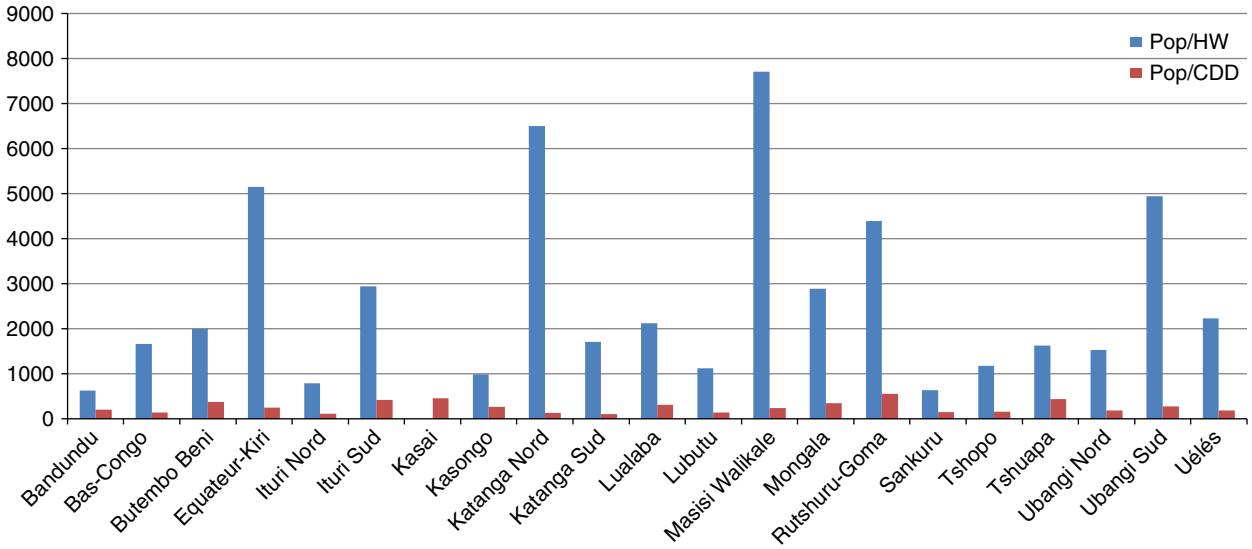

Figure 2 Number of persons at risk divided by the number of community-directed distributors (CDD) and health workers (HW) per project in Democratic Republic of Congo (DRC) in 2012. (N.B. No data available for HW in Kasai province).

hypo-endemic for onchocerciasis, and this was the area where the SAEs had largely occurred. This hypo-endemic area was then deemed not eligible for CDTI and was excluded from treatment. In 2005, only populations from the projects of Bandundu, Kasai and Sankuru were treated with ivermectin and the geographical coverage fell from 33.7% in 2004 to 25.5% in 2005.

The therapeutic coverage gradually increased but fell slightly from 34.6% in 2007 to 34.3% in 2008 due to insecurity (Table 8). The Bandundu CDTI project was not treated in 2007 because of lack of available funds and Rutshuru-Goma project did not receive treatment in 2008 because of a delay in the ivermectin delivery. The number of people who refused treatment in 2012 was 379 889 (1.2% of the population at risk), and the number of absentees was 727 346 (2.3% of the population at risk). Reasons given for refusal to take treatment included fear of side effects from ivermectin, drug administered by lay people unable to manage side effects, rumours of fatal incidents in Bas-Congo and eastern provinces, and personal and religious beliefs. Figure 4 shows the therapeutic coverage within each of the NOTF health areas in 2012.

Outcomes

If CDTI activities continue in DRC for several more years, in the long-term, we could expect to observe a reduction in onchocerciasis prevalence and even a reduction in *Onchocerca volvulus* infection and transmission to the extent that interventions could be stopped, although post-intervention surveillance would still be necessary. In 2009, APOC shifted its objective from disease control to elimination of onchocerciasis by 2025. DRC, however, is not expected to achieve elimination of onchocerciasis by 2025 as demonstrated by current predictive models (Winnen *et al.* 2002).

Discussion

Finances

Our analysis has shown that 93.9% of the funding for onchocerciasis control activities in DRC has been dependent on international aid (Table 2). APOC advocates an allocated amount of US$2 per treated person during the first 3 years of CDTI, US$1 the two following years and US$0.2 from the sixth year, but the amounts actually spent in DRC were substantially lower as funding from government failed to materialise and the numbers of people treated increased. The annual funding gap remained relatively constant between 2001 and 2012. Intermediate and longer term sustainability of CDTI requires an increase in national and government funding with long-term budget planning. Premature withdrawal of international funding in DRC would have devastating consequences. APOC responded to an external evaluation in 2005 by increasing financial support to projects in post-conflict areas. DRC's need to receive improved international support for control of onchocerciasis plus other

Table 7 Implementation of community-directed treatment with ivermectin (CDTI) in Democratic Republic of Congo, 2001–2012

Projects				
Year	No. of new projects undergoing CDTI	No. projects in retreatment	No. projects which temporarily suspended treatment	No. projects undergoing CDTI, *n* (%)
2001	1	0	0	1 (4.8)
2002	1	1	0	2 (9.5)
2003	4	2	0	6 (28.6)
2004	8	3	11	3 (14.3)
2005	0	3	11	3 (14.3)
2006	1	14	0	15 (71.4)
2007	1	14	1	15 (71.4)
2008	4	15	1	19 (90.5)
2009	0	20	0	20 (95.2)
2010	0	20	0	20 (95.2)
2011	0	20	0	20 (95.2)
2012	1	20	0	21 (100.0)
Total	21	21	0	21 (100.0)

NTDs has recently been highlighted (Rimoin & Hotez 2013).

Implementation of CDTI

Many structures within the health care system in DRC remain fragmented at both national and provincial level. There are currently 52 vertical programs in DRC, and districts and health areas have to cope with a myriad of uncoordinated bureaucracy. Although much of the success of CDTI comes from communities being able to circumvent dysfunctional health services, certain aspects such as the timing of delivery of supplies of ivermectin remain outside of their control. The Ministry of Health has now established a new framework to reform the country's health structure to promote decentralisation and integration.

The trend for increased therapeutic coverage and the increase in CDD over the years demonstrates good appropriation of CDTI by the rural population as has been described in Senegal, Mali and Guinea (Hopkins 2010). Community-based treatment with ivermectin may also be successfully integrated with other primary healthcare interventions such as management of malaria, distribution of insecticide-treated bednets and vitamin A supplementation (The CDI Study Group 2010). APOC actively endorses the extension of such community-directed interventions because of the great potential in reaching millions of people currently enrolled in CDTI projects with additional healthcare. Although there is a risk of compromising ivermectin therapeutic coverage if the CDD are too busy with other work (Katabarwa *et al.* 2010a), other research suggests that additional activities for CDD may actually strengthen sustainability and effectiveness of ivermectin treatment (Okeibunor *et al.* 2004). The effectiveness of CDD is improved if they are selected by their own communities, serve fewer households and largely work among kindred (Katabarwa *et al.* 2010b). The choice of the CDD by people of their community and community ownership are important determining factors of sustainability of CDTI programmes (Amazigo *et al.* 2007), and a model for evaluating the sustainability of CDTI projects has recently been proposed (Okeibunor *et al.* 2012).

Therapeutic and geographical coverages

Although APOC initially recommended a minimum therapeutic coverage of ≥65% for control of onchocerciasis as a public health problem, when its strategy moved from control towards elimination, this target was elevated to ≥80% with a recommended geographical coverage of 100% (World Health Organization 2010b). Unfortunately DRC's NOTF did not reach either of these goals between the years of CDTI control from 2001 to 2012. The second Congo war (1998–2003) devastated the country and despite the signing of peace in 2003, fighting continued in the eastern provinces. Nevertheless, a noticeable increase of the therapeutic coverage rates occurred during the last 4 years of the study period, particularly between 2008 and 2009 with a rise from 34.3% to 61.8%. Possible reasons for this increase include cessation of conflict (except in the East) permitting community participation, additional awareness-raising and social mobilisation

Table 8 Number of community-directed treatment with ivermectin (CDTI) treatments and therapeutic and geographical coverage per calendar year in Democratic Republic of Congo, 2001–2012

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
No. projects undergoing CDTI	1	2	5	5	3	15	15	19	20	20	20	21
No. communities at risk	41 618	41 618	41 618	41 618	41 618	41 618	41 618	41 618	41 618	41 618	41 618	41 618
No. persons at risk	22 598 584	23 276 542	23 974 838	24 694 083	25 434 906	26 197 953	26 983 891	27 793 408	28 627 211	29 486 027	30 370 608	31 281 726
No. treated communities	1968	4413	10 402	14 016	10 631	22 782	21 793	22 905	34 799	37 669	38 967	39 100
No. persons treated	606 420	1 630 344	4 117 035	5 051 770	4 876 791	8 310 318	9 343 606	9 534 666	17 704 257	20 290 244	22 403 957	23 216 855
No. persons who refused treatment	106 875	54 703	8957	110 735	131 296	112 166	453 589	371 756	513 225	207 034	484 214	379 889
No. persons who were absent	70 581	147 815	243 912	311 103	437 860	456 690	419 821	344 403	871 923	367 123	819 904	727 346
Geographical coverage (%)	4.7	10.6	25	33.7	25.5	54.7	52.4	55	83.6	90.5	93.7	93.9
Therapeutic coverage (%)	2.7	7	17.2	20.5	19.2	31.7	34.6	34.3	61.8	68.8	73.8	74.2

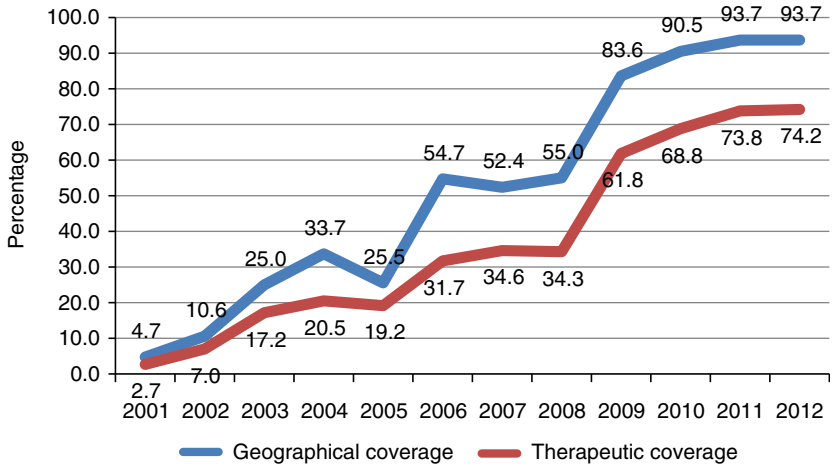

Figure 3 Trend of annual therapeutic and geographical coverage (%) for community-directed treatment with ivermectin (CDTI) projects in Democratic Republic of Congo (DRC), 2001–2012.

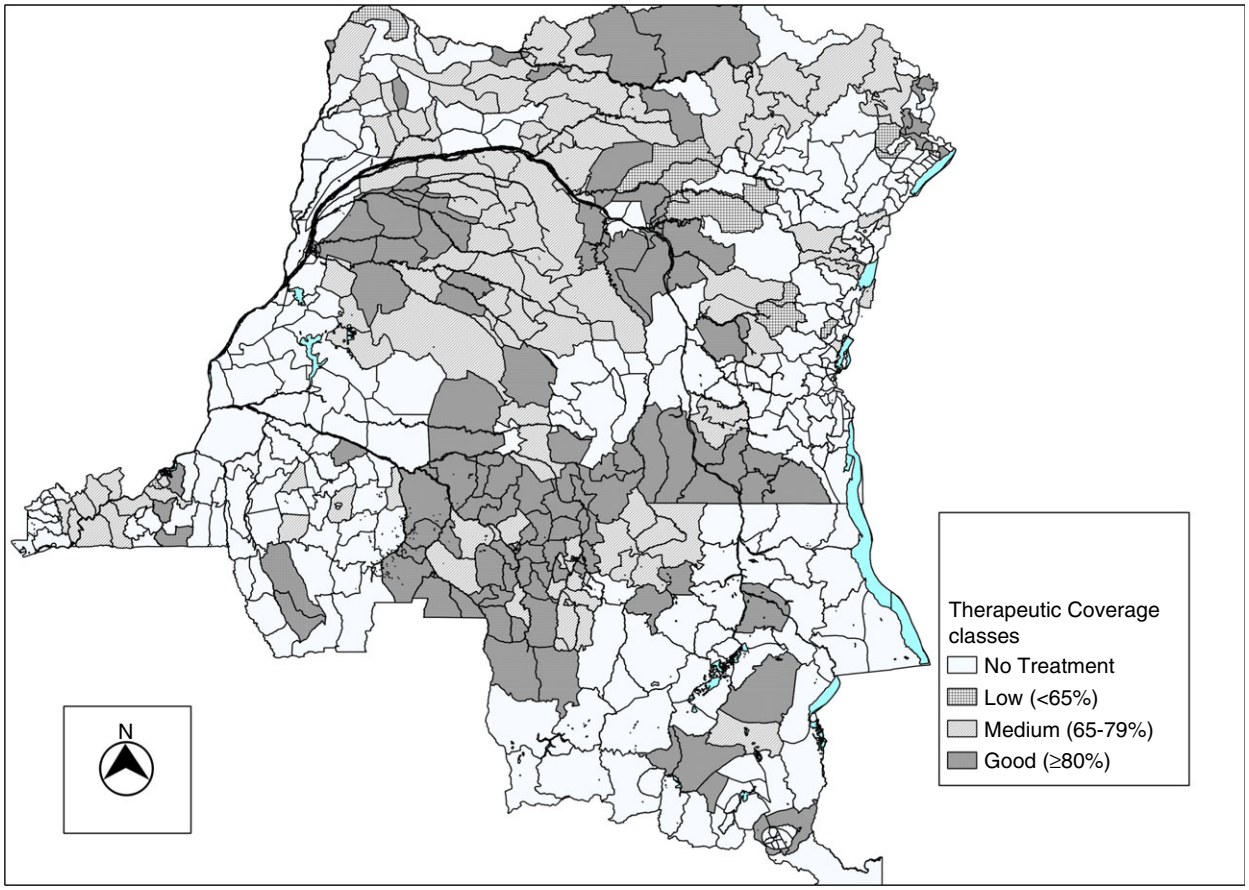

Figure 4 Therapeutic coverage map of community-directed treatment with ivermectin (CDTI) in Democratic Republic of Congo (DRC), 2012.

activities, improved supervision capacity at the national level and improved resources for the management of side effects of ivermectin. Geographical coverage rates also showed a trend for improvement, especially from 55% to 83.6% during 2008 and 2009 (Table 6). These averages, however, mask variable project performance with a few

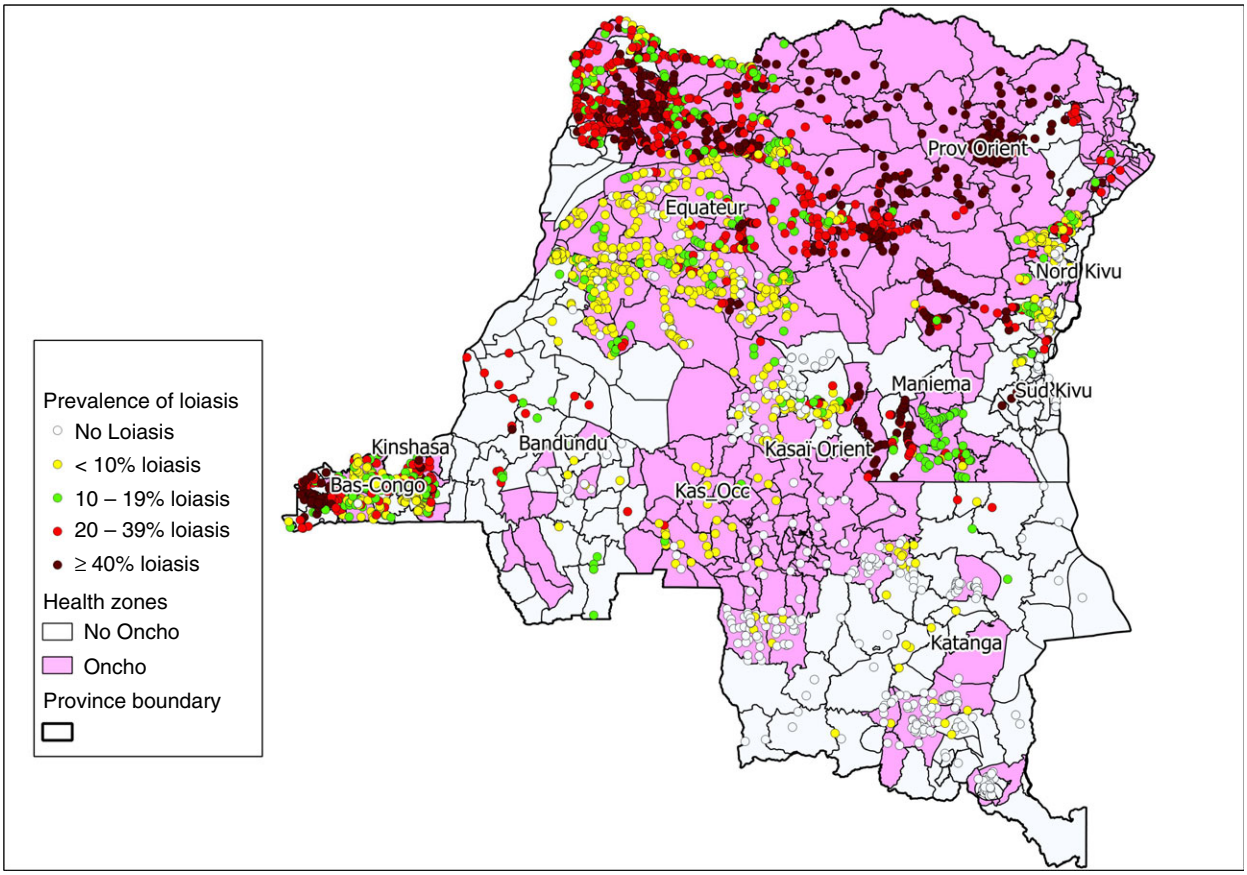

Figure 5 Map of Democratic Republic of Congo (DRC) showing areas co-endemic for onchocerciasis and loiasis.

well-performing projects having increased the overall averages (data not shown; World Health Organization 2010b). For comparison, summary data for *all* post-conflict APOC countries including DRC were therapeutic coverages of 46% and 64% and geographical coverages of 63% and 82% in 2008 and 2009, respectively (World Health Organization 2010b). Within DRC, conflict and socio-political instability have previously been documented as impeding control activities of another neglected tropical disease, human African trypanosomiasis (Berrang-Ford *et al.* 2011). Amazigo *et al.*'s (2007) study of CDTI projects in 10 countries found that therapeutic coverage was found to trend upward with each successive treatment round and in the present study DRC's peak therapeutic and geographical coverages of 74.2% and 93.9% were achieved in 2012.

Co-endemicity with loiasis also affected geographical coverage, as treatment was not complete in co-endemic areas in Equateur and eastern provinces. As many as 16 of the 21 projects in DRC are co-endemic for loiasis (Figure 5), and such communities may be at significant risk of severe adverse reactions after treatment with ivermectin (Gardon *et al.* 1997).

In 2004, SAEs in CDTI areas co-infected with loiasis were reported and resulted in 14 deaths in the project of Bas-Congo. This led to the temporary suspension of mass treatment with ivermectin in Bas-Congo, Tshopo and Uélés projects in the following year. These SAEs, characterised by encephalopathy, were similar to those observed in the central-southern region of Cameroon after ivermectin treatment (Twum-Danso 2003; Twum-Danso & Meredith 2003). In DRC, in 2008, 105 SAEs with six deaths were recorded, and in 2009, there were 137 SAEs with 12 deaths. Loiasis-endemic villages therefore need to be identified prior to ivermectin distribution, and the actual level of *Loa loa* endemicity determines the treatment strategy. Rapid screening for loiasis may be performed by asking subjects whether they have a history of eye worm (rapid assessment procedure for loiasis, RAPLOA), and the results are then subjected to a spatial analysis to pro-

duce prevalence of infection maps (Wanji *et al.* 2012). Little was known about the geographical distribution of loiasis within DRC at the start of the CDTI projects but, more recently, large-scale implementation of RAPLOA in 11 endemic countries, including DRC, has provided a more reliable global map of the disease (Zouré *et al.* 2011). Integration of rapid mapping of both onchocerciasis and loiasis has been shown to greatly reduce time and costs and facilitate decision-making about ivermectin treatment in co-endemic areas (Tekle *et al.* 2011). APOC provided increased financial support to peripheral health facilities for the required drugs and equipment to deal with severe adverse events, urged CDTI projects to raise awareness of communities to the risk of adverse events and provided special technical advisors for the management of severe adverse events. These extra precautions are difficult to implement in the poorest and post-conflict regions, and hence, although additional staff training on how to take care of individuals with SAEs has been carried out, loiasis co-endemicity continues to slow down improvements in the therapeutic and geographical coverage. The extension of ivermectin treatment to onchocerciasis hypo-endemic areas will be challenging due to the presence of *Loa loa* in many health zones. A larger number of trained CDD and HW could improve the therapeutic and geographical coverage and would allow projects to come closer to the APOC recommended standard of one CDD per 100 persons and one HW per 2500–5000 people. The capacity to retain CDDs for many years is an important predictor of sustainability of programmes but remains a challenge for many APOC countries. High workload, low salary and poor motivation are likely contributory factors, but more work is needed to determine the precise CDD attrition rates and causes within DRC.

Some CDTI projects covered several different districts and provinces, and the complex administration and large geographical areas covered made management and logistical support difficult. To control and, eventually, eliminate transmission of onchocerciasis in DRC, the number of projects should be increased.

The search for a safe, effective treatment for communities co-endemic for onchocerciasis and loiasis remains a priority. Community-directed treatment with doxycycline for 6 weeks is feasible in such communities (Wanji *et al.* 2009; Tamarozzi *et al.* 2012), but alternative anti-*Wolbachia* regimes that are suitable for children and pregnant women and with shorter treatment schedules are desirable. Another current challenge for areas co-endemic with lymphatic filariasis is integration of CDTI programmes with treatment for lymphatic filariasis (Kelly-Hope *et al.* 2011).

Although ivermectin can control onchocerciasis as a public health problem, it was not initially known whether it could also interrupt transmission and eventually eliminate onchocerciasis in Africa where the vectors are highly efficient. Studies in Mali, Senegal and Nigeria however, have shown that after 15–17 years of annual or six monthly ivermectin therapy, the prevalence of microfilariae plus vector infectivity rates were zero or below postulated thresholds for elimination, 3–5 years after stopping treatment (Tekle *et al.* 2012; Traore *et al.* 2012). Twice yearly treatment with ivermectin in an isolated focus in Uganda has also interrupted transmission and eliminated the disease (Katabarwa *et al.* 2012). The possibility of eliminating onchocerciasis in Africa with ivermectin is therefore feasible and APOC's objectives have been revised to include elimination of the disease.

African Programme for Onchocerciasis Control and its community-directed interventions have shown their potential to start to overcome onchocerciasis in DRC under even the most adverse conditions. Kisangani, DRC's second city located at the north-eastern end of the long navigable section of the Congo River, is an obvious example in that it had undergone 6 years of civil war during which time the already precarious infrastructure was completely destroyed. APOC has succeeded, however, in setting up a network of CDDs, which is now helping to expand coverage of ivermectin, vitamin A and mebendazole distribution throughout the entire country (WHO/APOC 2007).

Overall the APOC programme has been highly successful to date, but managerial, technical and socio-political challenges have been acknowledged in a midterm review (Amazigo *et al.* 2002). Particular challenges to CDTI in DRC have been serious adverse reactions from the use of ivermectin in loiasis co-endemic areas and conflict situations. APOC's recommended targets for personnel were not achieved. Similarly APOC's targets for therapeutic and geographical coverages were not met. Although the improving trend in these parameters over the first 12 years in DRC provides encouragement for the future, longer term funding and renewed efforts are required to achieve control and elimination of onchocerciasis in DRC.

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Corresponding Author **Michele E. Murdoch**, Department of Dermatology, Watford General Hospital, Watford, Herts., WD18 0HB, UK. Tel. +44 1923 436036; Fax +44 1923 217945; E-mail: michele.murdoch@nhs.net