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Kilangalanga, J; Ndjemba, JM; Uvon, PA; Kibangala, FM; Mwandulo, JSB; Mavula, N; Ndombe, M; Kazadi, J; Limbaka, H; Cohn, D; +10 more... Tougoue, JJ; Kabore, A; Rotondo, L; Willis, R; Bio, AA; Kadri, B; Bakhtiari, A; Ngondi, JM; Solomon, AW; Global Trachoma Mapping Project; (2017) Trachoma in the Democratic Republic of the Congo: Results of 46 Baseline Prevalence Surveys Conducted with the Global Trachoma Mapping Project. *Ophthalmic epidemiology*. pp. 1-9. ISSN 0928-6586 DOI: <https://doi.org/10.1080/09286586.2017.1306869>

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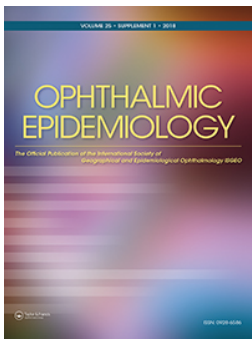
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To cite this article: Janvier Kilangalanga, Jean Marie Ndjemba, Pitchouna A. Uvon, Felix M. Kibangala, Jean-Lebone Safari B. Mwandulo, Nicaise Mavula, Martin Ndombe, Junior Kazadi, Henry Limbaka, Daniel Cohn, Jean-Jacques Tougoue, Achille Kabore, Lisa Rotondo, Rebecca Willis, Amadou Alfa Bio, Boubacar Kadri, Ana Bakhtiari, Jeremiah M. Ngondi, Anthony W. Solomon & for the Global Trachoma Mapping Project (2018) Trachoma in the Democratic Republic of the Congo: Results of 46 Baseline Prevalence Surveys Conducted with the Global Trachoma Mapping Project, *Ophthalmic Epidemiology*, 25:sup1, 192-200, DOI: [10.1080/09286586.2017.1306869](https://doi.org/10.1080/09286586.2017.1306869)

To link to this article: <https://doi.org/10.1080/09286586.2017.1306869>



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Published online: 29 Aug 2017.



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Trachoma in the Democratic Republic of the Congo: Results of 46 Baseline Prevalence Surveys Conducted with the Global Trachoma Mapping Project

Janvier Kilangalanga^a, Jean Marie Ndjemba^b, Pitchouna A. Uvon^b, Felix M. Kibangala^b, Jean-Lebone Safari B. Mwandulo^b, Nicaise Mavula^c, Martin Ndombe^c, Junior Kazadi^d, Henry Limbaka^e, Daniel Cohn^f, Jean-Jacques Tougouf^f, Achille Kabore^f, Lisa Rotondo^f, Rebecca Willis^g, Amadou Alfa Bio^h, Boubacar Kadriⁱ, Ana Bakhtiari^g, Jeremiah M. Ngondi^{j,†}, and Anthony W. Solomon^{k,l,†}, for the Global Trachoma Mapping Project*

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ABSTRACT

Purpose: Trachoma was suspected to be endemic in parts of the Democratic Republic of the Congo (DRC). We aimed to estimate prevalences of trachomatous inflammation–follicular (TF), trichiasis, and water and sanitation (WASH) indicators in suspected-endemic Health Zones.

Methods: A population-based prevalence survey was undertaken in each of 46 Health Zones across nine provinces of DRC, using Global Trachoma Mapping Project methods. A two-stage cluster random sampling design was used in each Health Zone, whereby 25 villages (clusters) and 30 households per cluster were sampled. Consenting eligible participants (children aged 1–9 years and adults aged ≥15 years) were examined for trachoma by GTMP-certified graders; households were assessed for access to WASH.

Results: A total of 32,758 households were surveyed, and 141,853 participants (98.2% of those enumerated) were examined for trachoma. Health Zone-level TF prevalence in 1–9-year-olds ranged from 1.9–41.6%. Among people aged ≥15 years, trichiasis prevalences ranged from 0.02–5.1% (95% CI 3.3–6.8). TF prevalence in 1–9-year-olds was ≥5% in 30 Health Zones, while trichiasis prevalence was ≥0.2% in 37 Health Zones.

Conclusion: Trachoma is a public health problem in 39 of 46 Health Zones surveyed. To meet elimination targets, 37 Health Zones require expanded trichiasis surgery services while 30 health zones require antibiotics, facial cleanliness and environmental improvement interventions. Survey data suggest that trachoma is widespread: further surveys are warranted.

ARTICLE HISTORY

Received 22 September 2016
Revised 22 January 2017
Accepted 5 March 2017

KEYWORDS

Baseline survey; Democratic Republic of the Congo; Global Trachoma Mapping Project; SAFE strategy; trachoma; trichiasis

Introduction

Trachoma, a neglected tropical disease, is the most common infectious cause of blindness. The World Health Organization (WHO) estimates that, globally, 200 million people are at risk of trachoma; 1.9 million people are blind or visually impaired from it; and 3.2 million people need surgery to avoid trachomatous blindness, in 42 countries.¹ Trachoma is considered to be a public health problem where prevalence of trachomatous inflammation–follicular (TF) in children aged 1–9 years is ≥5%, or trachomatous trichiasis (TT) in people aged ≥15 years is ≥0.2%.² Elimination of trachoma as a public health problem by the year 2020 (through the surgery, antibiotics, facial

cleanliness and environmental improvement: “SAFE” strategy) is a global target that was endorsed by the World Health Assembly in 1998.^{3,4} Prior to SAFE implementation, baseline surveys of trachoma prevalence are recommended to guide programs to deliver appropriate interventions.⁵

Trachoma has been suspected to be endemic in parts of the Democratic Republic of the Congo (DRC), but evidence to support program initiation has been limited. A review of medical records of 50,000 patients attending the eye hospital in Kinshasa from 1962 to 1979 concluded that trachoma was absent from the list of common blinding eye diseases.⁶ Between 1987 and 1991, Ukety documented 15 cases of trichiasis in areas of northeastern DRC (then Zaire), near the border with

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*See Appendix

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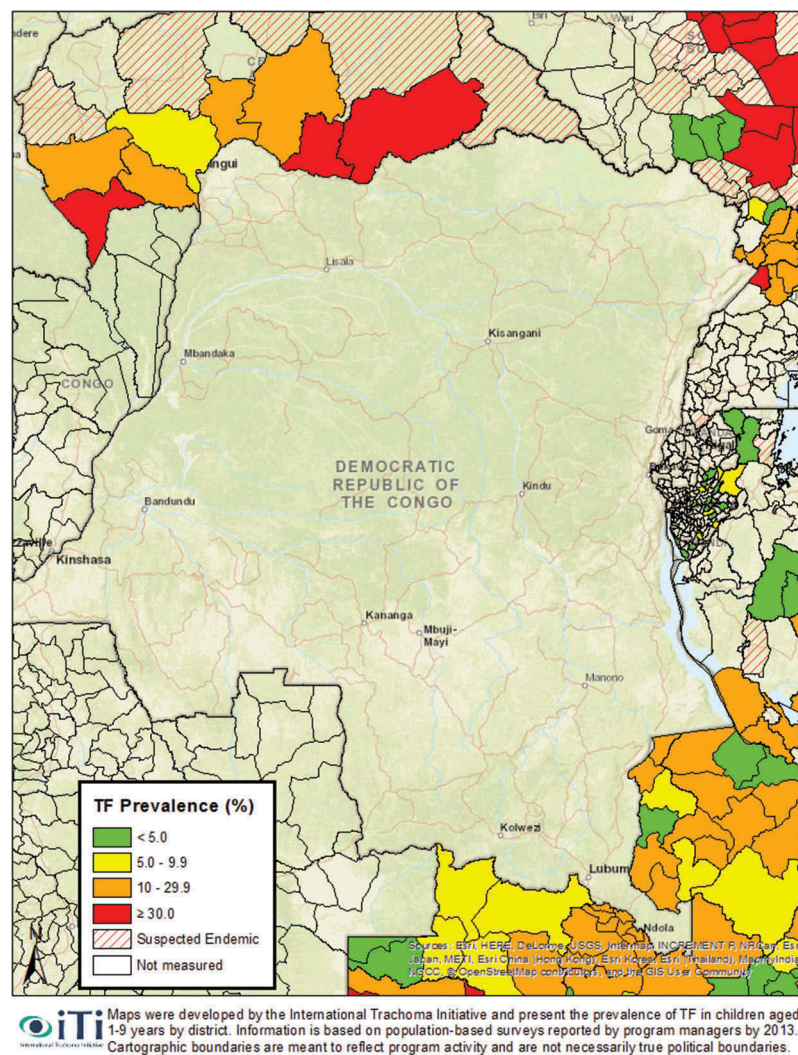


Figure 1. Prevalence of trachomatous inflammation–follicular (TF) in countries bordering Democratic Republic of the Congo, based on Global Trachoma Atlas data in 2013.

Uganda.⁷ In 2013, analyses of the geographic distribution of trachoma in Africa based on data from the Global Atlas of Trachoma (<http://www.trachomaatlas.org>) suggested that areas of DRC bordering Central African Republic, South Sudan and Zambia might also be endemic for trachoma (Figure 1).⁸

With only a few years to go before the 2020 target for global elimination of trachoma, mapping in areas suspected to be trachoma-endemic is essential for planning SAFE implementation. The population-based prevalence surveys reported here, conducted as part of the Global Trachoma Mapping Project (GTMP), aimed to estimate: the prevalence of TF in children aged 1–9 years; the prevalence of trichiasis in people aged ≥ 15 years; and key household-level water, sanitation and hygiene (WASH) indicators in suspected-endemic Health Zones of DRC.

Materials and methods

The GTMP methodology

The study was conducted using the methods of the GTMP.^{9,10} In brief, in each survey, in addition to individual-level demographic and clinical data, household-level WASH data were entered into the purpose-built LINKS application on Android smartphones, transmitted to the Cloud, then managed and reviewed by health ministries, as previously described.¹⁰ The main outcome measures were the prevalence of TF in children aged 1–9 years, prevalence of trichiasis in adults aged ≥ 15 years, percentage of households using safe methods for disposal of human feces, and percentage of households with proximate access to water for personal hygiene purposes, all at Health Zone level.

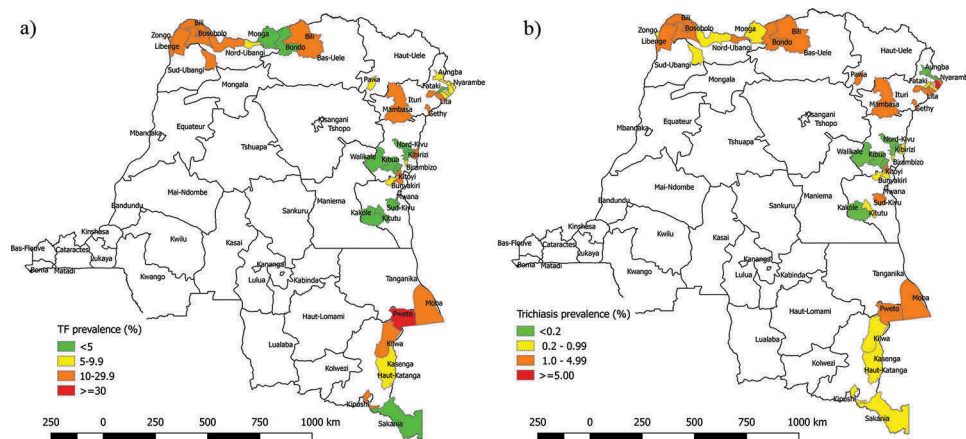


Figure 2. Location of provinces and health zones surveyed and prevalence of (a) trachomatous inflammation–follicular (TF) in children aged 1–9 years, and (b) trichiasis in adults aged ≥ 15 years, Global Trachoma Mapping Project, Democratic Republic of the Congo, 2014–2016.

Study settings

The surveys were undertaken from 2014 to 2016. Figure 2 shows the nine provinces (Nord-Ubangi, Sud-Ubangi, Bas-Uele, Haut-Uele, Ituri, Nord-Kivu, Sud-Kivu, Tanganika and Haut-Katanga) in which surveys were undertaken. A total of 46 Health Zones (defined as the operational unit for primary health care in DRC and encompassing populations of 100,000–150,000) were prioritized for surveys in the nine provinces, based on desk reviews, which included: (1) review of Global Atlas of Trachoma (www.trachomaatlas.org) data on trachoma prevalence in areas bordering DRC (Figure 1); (2) review of local clinical reports on trachoma; (3) questionnaire-based surveys of health care workers (in Nord-Ubangi, Sud-Ubangi, Bas-Uele, Haut-Uele, Ituri, Nord-Kivu and Sud-Kivu) enquiring about trichiasis cases seen; and (4) questionnaire-based surveys of key informants in the community (in Nord-Kivu and Sud-Kivu) enquiring about the presence of trichiasis. Based on inputs (1), (3) and (4), Health Zones in which (an arbitrarily-defined) five or more cases of trichiasis had been seen, and Health Zones bordering trachoma-endemic areas of Central African Republic (Nord-Ubangi, Sud-Ubangi, Bas-Uele), Uganda (Ituri) and Zambia (Haut-Katanga and Tanganika) were prioritized for trachoma surveys.

Sample size estimation

To estimate the Health Zone-level TF prevalence in children aged 1–9 years, the sample size was calculated using an expected prevalence of 10%, powering each survey to have 95% confidence of estimating that prevalence with

absolute precision of $\pm 3\%$. We included a design effect of 2.65, which resulted in a sample size estimate of 1019 children, then inflated that estimate by 20% to allow for expected non-response. The number of households needed in each Health Zone was the number calculated to house 1222 children aged 1–9 years.¹⁰ Given that 33% of the DRC population is aged 1–9 years, and a rural DRC household has a mean of 5.1 inhabitants,¹¹ we estimated that it was necessary to sample at least 727 households. If a team with one grader and one recorder could sample 30 households per day, 25 clusters (total 750 households) were needed in order to reach the required sample size. Although we also aimed to estimate trichiasis prevalence in ≥ 15 -year-olds, sample sizes were calculated based only on parameters relating to TF in children; the low prevalence of trichiasis means that accurately estimating its prevalence requires substantially larger samples. Having determined the number of households required to recruit sufficient children to estimate TF prevalence as above, the sample of ≥ 15 -year-olds used for estimating trichiasis prevalence was set as the adults living in those same households.¹⁰ For WASH indicators, the sample size was calculated to estimate a proportion of 50% of households with each indicator of interest, with absolute precision of $\pm 7\%$, a design effect of 3 and inflation by 20% to account for non-response, resulting in a sample size of 735 households per Health Zone. Therefore, all households sampled were assessed for access to WASH.

Sample selection

Selection of clusters

A two-stage cluster random sampling design was used. Clusters were defined as villages, the smallest

administrative unit in DRC. The list of villages in each Health Zone was obtained from provincial health offices. In the first sampling stage, 25 villages were systematically selected, with probability proportional to population size, using computer-generated random starting points.

Selection of households and participants

In the second sampling stage, 30 households were selected using the compact segment sampling method. A household was defined as persons living together and eating from the same pot. Each village was divided into segments of approximately 30 households. A single segment was then selected by random draw. Within the selected segment, all households were visited, and all eligible household participants (children aged 1–9 years and people aged ≥ 15 years) were examined for trachoma.

Household interviews

Household interviews on water sanitation and hygiene (WASH) were undertaken by trained recorders using a standard questionnaire.¹⁰ Heads of households were asked about types of water sources used, distance to water sources, and type of sanitation facilities used by adults of the household; when the family reported using a latrine, the latrine type was verified by observation.

Trachoma grading

Graders participating in the surveys had obtained a kappa for diagnosing TF of at least 0.7 in a formal inter-grader agreement test (based on a sample of 50 children), compared to a GTMP-certified grader trainer.⁹ The eyelid and tarsal conjunctiva of each eye were examined using a 2.5 \times magnifying loupe and torch or sunlight, looking for signs of active trachoma and trichiasis.

Data management and analysis

Data were collected electronically using Android smartphones and the LINKS system (<https://gtmp.linksystem.org/drc>) customized for the GTMP.^{9,10} Descriptive statistics were used to examine sample characteristics, prevalence of trachoma and proportion of households with key WASH indicators. WASH data were categorized based on WHO/UNICEF Joint Monitoring Program definitions for improved and unimproved water sources and sanitation facilities (<https://www.wssinfo.org/definitions-methods/watsan-categories/>). Prevalence estimates and 95% confidence

intervals for TF and trichiasis were generated using GTMP methods in R (R Foundation for Statistical Computing, Vienna, Austria) and Structured Query Language (SQL). For each cluster, the proportion of 1–9-year-olds with TF was adjusted for age, using data from the most recent census. Similarly, for each cluster, the proportion of ≥ 15 -year-olds with trichiasis was adjusted for age and gender.¹⁰ Health Zone-level prevalences of each sign were calculated as the mean of the adjusted cluster-level proportions, and confidence intervals were calculated by bootstrapping, with 10,000 replications. Associations of TF and WASH indicators were explored using Spearman's rank test. To investigate differences in estimated WASH coverage with previous estimates, overall proportions of WASH indicators pooled from the 46 surveys were compared with national-level 2013–2014 Demographic and Health Survey (DHS) data from DRC's rural population,¹¹ using a two-sample test of proportions.

Ethical considerations

Prior to the surveys, approval was obtained from the ethics committee of the London School of Hygiene & Tropical Medicine (reference 6319). Because the purpose of the data collection was programmatic rather than for research, the DRC Ministère de la Santé Publique ruled that local ethics committee review was not required (reference MS.1251/SG/EKA/2283/MK/2014). Verbal consent to participate in the survey was given by the head of each selected household; informed verbal consent for examination was given by each participant or their parent or guardian.

Results

Characteristics of survey population

Table 1 summarizes the characteristics of the population sampled, by Health Zone. Our teams examined a total of 141,853 participants (98.2% of those enumerated) in 32,758 households. A total of 83,247 children aged 1–9 years and 58,606 people aged ≥ 15 years were examined for TF and trichiasis, respectively. For all 46 surveys combined, the proportions of male participants among children aged 1–9 years and people aged ≥ 15 years were 49.7% and 41.9%, respectively. The mean ages (and standard deviations) among children aged 1–9 years and people aged ≥ 15 years were 4.9 years (2.5) and 34.5 years (15.2), respectively.

Table 1. Characteristics of survey population by Health Zone, Global Trachoma Mapping Project, Democratic Republic of the Congo, 2014–2016.

Province	Health Zone	Number of households sampled	Children aged 1–9 years		Adults aged ≥15 years	
			Number examined	Proportion male (%)	Number examined	Proportion male (%)
Nord-Ubangi	Bili	631	1425	50.2	1367	45.9
Nord-Ubangi	Bosobolo	647	1663	49.4	1335	47.9
Nord-Ubangi	Karawa	759	2048	54.5	1345	47.1
Nord-Ubangi	Mobayi	768	2134	51.6	1606	48.2
Nord-Ubangi	Yakoma	753	2137	49.8	859	37.8
Sud-Ubangi	Libenge	747	1943	51.5	1016	47.1
Sud-Ubangi	Zongo	737	1942	51.1	1493	45.9
Bas-Uele	Bili	711	1573	49.8	1284	43.2
Bas-Uele	Bondo	648	1624	53.3	1401	42.6
Bas-Uele	Monga	735	1820	52.1	1168	50.4
Haut-Uele	Pawa	671	1702	50.7	1499	44.2
Ituri	Angumu	625	1579	49.6	868	32.4
Ituri	Drodro	693	1594	52.6	776	39.7
Ituri	Nyarambe	607	1465	51.9	829	32.1
Ituri	Aungba	756	1604	50.8	1267	37.8
Ituri	Bambu	676	1636	48.0	1202	37.3
Ituri	Fataki	701	1623	50.5	1293	35.8
Ituri	Ghety	689	2016	52.0	1452	31.7
Ituri	Jiba	701	1522	49.4	1315	36.5
Ituri	Lita	675	1698	48.6	1148	34.3
Ituri	Mahagi	719	1658	51.9	1300	38.8
Ituri	Mambasa	680	1624	52.7	1149	39.4
Ituri	Rethy	693	1653	51.4	1361	34.3
Nord-Kivu	Binza	747	2082	51.4	1229	47.5
Nord-Kivu	Birambizo	766	2153	50.4	1363	44.2
Nord-Kivu	Katoyi	785	1994	47.7	1318	43.8
Nord-Kivu	Kayna	754	2160	49.3	1495	42.1
Nord-Kivu	Kibirizi	748	1983	48.4	1358	42.2
Nord-Kivu	Kibua	754	2021	48.0	1467	47.3
Nord-Kivu	Masisi	741	1848	49.6	1358	51.3
Nord-Kivu	Walikale	749	2140	48.9	1536	45.1
Sud-Kivu	Bunyakiri	739	2005	49.9	1180	36.5
Sud-Kivu	Kadutu	751	1965	46.3	1351	40.9
Sud-Kivu	Kalehe	749	1928	51.1	1361	42.9
Sud-Kivu	Kalole	756	2010	47.0	1569	50.0
Sud-Kivu	Kitutu	750	1934	44.3	1428	44.8
Sud-Kivu	Minova	758	2081	48.0	1434	39.3
Sud-Kivu	Mwana	720	1772	48.6	1387	44.8
Sud-Kivu	Mwenga	756	1937	44.6	1531	45.3
Sud-Kivu	Nyantende	741	1743	47.1	1467	47.3
Haut-Katanga	Kilwa	731	1674	51.0	1233	47.2
Haut-Katanga	Kipushi	705	1789	49.2	928	33.9
Haut-Katanga	Kasenga	631	1796	49.1	1081	30.7
Haut-Katanga	Pweto	609	1355	47.2	1084	40.6
Haut-Katanga	Sakania	669	1588	49.4	1003	25.5
Tanganika	Moba	627	1606	48.6	1112	36.0

Prevalence of trachoma

Health Zone-level prevalences of trachoma are shown in Table 2 and Figure 2. Prevalence of TF was ≥5% in 30 Health Zones, of which 11 had TF prevalences of 5.0–9.9%; 18 had TF prevalences of 10.0–29.9%; and one had a TF prevalence ≥30%. Trichiasis prevalence was ≥0.2% in 37 Health Zones.

Prevalence of access to water, sanitation, and hygiene

Table 3 summarizes key indicators on access to WASH. The overall proportion of households that: (1) reported using an improved drinking water source was 44.9% (range by Health Zone, 3–95); (2) had drinking water

source in the household yard or within 1 km of it was 64.7% (range by Health Zone, 39–96); and (3) had access to improved sanitation facilities was 13.8% (range by Health Zone, 0–96). In the majority (54%) of Health Zones, the proportion of households with access to improved sanitation facilities was <10%. Health Zone-level TF prevalence was not correlated with any of the main WASH indicators: proportion of households with improved drinking water source ($p = 0.19$); proportion of households with drinking water source in the yard or within 1 km ($p = 0.25$); and proportion of households with sanitation facilities ($p = 0.16$). Compared to national-level DHS estimates for the rural population of DRC, proportions of households with access to improved water sources (DHS 32.2% vs. GTMP 48.9%; test of proportions, $p <$

Table 2. Prevalence of trachoma by Health Zone, Global Trachoma Mapping Project, Democratic Republic of the Congo, 2014–2016.

Province	Health Zone	Prevalence of	
		Prevalence of TF % in children aged 1–9 years (95% CI) ^a	trichiasis % in adults aged ≥15 years (95% CI) ^b
Nord-Ubangi	Bili	15.2 (10.6–20.2)	1.55 (0.69–2.75)
Nord-Ubangi	Bosobolo	10.0 (8.1–12.3)	1.52 (1.07–2.10)
Nord-Ubangi	Karawa	11.4 (9.0–13.4)	0.21 (0.05–0.45)
Nord-Ubangi	Mobayi	17.6 (12.5–23.4)	0.45 (0.16–0.88)
Nord-Ubangi	Yakoma	8.3 (6.6–10.1)	2.55 (1.12–4.67)
Sud-Ubangi	Libenge	14.5 (10.8–19.1)	1.66 (0.39–3.52)
Sud-Ubangi	Zongo	10.2 (7.2–14.5)	0.76 (0.20–1.66)
Bas-Uele	Bili	12.7 (10.4–14.7)	1.05 (0.64–1.54)
Bas-Uele	Monga	3.5 (2.1–5.0)	0.99 (0.28–1.95)
Bas-Uele	Bondo	4.7 (2.6–7.2)	2.04 (1.01–3.05)
Haut-Uele	Pawa	7.4 (5.6–9.2)	4.00 (2.39–5.74)
Ituri	Angumu	9.5 (7.9–11.1)	5.09 (3.28–6.76)
Ituri	Drodro	6.0 (3.9–8.7)	1.16 (0.70–1.76)
Ituri	Nyarambe	8.8 (6.1–11.8)	2.47 (1.28–4.00)
Ituri	Aungba	8.5 (6.5–10.9)	0.18 (0.05–0.35)
Ituri	Bambu	19.3 (15.6–23.7)	3.86 (2.64–5.46)
Ituri	Fataki	3.5 (2.1–5.3)	0.59 (0.13–1.46)
Ituri	Ghety	18.6 (16.5–20.9)	2.76 (1.94–3.50)
Ituri	Jiba	7.5 (5.0–10.3)	0.77 (0.38–1.21)
Ituri	Lita	19.4 (16.7–23.3)	2.87 (1.83–4.25)
Ituri	Mahagi	5.8 (3.3–8.3)	0.08 (0.00–0.19)
Ituri	Mambasa	10.2 (8.0–11.7)	1.46 (0.86–2.01)
Ituri	Rethy	3.9 (2.3–6.1)	0.22 (0.06–0.45)
Nord-Kivu	Binza	11.1 (9.2–13.6)	1.00 (0.61–1.53)
Nord-Kivu	Birambizo	6.6 (4.9–8.3)	0.42 (0.20–0.70)
Nord-Kivu	Katoyi	17.6 (15.6–20.4)	1.08 (0.70–1.49)
Nord-Kivu	Kayna	1.9 (0.9–3.2)	0.16 (0.04–0.34)
Nord-Kivu	Kibirizi	3.0 (1.6–5.0)	0.15 (0.00–0.37)
Nord-Kivu	Kibua	2.0 (1.2–3.1)	0.08 (0.00–0.18)
Nord-Kivu	Masisi	4.8 (2.5–8.2)	0.13 (0.03–0.30)
Nord-Kivu	Walikale	2.1 (1.2–3.1)	0.02 (0.00–0.05)
Sud-Kivu	Bunyakiri	6.6 (4.1–9.0)	0.48 (0.23–0.69)
Sud-Kivu	Kadutu	4.5 (3.3–5.9)	0.23 (0.04–0.49)
Sud-Kivu	Kalehe	11.7 (8.3–16.5)	0.95 (0.62–1.32)
Sud-Kivu	Kalole	2.0 (0.6–3.6)	0.13 (0.03–0.26)
Sud-Kivu	Kitutu	3.0 (1.8–4.7)	0.65 (0.26–1.28)
Sud-Kivu	Minova	15.2 (10.6–21.1)	1.10 (0.54–1.81)
Sud-Kivu	Mwana	3.3 (1.5–5.7)	1.31 (0.73–2.12)
Sud-Kivu	Mwenga	2.1 (1.2–3.2)	1.70 (0.62–3.60)
Sud-Kivu	Nyantende	2.2 (1.2–3.2)	0.11 (0.00–0.29)
Haut-Katanga	Kilwa	13.7 (9.6–17.3)	0.65 (0.33–1.05)
Haut-Katanga	Kipushi	16.9 (8.0–25.5)	0.90 (0.07–2.00)
Haut-Katanga	Kasenga	9.2 (7.4–11.3)	0.47 (0.22–0.72)
Haut-Katanga	Pweto	41.6 (32.4–50.6)	2.85 (1.92–4.08)
Haut-Katanga	Sakania	2.5 (1.2–4.4)	0.20 (0.01–0.53)
Tanganika	Moba	15.3 (12.6–18.6)	3.33 (1.93–5.05)

^aAdjusted for age, in 1-year bands.^bAdjusted for gender and age, in 5-year bands. CI, confidence interval.

0.001) and with drinking water sources in the yard or within 1 km distance (DHS 41.8% vs. GTMP 64.7%; test of proportions, $p < 0.001$) were higher in our surveys overall. However, the proportion of households with access to improved sanitation facilities was lower in our surveys (DHS 17.1% vs. GTMP 13.8%; test of proportions, $p < 0.001$).

Discussion

To achieve trachoma elimination, timely baseline surveys of trachoma in suspected-endemic districts are

Table 3. Proportion of households with key water, sanitation and hygiene indicators, by Health Zone, Global Trachoma Mapping Project, Democratic Republic of the Congo, 2014–2016.

Province	Health Zone	Proportion of households (%)		
		Using improved drinking water source	With drinking water source in yard/within 1 km	With improved sanitation facilities
Nord-Ubangi	Bili	4.9	73.7	3.0
Nord-Ubangi	Bosobolo	8.5	57.5	0.9
Nord-Ubangi	Karawa	28.5	58.6	0.00
Nord-Ubangi	Mobayi	26.7	62.0	0.1
Nord-Ubangi	Yakoma	8.1	73.0	9.0
Sud-Ubangi	Libenge	41.4	71.6	11.2
Sud-Ubangi	Zongo	24.3	46.8	0.5
Bas-Uele	Bili	3.0	52.9	0.1
Bas-Uele	Bondo	3.5	80.9	22.5
Bas-Uele	Monga	4.1	69.0	24.6
Haut-Uele	Pawa	8.6	84.1	27.1
Ituri	Angumu	29.4	65.6	20.6
Ituri	Drodro	35.9	58.9	19.7
Ituri	Nyarambe	55.8	55.8	12.4
Ituri	Aungba	29.9	76.1	17.7
Ituri	Bambu	28.0	50.1	7.0
Ituri	Fataki	74.0	69.9	24.1
Ituri	Ghety	45.1	52.1	0.1
Ituri	Jiba	64.2	76.0	22.3
Ituri	Lita	45.9	39.4	0.1
Ituri	Mahagi	66.2	81.4	20.7
Ituri	Mambasa	33.8	59.7	0.0
Ituri	Rethy	76.6	57.9	20.6
Nord Kivu	Binza	44.2	95.6	0.5
Nord-Kivu	Birambizo	44.1	48.0	2.6
Nord-Kivu	Katoyi	31.5	58.7	3.8
Nord-Kivu	Kayna	59.0	57.2	4.9
Nord-Kivu	Kibirizi	40.9	57.8	0.4
Nord-Kivu	Kibua	62.7	67.4	9.7
Nord-Kivu	Masisi	76.9	49.4	2.4
Nord-Kivu	Walikale	35.8	68.6	9.6
Sud-Kivu	Bunyakiri	69.1	80.1	28.4
Sud-Kivu	Kadutu	94.9	91.9	63.5
Sud-Kivu	Kalehe	84.4	78.9	25.1
Sud-Kivu	Kalole	22.6	81.7	13.8
Sud-Kivu	Kitutu	68.7	53.5	1.5
Sud-Kivu	Minova	78.2	65.8	29.2
Sud-Kivu	Mwana	59.7	56.8	1.2
Sud-Kivu	Mwenga	62.8	63.9	1.7
Sud-Kivu	Nyantende	88.0	50.1	3.8
Haut Katanga	Kilwa	59.0	58.7	17.5
Haut-Katanga	Kipushi	80.6	74.9	61.4
Haut-Katanga	Kasenga	26.0	43.6	42.6
Haut-Katanga	Pweto	30.7	60.3	6.9
Haut-Katanga	Sakania	25.9	82.2	42.9
Tanganika	Moba	50.7	52.5	1.4

vital for planning SAFE interventions. Our findings suggest that trichiasis is widespread in surveyed areas of DRC, and public health-level actions to provide surgery services are required in 37 Health Zones in which trichiasis prevalences in adults were $\geq 0.2\%$. Based on TF prevalences, a total of 30 Health Zones are eligible for mass drug administration (MDA) with azithromycin before repeat prevalence surveys, as follows: a single dose for all residents of the 11 Health Zones with TF prevalences of 5.0–9.9%; three annual rounds in 18 Health Zones with TF prevalences of 10.0–29.9%; and five annual rounds in one Health

Zone with TF prevalence $\geq 30\%$. While access to WASH varied markedly by Health Zone, overall, less than half of all households reported using an improved drinking water source, and less than 2 in 10 households had an improved sanitation facility. Therefore, implementation of the F and E components of SAFE should be a priority, for the sake of more than just elimination of trachoma.^{12,13}

The surveys reported here used methods recommended by WHO for sampling of populations and examination for trachoma.¹⁰ However, there are a number of limitations. First, despite the low proportion (1.8%) of eligible participants recorded as being absent from surveyed households, in most Health Zones, a substantial proportion of adult men refused to participate in the surveys and declined even to have their existence recorded. While the relative paucity of adult men is a potential source of bias and might tend to overestimate the prevalence of trichiasis (given that trichiasis is generally more common in women than men),¹⁴ standardization of prevalence estimates by age and gender was intended to minimize—but does not negate—this bias. Second, recent evidence from Ethiopia suggests that trichiasis is frequently attributable to metaplastic or misdirected eyelashes,¹⁵ often from aetiologies other than trachoma. However, in the DRC surveys, we did not examine eyes with trichiasis for trachomatous conjunctival scarring (TS),¹⁶ so we report in this paper prevalences of any-trichiasis (with or without TS). Management strategies for non-trachomatous trichiasis are less well defined than for trachomatous trichiasis, and the background prevalence of non-trachomatous trichiasis in trachoma-endemic or non-trachoma-endemic environments is presently unknown. Awareness of the potential importance of non-trachomatous trichiasis to estimates of the prevalence of trachoma has arisen only relatively recently.¹⁷ Generation of estimates of any-trichiasis at baseline does not necessarily impact on planning SAFE implementation, depending on national policies for the management of non-trachomatous trichiasis, but may represent over-estimates for the purposes of determining whether elimination goals have been reached. Methods for trachoma impact surveys have now been refined to include examination for TS in eyes with trichiasis, thus allowing distinction between non-trachomatous and trachomatous disease.¹⁸ Finally, the GTMP acknowledges that estimates of TT prevalence lack ideal precision.¹⁰ We present our confidence intervals here, and continue to work on ways to better determine the population frequency of this low prevalence condition, which is an epidemiological problem that is not unique to trachoma.

Compared to rural WASH indicators from DHS 2013–2014,¹¹ households in our series of surveys had better access to improved water sources but worse access to improved sanitation facilities. Our methods for assessment of WASH were consistent with those of the DHS, as specified by the WHO/UNICEF Joint Monitoring Program. It is worth noting that our surveys are far more granular than the DHS, and covered only a small proportion of the country, whereas DHS data were designed to be representative at national level. In other words, these discrepancies probably reflect real differences in WASH access for our populations compared to national means.

These surveys were undertaken in 46 priority Health Zones in which trachoma was suspected to be endemic, based on the preceding desk reviews. It may be inferred from our results that we have not yet found the edges of the endemic foci, and therefore that further baseline surveys should be considered. Priority could be given to Health Zones bordering those with prevalences of TF $\geq 10\%$ or of trichiasis $\geq 1\%$. In Health Zones bordering surveyed areas with TF prevalences of 5.0–9.9% or trichiasis prevalences of 0.2–0.9%, trachoma rapid assessments could be considered to help determine whether further formal surveys are needed.¹⁹

The survey findings reported here suggest that 30 Health Zones qualify for mass drug administration with azithromycin and implementation of the F&E components of SAFE for trachoma elimination purposes, while public health-level action to deliver trichiasis surgery is needed in 37 Health Zones. These important findings will facilitate planning SAFE interventions and elimination of trachoma from DRC. In addition, we note that further baseline surveys in DRC are required.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the writing and content of this article.

Funding

The survey field work was made possible through support provided to RTI International via the ENVISION Project (Cooperative Agreement no. AID-OAA-A-11-00048) by the United States Agency for International Development. Core support to the Global Trachoma Mapping Project was provided by a grant from the United Kingdom's Department for International Development (ARIES: 203145) to Sightsavers, which led a consortium of non-governmental organizations and academic institutions to complete baseline trachoma mapping worldwide. A committee established in March 2012 to examine issues surrounding completion of global trachoma mapping was initially supported by a grant from

Pfizer to the International Trachoma Initiative. AWS was a Wellcome Trust Intermediate Clinical Fellow (098521) at the London School of Hygiene & Tropical Medicine, and is now an employee of WHO; the views expressed in this paper are the views of the authors alone and do not necessarily reflect the decisions or the stated policy of WHO. The funders of this study had no role in the study design, data collection, data analysis, data interpretation, or the writing of the report.

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