Title
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Journal
Ophthalmic Epidemiology, 25(sup1)

ISSN
0928-6586

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Publication Date
2018-12-28

DOI
10.1080/09286586.2018.1546877

Peer reviewed

OPHTHALMIC EPIDEMIOLOGY
2018, VOL. 25, NO. S1, 143–154
https://doi.org/10.1080/09286586.2018.1546877

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Prevalence of trachoma in the Republic of Chad: results of 41 population-based surveys

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ABSTRACT

Purpose: To estimate the prevalence of trachoma in suspected-endemic areas of Chad, and thereby determine whether trachoma is a public health problem requiring intervention.

Methods: We divided the suspected-endemic population living in secure districts into 46 evaluation units (EUs), and used the standardized methodologies of the Global Trachoma Mapping Project. A two-stage cluster-sampling procedure was adopted. In each EU, the goal was to examine at least 1019 children aged 1–9 years by recruiting 649 households; all consenting residents aged ≥ 1 year living in those households were examined. Each participant was examined for trachomatous inflammation—follicular (TF), trachomatous inflammation—intense (TI), and trichiasis.

Results: Two EUs had data that could not be validated, and were excluded from the analysis. GPS data for three other pairs of EUs suggested that EU divisions were inaccurate; data for each pair were combined within the pair. In the 41 resulting EUs, 29,924 households in 967 clusters were visited, and 104,584 people were examined. The age-adjusted EU-level prevalence of TF in 1–9-year-olds ranged from 0.0% to 23.3%, and the age- and gender-adjusted EU-level prevalence of trichiasis in ≥ 15-year-olds ranged from 0.02% to 1.3%. TF was above the WHO elimination threshold in 16 EUs (39%) and trichiasis was above the WHO elimination threshold in 29 EUs (71%). Women had a higher prevalence of trichiasis than did men in 31 EUs (76%). A higher ratio of trichiasis prevalence in women to trichiasis prevalence in men was associated (p = 0.03) with a higher prevalence of trichiasis at EU level.

Conclusion: Public health-level interventions against trachoma are needed in Chad. Over 10,000 people need management of their trichiasis; women account for about two-thirds of this total. The association between a higher ratio of trichiasis prevalence in women to that in men with higher overall trichiasis prevalence needs further investigation.

ARTICLE HISTORY
Received 30 April 2018
Revised 12 October 2018
Accepted 6 November 2018

KEYWORDS
Chad; global trachoma mapping project; prevalence; trachoma; trichiasis; gender

Background

Trachoma, the leading infectious cause of blindness worldwide,[1] is a chronic kerato-conjunctivitis caused by the bacterium *Chlamydia trachomatis*.[2] Infections, most commonly occurring in children,[3] may lead to sub-epithelial follicles or more pronounced inflammation.[4] Repeated infection[5,6] can lead to scarring of the conjunctivae[7] which, when severe enough, can deform the eyelid and cause eyelashes to touch the globe (trichiasis).[4] Uncorrected trichiasis can result in corneal abrasion, ulceration, opacification, and potentially, vision loss and blindness.

In 1993, the World Health Organization (WHO) endorsed the SAFE strategy,[8] a comprehensive management plan for elimination of trachoma as a public health problem. SAFE refers to surgery (S) to correct trichiasis, mass distribution of antibiotics (A) to clear infection, and facial cleanliness (F) and environmental improvement (E) to reduce *C. trachomatis* transmission.[9] To determine whether public health-level interventions are required, population-based surveys to generate prevalence estimates of trachomatous inflammation—follicular (TF) and trichiasis are recommended.[10,11]

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/iope.
*See Appendix.

Chad is a central African country of approximately 12 million people spread across three distinct ecologic zones: the Sahara Desert, the Sahel, and the Savanna. Currently the country has a total of 33 ophthalmic nurses; 35 ophthalmic technicians; and nine ophthalmologists (approximately one for every 1.5 million people) of whom 5 are in the capital N'Djamena. Though absolute numbers of eye-care personnel are low, Chad is fortunate that 90% of them work in the public sector – specifically in five departments of ophthalmology (within two secondary and three tertiary hospitals) and 21 secondary eye care units.

A number of population-based trachoma prevalence surveys were undertaken in Chad in 1984,[12] 1985,[13] 2001[14] and 2004[15] (Table 1); however, due to financial constraints, SAFE strategy implementation was not commenced until 2015. The 1984–2004 surveys occurred prior to the recent growth in interest in trachoma elimination,[17] and were conducted at region level, covering large populations and wide geographical areas (Table 1). Because of the age and relatively low resolution of existing data, in order to inform programmatic action, baseline mapping or re-mapping was felt to be required.[18] We set out to estimate the prevalence of TF in 1–9-year-olds and the prevalence of trichiasis in adults in population units of 100,000–250,000 people in suspected-trachoma-endemic areas of rural Chad.

Materials and methods

Administratively, Chad is divided into 23 regions. Each region (other than the capital, N'Djamena, which has a different internal administrative structure) is divided into two to six health districts, the level at which trachoma elimination activities are implemented.[19] There are 61 health districts in total, of which 45 were suspected to have trachoma as a public health problem and therefore to qualify for mapping, based on criteria published elsewhere.[20] Surveys were conducted in 2014 and 2015. Due to insecurity prevailing at that time, five suspected-trachoma-endemic health districts (Bol and Ngouri in Lac Region, Nokou in Kanem Region, Mandelia in Chari Baguirmi Region and Bardaï in Tibesti Region) could not be surveyed.

Survey design, field team training and certification, fieldwork, and data handling were conducted according to the systems and methodologies of the Global Trachoma Mapping Project (GTMP).[20–23] Each of the 40 secure health districts was generally surveyed as a single evaluation unit (EU), though six health districts with populations (estimated using 2009 population census data[24] and a mean annual population growth rate of 3.6%) significantly larger than the standard 100,000--250,000-person EU were divided into two EUs each, resulting in a total of 46 independent EUs.

Village-level population estimates were provided by the Division of Health & Information Systems. According to the 2009 census,[24] the proportion of the population aged 1–9 years was 36% and rural households had a mean of 5.3 residents. The estimated sample size requirement per EU was based on an expected TF prevalence of 10% in children aged 1–9 years, a design effect of 2.65, and a desire to be 95% confident of estimating the TF prevalence with ± 3% absolute

Table 1. Findings from trachoma prevalence surveys in Chad, 1984–2004.

Region(s) surveyed	Year survey completed	Estimated population at time of survey	Active trachoma indicator reported	Number of 0–9-year-olds examined	Active trachoma prevalence in 0–9-year-olds (%) [95% CI][b]	Trichiasis indicator reported	Number of adults examined	Trichiasis prevalence in (%)[b]	Ref
Lac and Kanem	1984	322,289	F_3P_3 or F_3P_2[a]	213	30.5	Trichiasis in ≥ 15-year -olds	256	5.5	12
Ouaddaï and Biltine	1985	1,558,953	F_3P_3 or F_3P_2[a]	211	27.5	Trichiasis in ≥ 15-year -olds	314	3.5	13
Lac, Kanem, Chari Baguirmi	2001	1,798,240	TF	2046	33.2 [29.2–37.5]	Trichiasis in ≥ 15-year-old ♀s	1252	1.3	14
Ouaddaï and Biltine	2001	1,663,512	TF	1906	29.7 [25.6–34.1]	Trichiasis in ≥ 15-year-old ♀s	1240	1.7	14
Moyen Chari	2004	757,127	TF	2409	17.5	Trichiasis in ≥ 15-year-old ♀s	1626	1.4	15
Guéra and Salamat	2004	1,072,034	TF	2119	26.9	Trichiasis in ≥ 15-year-old ♀s	1605	6.2	15

[a]Indicators of severe active trachoma in WHO's 1981 revision of the "FPC" grading system[16]
[b]Unadjusted
TF, trachomatous inflammation—follicular; TI, trachomatous inflammation—intense

precision.[22] The resulting sample size (n = 1019) was increased by 20% to account for non-response; this resulted in a total of 649 households being required per EU.

Using a two-stage cluster-sampling design, 22 clusters (villages or neighbourhoods) were systematically selected in each EU using probability-proportional-to-population -size sampling. In each cluster, compact segment sampling[25,26] was then used to select 30 households. All residents over the age of 12 months who had resided for at least six months in selected households were eligible for enrolment.

A survey team consisted of a grader (ophthalmic technician), a recorder (high school graduate at ease with Android smart phones and fluent in major local languages), a local facilitator and a driver. Members of the survey team underwent standardized GTMP training, using version 2 of the system.[27] Candidate graders were assessed after training, and only those obtaining a kappa of ≥ 0.7 for diagnosis of TF in an inter-grader agreement test with a GTMP-certified grader trainer were accepted as survey graders. Trachoma grading was done according to the WHO simplified grading system.[4] Graders used 2.5× magnifying binocular loupes and sunlight illumination to examine consenting residents. In eyes diagnosed as having trichiasis, the presence or absence of trachomatous conjunctival scarring[28,29] was not recorded, so we are unable to confirm that trichiasis cases detected were due to trachoma; consequently, we refer here to the prevalence of trichiasis instead of the prevalence of trachomatous trichiasis. Each survey team was trained to ask questions relating to access to water and sanitation at each selected household.[27]

All data were captured electronically, through the Open Data Kit-based Android phone application purpose-built for the GTMP. Once saved, data were sent to and stored on the GTMP Cloud-based secure server, then cleaned and analyzed.[22] For each survey cluster, the proportion of 1–9-year-old children with TF was adjusted by age in one-year age bands, while the proportion of ≥ 15-year-olds with trichiasis was adjusted by age and gender in five-year age bands; age and gender data from the 2009 Chad census were used as the reference population for this purpose.[24] For each EU, the primary outcome of interest was the age-adjusted prevalence of TF in 1–9-year-olds; intended secondary outcomes were the age- and gender-adjusted prevalence of trichiasis in ≥ 15-year-olds, and household-level access to water and sanitation. Confidence intervals for TF and trichiasis prevalence estimates were calculated by bootstrapping sets of 22 adjusted cluster-level proportions for each sign, with replacement, over 10,000 replicates, and taking the 2.5th and 97.5th centiles of the ordered results. Additional gender-specific age-adjusted estimates of trichiasis prevalence, with 95% confidence intervals, were calculated in analogous fashion. The ratio of trichiasis prevalence in females to that in males in each EU was also determined, and linear regression modelling (Stata 11, College Station TX, USA) used to generate an intra-class correlation coefficient, to assess the association between EU-level trichiasis prevalence and ratio of gender-specific prevalences.

Ethical clearance was obtained from the Chadian Ethical Committee for Applied Research, led by the Ministry of Higher Education; and from the London School of Hygiene & Tropical Medicine (6319). The examination procedure was explained to each eligible adult in the local language and verbal consent for enrolment and examination was obtained. For eligible children, verbal consent was obtained from a parent or guardian. Individuals with active trachoma were offered 1% tetracycline ointment for application into the conjunctival sac twice-daily for six weeks. Individuals with trichiasis were offered management by a surgeon.

Results

Fieldwork was undertaken from May 2014 to November 2015. At a subsequent field team meeting, it emerged that fieldworkers had considered their main task to be the acquisition of information on TF and trichiasis. Contrary to the survey protocol and the standard GTMP training package, in some villages, questions about access to water and sanitation had not been systematically asked in each selected household. Rather, information had been collected from the head of the village at the beginning of the day and those answers used for each household visited. Although this shortcut was not employed by all teams, it cast doubt on the accuracy of our water and sanitation data, and we do not include those data in this manuscript. Data cleaning revealed inconsistency in definitions of EU and district boundaries. In particular, in three health districts (Pala, Béré & Kélo, and Donomanga & Laï) that had each been split into two EUs, GPS data revealed considerable overlap between clusters that had ostensibly been drawn from separate EUs. Data from these pairs of within-health-district EUs were therefore combined to re-constitute health-district-level EUs; the numbers of clusters finally included in each EU are shown in Table 2. GPS data[30] were not received at all from a high proportion of households mapped in both of Moundou's two EUs; those that had GPS data were geolocated in a pattern inconsistent with

Table 2. Numbers of children and adults enumerated and examined, by evaluation unit, Global Trachoma Mapping Project, Chad, 2014–2015.

Region	Evaluation unit (label in Figures 1 and 2)	Population	Number of clusters enrolled	Number of households enrolled	Number of 1–9-year-olds enumerated	Number of 1–9-year-olds absent	Number of 1–9-year-olds refused	Number of 1–9-year- olds examined	Number of ≥ 15-year-olds enumerated	Number of ≥ 15-year-olds absent	Number of ≥ 15-year-olds refused	Number of ≥ 15-year-olds examined
Batha	Ati (1)	274,781	22	659	1324	0	0	1324	1050	0	0	1050
Batha	Oum Hadjer (2)	233,223	22	651	1143	2	0	1141	840	1	3	836
Batha	Yao (3)	143,616	22	649	1319	1	1	1317	935	0	9	926
Logone Occidental	Laokassy (4)	105,630	22	674	1479	0	0	1479	1127	1	0	1126
Logone Occidental	Bénoye (5)	215,959	22	671	1240	1	0	1239	1111	0	0	1111
Logone Oriental	Doba (6)	276,045	22	656	1145	0	0	1145	1072	0	2	1070
Logone Oriental	Béboto (7)	138,022	23	683	1162	0	0	1162	1238	1	0	1237
Logone Oriental	Bébédjia (8)	156,476	22	653	987	0	9	978	946	1	3	942
Logone Oriental	Goré (9)	188,824	22	662	1011	4	9	998	878	2	4	872
Logone Oriental	Bessao (10)	225,366	22	656	1127	1	6	1120	937	0	3	934
Mayo Kebbi Est	Bongor (11)	249,290	22	621	1263	2	0	1261	863	2	0	861
Mayo Kebbi Est	Gounou Gaya (12)	289,412	22	1217	2742	0	0	2742	1233	0	0	1233
Mayo Kebbi Est	Guélengdeng (13)	124,644	22	672	984	0	1	983	911	0	1	910
Mayo Kebbi Est	Fianga (14)	287,664	22	641	1331	0	0	1331	967	0	0	967
Mayo Kebbi Ouest	Pala[a] (15)	418,505	44[a]	1759	4023	0	0	4023	2617	0	1	2616
Mayo Kebbi Ouest	Léré (16)	280,168	23	685	1053	0	0	1053	1452	0	0	1452
Tandjilé	Béré & Kélo[a] (17)	349,348	42	1284	3156	1	0	3155	2327	0	1	2326
Tandjilé	Donomanga & Laï[a] (18)	261,505	44 [a]	1363	2843	0	0	2843	2592	0	0	2592
Moyen Chari	Sarh (19)	394,519	22	655	956	0	0	956	943	0	1	942
Moyen Chari	Danamadji (20)	130,286	22	648	972	0	0	972	1028	0	0	1028
Moyen Chari	Kyabé (21)	214,913	22	655	1041	0	0	1041	900	0	1	899
N'Djamena	Suburbs (22)	1 228 352	22	660	1355	0	0	1355	1183	0	1	1182
Borkou	Faya (23)	115,710	22	623	1080	1	1	1078	1097	2	4	1091
Ennédi (West & East)	Fada & Bahai (24)	214,646	21	591	1095	0	3	1092	927	0	3	924
Bahr El Gazel	Moussoro (25)	322,533	22	650	1074	0	4	1070	844	0	7	837
Chari Baguirmi	Massenya (26)	186,922	22	646	956	0	0	956	890	1	0	889
Chari Baguirmi	Dourbali (27)	193,305	22	660	1007	0	0	1007	964	0	2	962
Chari Baguirmi	Bousso (28)	195,242	22	657	1061	1	0	1060	975	0	1	974
Hadjer Lamis	Massakory (29)	232,731	22	655	1122	0	5	1117	878	0	5	873
Hadjer Lamis	Massaguet (30)	191,689	22	671	1330	0	0	1330	1213	0	0	1213
Kanem	Mao-1 (31)	165,060	20	608	1066	0	0	1066	853	0	0	853
Kanem	Mao-2 (32)	152,363	24	729	1297	0	0	1297	987	3	0	984
Mandoul	Koumra (33)	242,159	22	661	1384	0	0	1384	1289	0	0	1289
Mandoul	Goundi (34)	181,620	22	658	1206	0	0	1206	1178	0	0	1178
Mandoul	Moïssala (35)	242,834	22	660	1248	0	0	1248	1147	0	0	1147
Mandoul	Bédjondo (36)	121,081	22	659	1097	0	0	1097	818	0	0	818
Wadi Fira	Biltine (37)	301,263	22	659	1259	0	0	1259	1430	0	0	1430
Wadi Fira	Guéréda (38)	192,918	22	657	1124	0	0	1124	1649	0	0	1649
Wadi Fira	Iriba (39)	117,753	22	659	1304	0	0	1304	1481	1	0	1480
Hadjer Lamis	Bokoro-1 (40)	127,661	22	665	1400	0	0	1400	1395	0	0	1395
Hadjer Lamis	Bokoro-2 (41)	143,958	22	668	1449	0	0	1449	1363	1	0	1362
Total		8,599,644	967	29,910	56,215	14	39	56,162	48,528	16	52	48,460

[a]Intended to be mapped as two EUs (please see text)

known administrative divisions. For that reason, the data from Moundou did not pass GTMP quality control, and the outputs were, as expected, rejected by the health ministry. We therefore present data here from what became a total of 41 surveys.

In total, 104,705 people were enrolled and 104,584 (99%) examined in 29,239 households recruited from 967 clusters (Table 2). There were almost equal numbers of 1–9-year-olds (n = 55,885) and ≥ 15-year-olds (n = 48,699) examined. While the sampling process was designed to facilitate examination of at least 1,019 children in each EU, the survey teams in five EUs did not reach this target, with the lowest number of 1–9-year-olds examined in an EU being 956; reports from the field indicated that in many locations, households had fewer resident children than expected.

The adjusted TF prevalence in 1–9-year-old children was ≥ 5% (above the WHO threshold for elimination[31]) in 16 (39%) of the 41 EUs. Five EUs (12%) had TF prevalence estimates of 10–29.9%, and 11 EUs (27%) had TF prevalence estimates of 5–9.9% (Table 3, Figure 1).

In 12 EUs (29%), the age- and gender-adjusted trichiasis prevalence was below the WHO elimination threshold[31] of 0.2% in ≥ 15-year-olds (Table 3, Figure 2). In the remaining 29 EUs, trichiasis prevalence was ≥ 0.2%. Two EUs had trichiasis prevalence estimates of > 1%. The estimated number of trichiasis patients requiring management to achieve elimination of trichiasis as a public health problem at the time of conclusion of the surveys was 10,562 (Table 3).

Analysis of gender-specific age-adjusted trichiasis prevalence estimates revealed mean EU-level prevalences of 0.55% in women and 0.28% in men; in 31 (76%) of the 41 EUs, the prevalence of trichiasis was higher in women than men (Table 4). There were five EUs in which none of the men examined had trichiasis. The mean ratio of prevalence in women to that in men (excluding the five EUs in which prevalence in men was 0) was 1.70 (SE = 0.53) in the EUs below the WHO elimination threshold, and 2.31 (SE = 0.48) in the EUs above the WHO elimination threshold. A higher prevalence of trichiasis was associated with a greater excess of disease in women (correlation coefficient = 250, SE = 114, p = 0.03).

Discussion

The results of these and previous surveys demonstrate that trachoma is a public health problem in Chad. To move towards elimination of trachoma as a public health problem, AFE interventions should be implemented for at least three years before re-survey for the approximately 887,000 people in the five EUs in which TF prevalence was ≥ 10%, and for at least one year before re-survey for the nearly 2.8 million people in the 11 EUs in which TF prevalence was 5–9.9%. Although we are unable to report our own data on access to water and sanitation, 2017 data released by the Chad Government and UNICEF suggest that region-level proportions of the population with access to potable water are as low as 12% (Ennedi-Est), and that outside N'Djamena, region-level rates of open defecation range from 61 to 93%. These conditions are associated with high risk of active trachoma,[32,33] highlighting the need for the F&E components of the SAFE strategy here.

The TF prevalence estimates from these GTMP-supported surveys are considerably lower than those of previous surveys completed in Chad.[13–15] There are a number of possible explanations for this. When surveys were first planned here, it would have been logical to choose to start in districts with higher expected burdens of trachoma – where, in other words, eye health professionals were already aware of cases. There may also, or alternatively, have been a temporal decline in the prevalence of active trachoma in the intervening period,[34–37] with older surveys reflecting *C. trachomatis* transmission intensities[38] occurring before more recent improvements in access to water, sanitation and health care. The GTMP's emphasis on standardization of trachoma grading (including grader training and qualification based on examination of real people, rather than projected images[20]) may also have contributed.

Trichiasis is widespread in Chad (Figure 2), with more than two-thirds of EUs surveyed in 2014–2015 having trichiasis prevalence estimates above the WHO elimination threshold. Establishing a public health-level response to trichiasis throughout the widely dispersed communities in these EUs will require considerable capacity building for delivery of high-quality trichiasis surgery and programme management, as well as community-based efforts to generate awareness and encourage uptake of services.[39,40] The excess burden of trichiasis among females (Table 4), also noted elsewhere,[25,41,42] compels us to ensure that such efforts particularly serve women. Experience in other countries can inform strategies to improve use of eye care services by women.[43,44] The association noted here between higher prevalence of trichiasis and greater ratio of trichiasis prevalence in women to trichiasis prevalence in men cannot be explained from our data alone. We note that this was not a pre-specified hypothesis of the current work, and suggest only that further investigation is indicated.

Our work has a number of limitations. First, in five EUs, we did not quite reach the estimated sample size

Table 3. Prevalence of trachomatous inflammation—follicular (TF) in 1–9-year-olds, prevalence of trichiasis in ≥ 15-year-olds, backlog of trichiasis cases and number of trichiasis cases needing management to reach the WHO elimination threshold, by evaluation unit, Global Trachoma Mapping Project, Chad, 2014–2015.

Region	Evaluation unit (label in Figures 1 and 2)	TF prevalence[a], % (95% CI)	Trichiasis prevalence[b], % (95% CI)	Estimated backlog of trichiasis cases[c]	Estimated number of trichiasis cases needing management to reach WHO elimination threshold
Batha	Ati (1)	10.9 (7.3–14.7)	0.57 (0.25–0.98)	774	499
Batha	Oum Hadjer (2)	8.6 (6.0–11.7)	0.55 (0.25–0.96)	634	401
Batha	Yao (3)	5.4 (3.4–6.8)	0.30 (0.07–0.64)	213	69
Logone Occidental	Laokassy (4)	2.5 (1.5–3.5)	0.29 (0.07–0.62)	151	45
Logone Occidental	Bénoye (5)	1.9 (1.1–2.9)	0.02 (0.0–0.05)	21	0
Logone Oriental	Doba (6)	5.9 (3.2–9.6)	0.14 (0.0–0.38)	191	0
Logone Oriental	Béboto (7)	3.4 (1.4–6.3)	0.15 (0.04–0.30)	102	0
Logone Oriental	Bébédjia (8)	1.3 (0.4–2.4)	0.36 (0.10–0.64)	278	122
Logone Oriental	Goré (9)	3.4 (1.9–5.2)	0.72 (0.32–1.27	672	483
Logone Oriental	Bessao (10)	3.9 (2.0–5.9)	0.92 (0.26–1.66)	1024	799
Mayo Kebbi Est	Bongor (11)	2.7 (1.5–4.0)	0.34 (0.0–0.93)	419	170
Mayo Kebbi Est	Gounou Gaya (12)	2.4 (1.7–3.0)	0.08 (0.0–0.20)	114	0
Mayo Kebbi Est	Guélengdeng (13)	6.0 (2.9–10.1)	0.59 0.23–1.09)	363	238
Mayo Kebbi Est	Fianga (14)	1.8 (0.6–3.5)	0.14 (0.0–0.33)	199	0
Mayo Kebbi Ouest	Pala (15)	6.6 (5.1–8.4)	0.20 (0.07–0.36)	413	0
Mayo Kebbi Ouest	Léré (16)	4.5 (2.9–5.6)	0.47 (0.09–1.08)	650	370
Tandjilé	Béré & Kélo (17)	0.1 (0.0–0.3)	0.06 (0.0–0.16)	104	0
Tandjilé	Donomanga & Laï (18)	0.2 (0.0–0.5)	0.50 (0.17–0.94)	646	384
Moyen Chari	Sarh (19)	5.1 (3.1–7.4)	0.33 (0.13–0.51)	643	248
Moyen Chari	Danamadji (20)	4.3 (2.2–6.2)	0.17 (0.04–0.36)	109	0
Moyen Chari	Kyabé (21)	7.3 (5.4–8.9)	0.93 (0.44–1.49)	987	772
N'Djamena	Suburbs (22)	4.2 (2.5–6.6)	0.13 (0.0–0.31)	789	0
Borkou	Faya (23)	10.1 (4.0–19.0)	1.21 (0.31–2.01)	692	576
Ennédi (West & East)	Fada & Bahai (24)	8.5 (4.3–14.2)	0.18 (0.0–0.41)	191	0
Bahr El Gazel	Moussoro (25)	0.0 (0.0–0.0)	0.60 (0.15–1.25)	956	633
Chari Baguirmi	Massenya (26)	4.1 (1.6–6.8)	0.17 (0.04–0.32)	157	0
Chari Baguirmi	Dourbali (27)	4.9 (2.2–7.6)	0.52 (0.22–0.92)	497	304
Chari Baguirmi	Bousso (28)	7.9 (4.1–14.3)	0.39 (0.15–0.59)	376	181
Hadjer Lamis	Massakory (29)	0.1 (0.0–0.2)	0.45 (0.09–0.83)	517	284
Hadjer Lamis	Massaguet (30)	0.4 (0.1–0.9)	0.19 (0.05–0.35)	180	0
Kanem	Mao-1 (31)	23.3 (19.0–29.4)	0.44 (0.11–0.84)	358	193
Kanem	Mao-2 (32)	16.2 (12.7–20.2)	0.23 (0.02–0.50)	173	21
Mandoul	Koumra (33)	3.5 (1.8–5.9)	0.87 (0.39–1.32)	1041	799
Mandoul	Goundi (34)	11.4 (8.6–15.0)	0.55 (0.31–0.95)	493	311
Mandoul	Moïssala (35)	9.8 (7.0–13.8)	0.69 (0.29–1.06)	828	585
Mandoul	Bédjondo (36)	0.0 (0.0–0.0)	0.20 (0.0–0.48)	120	0
Wadi Fira	Biltine (37)	6.9 (5.4–8.8)	1.30 (0.79–1.86)	1935	1634
Wadi Fira	Guéréda (38)	0.3 (0.0–0.6)	0.37 (0.11–0.74)	353	160
Wadi Fira	Iriba (39)	1.7 (0.8–2.9)	0.31 (0.09–0.60)	180	62
Hadjer Lamis	Bokoro-1 (40)	1.1 (0.2–2.4)	0.55 (0.11–1.19)	347	219
Hadjer Lamis	Bokoro-2 (41)	2.0 (0.5–4.8)	0.16 (0.03–0.34)	114	0
Total				19,004	10,562

[a]Adjusted for age in 1-year age bands (see text)
[b]Adjusted for gender and age in 5-year age bands (see text)
[c]Backlog calculated as prevalence × population × proportion of population aged ≥ 15 years (0.494)
[d]Number of cases needing management to reach WHO elimination threshold calculated as backlog – (0.002 × population aged ≥ 15 years)
CI, confidence interval

requirement. We report confidence intervals here, however, which facilitates objective assessment of the likely repeatability of our estimates. In future surveys in Chad, the sampling approach will be revised slightly to reflect the smaller-than-expected mean number of children encountered per household. Second, we recruited these marginally low numbers of examinees despite what was apparently an extraordinarily high enrolment rate: 99% of enumerated residents. We wonder whether field teams, fearing criticism for incomplete enrolment, may have failed to register absentees: anecdotally, this occurred in other constituent projects of the GTMP, but obtaining definitive proof was difficult.[20] Third, this survey work was commenced prior to the inclusion of examination for trachomatous conjunctival scarring (TS[4]) in standard GTMP protocols,[45] as later recommended by a global scientific meeting.[29] It is therefore likely that some of the trichiasis cases included in our prevalence estimates were due to conditions other than trachoma[28,29]; this may explain part of the association

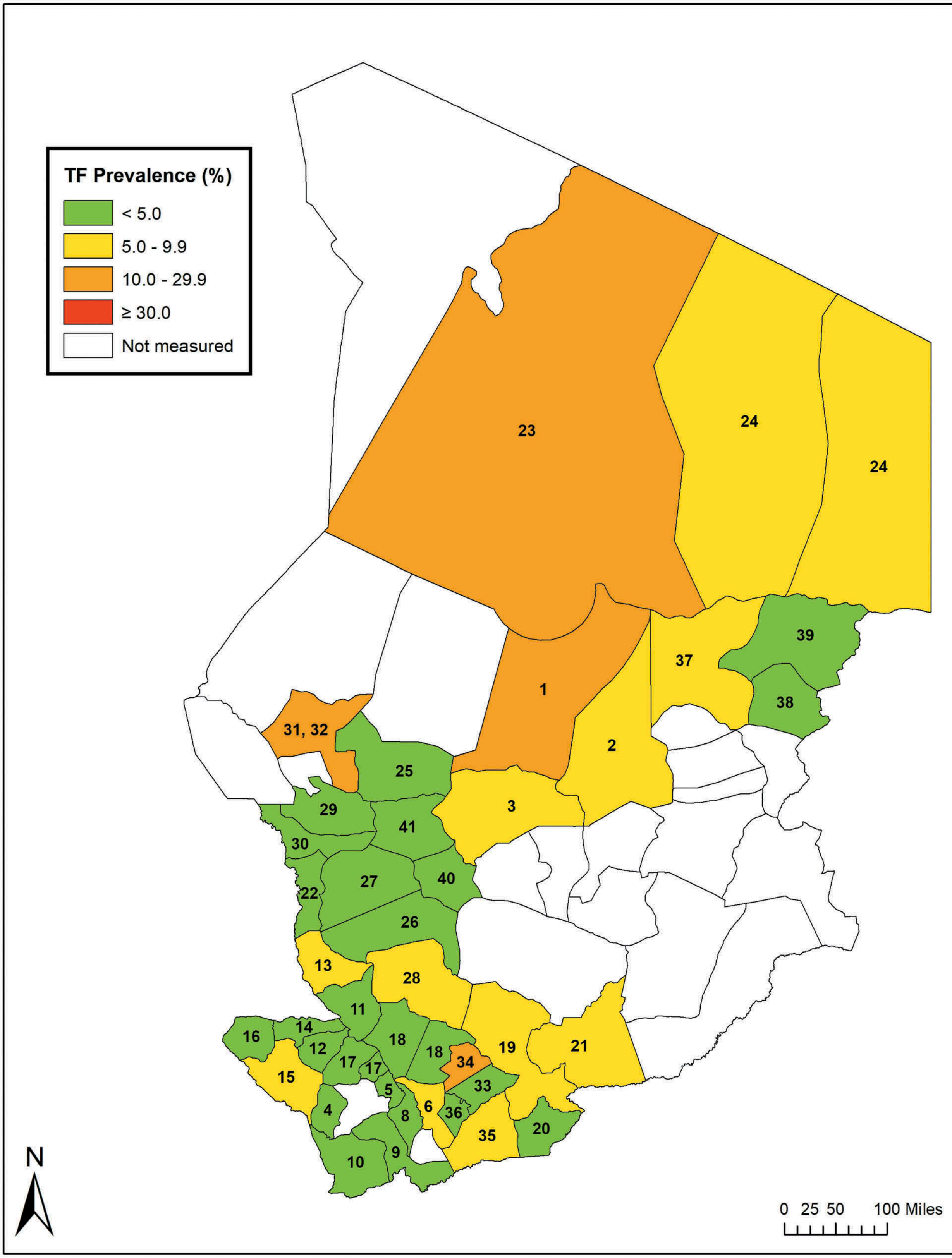

Figure 1. Prevalence of trachomatous inflammation—follicular (TF) in 1–9-year-olds, Global Trachoma Mapping Project, Chad, 2014–2015. Evaluation units are labelled with numbers; the key is found in Tables 2, 3 and 4.

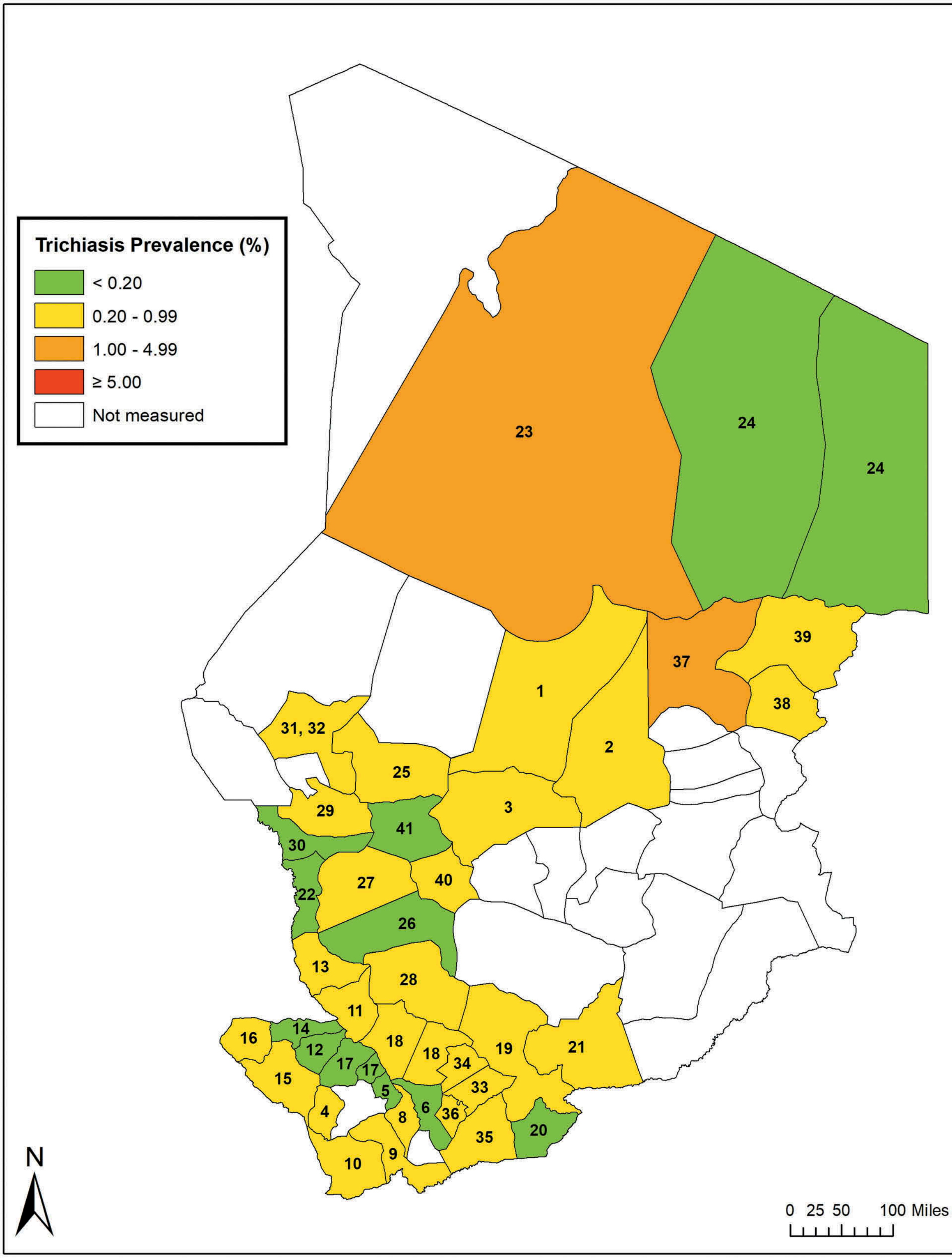

Figure 2. Prevalence of trichiasis in ≥ 15-year-olds, Global Trachoma Mapping Project, Chad, 2014–2015. Evaluation units are labelled with numbers; the key is found in Tables 2, 3 and 4.

Table 4. Prevalence of trichiasis in males and females aged ≥ 15 years, by evaluation unit, Global Trachoma Mapping Project, Chad, 2014–2015.

Region	Evaluation unit	Trichiasis prevalence in all ≥ 15-year-olds[a], % (95% CI)	Trichiasis prevalence in ♀ ≥ 15-year-olds[b], % (95% CI)	Trichiasis prevalence in ♂ ≥ 15-year-olds[b], % (95% CI)	Ratio of prevalence in ♀: prevalence in ♂s
Batha	Ati (1)	0.57 (0.25–0.98)	0.62 (0.17–1.24)	0.50 (0.0–1.19)	1.2
Batha	Oum Hadjer (2)	0.55 (0.25–0.96)	0.54 (0.17–1.13)	0.56 (0.09–1.30)	1.0
Batha	Yao (3)	0.30 (0.07–0.64)	0.57 (0.14–1.23)	0 (0.0–0.0)	NA
Logone Occidental	Laokassy (4)	0.29 (0.07–0.62)	0.33 (0.05–0.70)	0.25 (0.0–0.77)	1.3
Logone Occidental	Bénoye (5)	0.02 (0.0–0.05)	0.03 (0.0–0.10)	0 (0.0–0.0)	NA
Logone Oriental	Doba (6)	0.14 (0.0–0.38)	0.08 (0.0–0.24)	0.21 (0.0–0.63)	0.4
Logone Oriental	Béboto (7)	0.15 (0.04–0.30)	0.08 (0.0–0.19)	0.22 (0.0–0.54)	0.4
Logone Oriental	Bébédjia (8)	0.36 (0.10–0.64)	0.30 (0.06–0.52)	0.41 (0.0–1.04)	0.7
Logone Oriental	Goré (9)	0.72 (0.32–1.27	1.38 (0.62–2.42)	0 (0.0–0.0)	NA
Logone Oriental	Bessao (10)	0.92 (0.26–1.66)	1.02 (0.25–1.70)	0.81 (0.0–2.30)	1.6
Mayo Kebbi Est	Bongor (11)	0.34 (0.0–0.93)	0.65 (0.0–1.76)	0 (0.0–0.0)	NA
Mayo Kebbi Est	Gounou Gaya (12)	0.08 (0.0–0.20)	0.07 (0.0–0.17)	0.10 (0.0–0.29)	0.7
Mayo Kebbi Est	Guélengdeng (13)	0.59 0.23–1.09)	0.89 (0.33–1.67)	0.26 (0.0–0.69)	3.4
Mayo Kebbi Est	Fianga (14)	0.14 (0.0–0.33)	0.28 (0.0–0.62)	0 (0.0–0.0)	NA
Mayo Kebbi Ouest	Pala (15)	0.20 (0.07–0.36)	0.12 (0.0–0.28)	0.27 (0.05–0.59)	0.4
Mayo Kebbi Ouest	Léré (16)	0.47 (0.09–1.08)	0.70 (0.16–1.58)	0.21 (0.0–0.56)	3.3
Tandjilé	Béré & Kélo (17)	0.06 (0.0–0.16)	0.07 (0.0–0.20)	0.06 (0.0–0.17)	1.2
Tandjilé	Donomanga & Laï (18)	0.50 (0.17–0.94)	0.81 (0.22–1.63)	0.16 (0.0–0.43)	5.2
Moyen Chari	Sarh (19)	0.33 (0.13–0.51)	0.30 (0.13–0.54)	0.37 (0.0–0.69)	0.8
Moyen Chari	Danamadji (20)	0.17 (0.04–0.36)	0.15 (0.0–0.34)	0.18 (0.0–0.55)	0.8
Moyen Chari	Kyabé (21)	0.93 (0.44–1.49)	1.17 (0.61–1.63)	0.67 (0.0–1.53)	1.7
N'Djamena	Suburbs (22)	0.13 (0.0–0.31)	0.18 (0.0–0.47)	0.08 (0.0–0.20)	2.4
Borkou	Faya (23)	1.21 (0.31–2.01)	2.15 (0.55–3.63)	0.19 (0.0–0.37)	11.6
Ennédi (West & East)	Fada & Bahai (24)	0.18 (0.0–0.41)	0.27 (0.0–0.63)	0.09 (0.0–0.26)	3.2
Bahr El Gazel	Moussoro (25)	0.60 (0.15–1.25)	0.91 (0.15–2.16)	0.27 (0.0–0.53)	3.4
Chari Baguirmi	Massenya (26)	0.17 (0.04–0.32)	0.18 (0.0–0.42)	0.15 (0.0–0.40)	1.2
Chari Baguirmi	Dourbali (27)	0.52 (0.22–0.92)	0.68 (0.23–1.31)	0.35 (0.0–0.95)	1.9
Chari Baguirmi	Bousso (28)	0.39 (0.15–0.59)	0.41 (0.08–0.67)	0.36 (0.08–0.73)	1.2
Hadjer Lamis	Massakory (29)	0.45 (0.09–0.83)	0.55 (0.09–1.00)	0.35 (0.0–0.89)	1.6
Hadjer Lamis	Massaguet (30)	0.19 (0.05–0.35)	0.26 (0.03–0.58)	0.12 (0.0–0.25)	2.1
Kanem	Mao-1 (31)	0.44 (0.11–0.84)	0.51 (0.12–0.89)	0.37 (0.0–1.10)	1.4
Kanem	Mao-2 (32)	0.23 (0.02–0.50)	0.16 (0.0–0.39)	0.30 (0.0–0.77)	0.5
Mandoul	Koumra (33)	0.87 (0.39–1.32)	0.88 (0.28–1.57)	0.86 (0.14–1.58)	1.0
Mandoul	Goundi (34)	0.55 (0.31–0.95)	0.73 (0.32–1.34)	0.35 (0.09–0.68)	2.1
Mandoul	Moïssala (35)	0.69 (0.29–1.06)	0.83 (0.23–1.36)	0.54 (0.08–1.25)	1.6
Mandoul	Bédjondo (36)	0.20 (0.0–0.48)	0.30 (0.0–0.69)	0.08 (0.0–0.25)	3.6
Wadi Fira	Biltine (37)	1.30 (0.79–1.86)	1.64 (0.87–2.83)	0.90 (0.24–1.52)	1.8
Wadi Fira	Guéréda (38)	0.37 (0.11–0.74)	0.60 (0.18–1.23)	0.13 (0.0–0.38)	4.8
Wadi Fira	Iriba (39)	0.31 (0.09–0.60)	0.40 (0.09–0.88)	0.20 (0.0–0.54)	2.0
Hadjer Lamis	Bokoro-1 (40)	0.55 (0.11–1.19)	0.44 (0.16–0.83)	0.67 (0.0–1.76)	0.7
Hadjer Lamis	Bokoro-2 (41)	0.16 (0.03–0.34)	0.26 (0.0–0.61)	0.04 (0.0–0.13)	6.2

[a]Adjusted for gender and age in 5-year age bands (see text)
[b]Adjusted for age in 5-year age bands (see text)
CI, confidence interval; NA, not applicable

between the overall prevalence of trichiasis and the ratio of gender-specific prevalence estimates. We also did not ask about previous management of trichiasis, so the trichiasis prevalence estimates reported here include both cases known and unknown to the health system.[19] These refinements can be helpful in influencing whether or not public-health-level interventions are needed against trichiasis.[46] Fourth, as noted in the results section, three EU pairs were combined at the data cleaning stage; the main implication of this is that the resulting EU populations (like that for N'Djamena suburbs) are larger than the recommended 100,000–250,000 people.[19] Fifth, as also already noted, data from two EUs in Moundou, Logone Occidental Region, could not be approved due to missing GPS data; as a consequence, results from this EU are not included in the current report. Sixth, because household-level questions were not used as set out in the survey protocol, we are unable to report data on access to water and sanitation. Though unfortunate, as much as this situation reveals a weakness in one part of fieldwork execution, it also demonstrates strength in fieldwork supervision.

Subsequent to completing these surveys, in addition to expanding SAFE interventions, the Ministry of Health commenced planning to re-map Moundou as well as to undertake mapping in some of, but not all, the EUs in which surveys were not attempted in 2014–2015. Undertaking those surveys will contribute to the completion of nationwide mapping of suspected-trachoma-endemic areas of Chad, and help chart a course towards national elimination of trachoma as a public health problem.[47]

Disclosure Statement

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

Funding

This study was funded by the Global Trachoma Mapping Project (GTMP) 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 support health ministries to complete baseline trachoma mapping worldwide, and by the United States Agency for International Development (USAID) through the ENVISION project implemented by RTI International under cooperative agreement number AID-OAA-A-11-00048. The GTMP was also funded by USAID through the END in Asia project implemented by FHI360 under cooperative agreement number OAA-A-10-00051. A committee established in March 2012 to examine issues surrounding completion of global trachoma mapping was initially funded 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 a staff member of the World Health Organization. The authors alone are responsible for the views expressed in this article and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated. None of the funders had any role in project design, in project implementation or analysis or interpretation of data, in the decisions on where, how or when to publish in the peer reviewed press, or in preparation of the manuscript.

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Appendix

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Key: (1) Advisory Committee, (2) Information Technology, Geographical Information Systems, and Data Processing, (3) Epidemiological Support, (4) Ethiopia Pilot Team, (5) Master Grader Trainers, (6) Methodologies Working Group, (7) Prioritisation Working Group, (8) Proposal Development, Finances and Logistics, (9) Statistics and Data Analysis, (10) Tools Working Group, (11) Training Working Group.