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Achieving trachoma control in Ghana after implementing the SAFE strategy

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Summary The Ghana Health Service plans to eliminate blinding trachoma by 2010 and has implemented the SAFE strategy since 2001. The programme impact was assessed in all endemic districts. A two-stage, cluster random sample of 720 households was selected in each of 18 endemic districts in Upper West and Northern Regions. All eligible residents were examined for trachoma signs. Household environmental risk factors were assessed. In total, 74 225 persons from 12 679 households were examined. Prevalence of trachomatous inflammation-follicular in 1–9 year-old children was 0.84% (95% CI 0.63–1.05, range of point estimates by district 0.14–2.81%) and prevalence of trichiasis in adults aged ≥15 years was 0.31% (95% CI 0.24–0.38, range by district 0.00–1.07%). An estimated 4950 persons have trichiasis, of whom 72.6% are aged ≥60 years and 71.4% are women. Latrines were observed in 11.6% of households and 79.2% of interview respondents reported use of an improved water source. Active trachoma is no longer a public health problem in Ghana after successful implementation of the SAFE strategy. The programme should maintain health education, advocate for improved water and sanitation and focus on providing surgery. Surveillance activities are needed to ensure sustained control.

1. Introduction

Trachoma, a chronic keratoconjunctivitis caused by *Chlamydia trachomatis*, is the leading cause of infectious blindness worldwide and is considered to be responsible for 3.6% of all blindness in the world.[1,2] The WHO recommends

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a package of interventions to prevent blinding trachoma known by the acronym SAFE.[3] Surgery, the 'S' component, is used to correct trichiasis using a simple surgical procedure. Distribution of antibiotics, the 'A', is intended to treat trachoma eye infections and reduce the infectious reservoir thereby reducing transmission. Facial cleanliness and hand hygiene, the focus of the 'F' intervention, reduces trachoma transmission.[4] Activities of the 'E' component involve environmental improvements leading to improved access to water and sanitation. Water availability enables improved

Table 1 Baseline trachoma prevalence in Northern and Upper West Regions of Ghana and subsequent programme interventions by district as reported by the Ghana Health Service

District	% TF[a]	% TF/TI[a]	% TT[b]	Year of baseline survey	Intervention strategy
Category 1					
Savelugu/Nanton	—	9.7	4.3	2000	○ TT surgeries provided at clinics and through active TT case search and community surgery
Tolon/Kumbungu	—	12.4	8.4	2000	○ Annual MDA on a community-by-community basis with azithromycin, 2001—2003; district-wide MDA 2004—2007
West Gonja	—	11.7	3.7	2002	○ School-based trachoma health education, ongoing radio programming, training of health educators, environmental health officers, school teachers and volunteers; community and household education session
Sissala	—	11.5	5.9	2000	○ Promotion of latrine use, training masons to build latrines, provision of latrines in some communities and advocating for new water points
Wa	—	16.1	1.3	2000	
Category 2					
Bole/Salwa-Tuna-Kalba	8.2	—	1.8	2003	○ Decentralized trichiasis surgery referral programme and clinic-based surgery
Tamale Municipal[c]	5.7	6.1	2.3	2000	○ Annual MDA with azithromycin in endemic communities, 2004—2007
West Mamprusi	6.8	—	0.8	2003	○ School-based trachoma health education, ongoing radio programming, training of health educators, environmental health officers, school teachers and volunteers; community and household education session
Zabzugu/Tatale	6.7	—	0.4	2003	○ Promotion of latrine use and advocating for new water points
Jirapa/Lambussie	5.0	—	0.8	2003	
Category 3					
East Gonja	3.7	—	0.9	2003	○ Trichiasis surgery referral programme and clinic-based surgery
East Mamprusi	2.8	—	0.6	2003	
Gushiegu/Karaga	4.4	—	0.8	2003	○ Community-by-community assessment and annual MDA in trachoma-endemic communities, no distribution in non-endemic communities
Nanumba	3.8	—	0.5	2003	
Saboba/Chereponi	3.2	—	0.5	2003	○ School-based trachoma health education, ongoing radio programming, training of health educators, environmental health officers, school teachers and volunteers; community and household education session
Yendi	3.5	—	1.0	2003	
Lawra	2.8	—	0.7	2003	○ Promotion of latrine use and advocating for new water points
Nadowli	3.6	—	1.3	2003	

TF: trachomatous inflammation-follicular; TI: trachomatous inflammation intense; TT: trachomatous trichiasis; MDA: mass drug administration.

[a] Reported in children aged 1—9 years as assessed in Category 1 districts and in children aged 1—5 years as assessed in Category 2 and 3 districts.

[b] Reported in women aged ≥40 years in all categories.

[c] Interventions started community by community in 2001 as in Category 1.

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Table 2 Achievements in implementing SAFE activities in Northern and Upper West Regions of Ghana from 2001 to March 2008[a]

Indicators		Cumulative totals (2001–2008)
S	No. of people operated for trichiasis	4542
A	No. doses of azithromycin distributed	3 151 424
F	No. of villages with ongoing health education	1850
	No. of schools with ongoing health education	91
	No. of trainers trained for health education	1460
E	No. of household latrines built	12 507
	No. of water points constructed	2134

[a] As reported in Trachoma Control Programme Mid-term Review Report, 21 June 2008, Ghana Health Service presentation.

hygiene, and latrine use reduces the breeding material available for vector flies.[5,6]

Trachoma was first documented as a cause of blindness in the Northern Region of Ghana in 1959.[7] A small pilot project to control trachoma was first implemented in Upper West Region by the Ghana Health Service in 1995.[8] In 1998 the World Health Assembly called for the global elimination of blinding trachoma as a public health problem by the year 2020 (GET 2020) through resolution WA51.11.[9] After baseline trachoma prevalence surveys were completed in areas suspected to be endemic for the disease, the Ghana Health Service, with support from partners, initiated a programme to eliminate blinding trachoma in the Northern and Upper West Regions in 2000. SAFE activities were initially implemented in the five most endemic districts, and by 2004 all endemic communities in the 18 endemic districts had been identified and were receiving interventions. The National Trachoma Control Programme developed a 5-year strategic plan to guide trachoma control activities and set an ultimate goal to eliminate blinding trachoma by 2010. In 2006, according to a report from the Ghana Health Service, a prevalence survey in the Upper East Region confirmed that trachoma was not a public health problem there (Gyasi et al., personal communication).

Table 1 provides the baseline estimates of trachoma prevalence in the Northern and Upper West Regions and a summary of the subsequent interventions implemented. The districts are organized into three categories based on the prevalence of active trachoma in children in initial surveys and the intervention approach. Active trachoma prevalence in children was ≥10% in Category 1 districts. These districts received SAFE on a community basis between 2001 and 2003 and on a district-wide scale from 2004 to 2007. All communities considered endemic at baseline received SAFE interventions for at least 5 years. In Category 2 districts, estimates of active trachoma in children were between 5

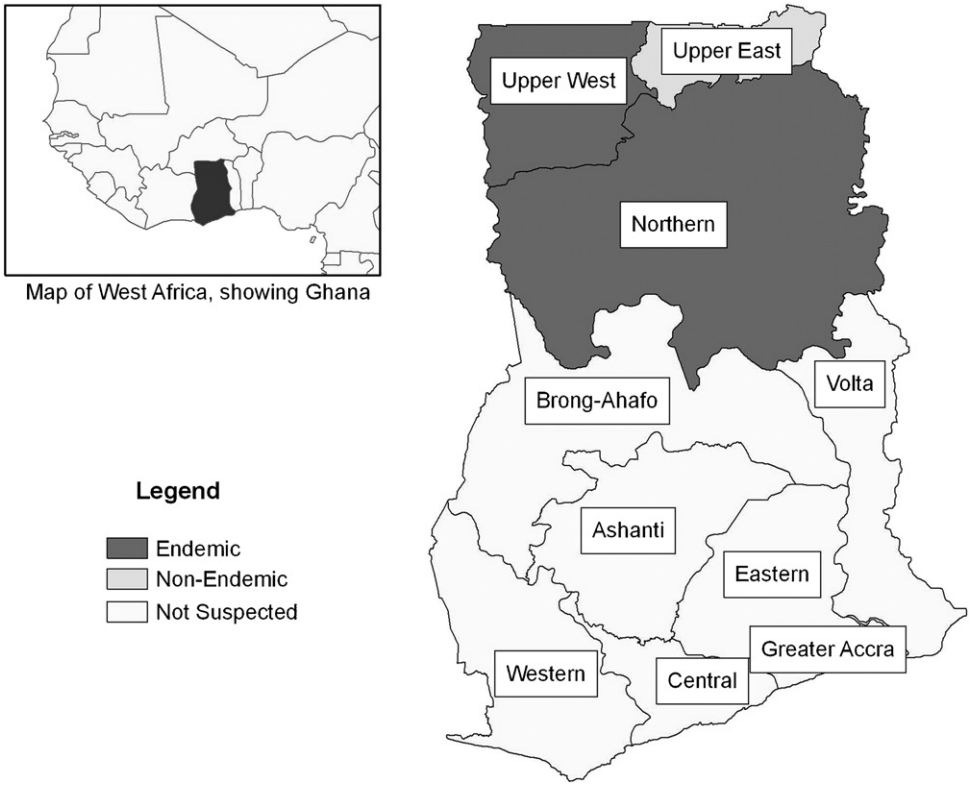

Figure 1 Trachoma-endemic regions of Ghana.

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and 9% and initially interventions were implemented on a community-by-community basis until 2004 when SAFE was implemented district-wide. In Category 3 districts, the baseline estimate of active trachoma in children was <5% overall and subsequent community surveys found a range of active trachoma of 0—53.3%. Interventions to control trachoma were implemented in communities with >5% active trachoma (314 of 551) and were never extended to the whole district. As of the first quarter 2008, all trachoma-endemic communities in the Northern and Upper West Regions had received at least 3 years of SAFE interventions.

Table 2 shows the cumulative achievements in implementing SAFE activities since the inception of the programme. The purpose of this study was to determine the prevalence of blinding trachoma in all districts after trachoma-endemic communities had received at least 3 years of SAFE interventions in accordance with WHO guidelines.[10]

2. Materials and methods

2.1. Sampling frame

The entire area of the two trachoma-endemic regions, Northern and Upper West (NR and UWR; Figure 1) was surveyed. At baseline in 2000 and 2003, there were 18 districts in the two regions. After 2003, some of these were split to create a total of 26 districts. From 2004, implementation of programme activity was based on the new districts. However, in this survey we aggregated the new districts back into the original 18 to allow a closer comparison with the baseline prevalence estimates and did not treat the new districts as separate domains. In the tables the current names of all districts merged together for sampling purposes are given for each domain (e.g. Bole/Salwa-Tuna-Kalba reflects the former district of Bole which is now split into Bole and Salwa-Tuna-Kalba). Each of the 18 districts was considered a separate domain utilizing multistage, cluster random sampling methodology to provide robust district level prevalence estimates of trachoma.

2.2. Sample size estimates

Assuming that actual prevalence of trachomatous inflammation-follicular (TF) in 1—9 year-olds is 3.0% and to provide at least an 80% chance (power) of correctly determining that the upper 95% CI of TF in this age group is <5.0%, an effective sample size of 343 children was needed for each district. The following additional assumptions were made: a mean household size of six persons; children aged 1—9 years comprise 28% of the population; approximately 15% non-response rate; and a design effect of 3.0 to allow for the complex survey design. The design effect chosen was based on a similar trachoma prevalence survey conducted previously. Due to logistical constraints in planning we selected 24 clusters of 30 households per domain, rather than a statistically preferred 30 clusters with fewer households. In each domain we estimated that a selection of 24 clusters of 30 households (a total of 720 households per domain) was likely to provide 1028 children aged 1—9 years, with a total sample size of 452 clusters and 12 960 households for the 18 domains in the two regions.

2.3. Sampling

In this study, we adhered to the WHO guidelines for assessing prevalence of active and blinding trachoma.[10] Surveys were conducted using each district as a separate domain and villages of <200 or >5000 people were excluded from the sampling frame. A cluster was defined as a village which was the primary implementation unit for trachoma control in most districts. In each selected cluster, the second stage involved random selection of 30 households, which were defined as either: a man, his wife or wives plus any dependents; a widow plus her dependents; or an elder brother or sister and their dependents if orphaned. Clusters were selected using probability proportional to size and a segmentation method that included all households was used to randomly select 30 households.[11] Selected households were not replaced if residents were absent or they declined to be examined.

2.4. Trachoma grading and standardization

Eighteen ophthalmic nurses experienced in conducting trachoma surveys were retrained in examination techniques, the use of the WHO simplified grading system for trachoma,[12] how to select households within a cluster and recording findings on standard forms. Training included a formal inter-observer reliability test of trachoma grading against a standardized set of 50 slides. It was not possible to conduct a reliability study among patients due to insufficient people with clinical signs of trachoma in the non-sample village selected for practical training.

2.5. Clinical survey and questionnaire

Ophthalmic nurses who scored >80% overall against the gold standard were assigned to survey areas where they had not been involved in delivering community interventions. In each selected household, only residents were enumerated. All available residents aged >6 months and for whom consent had been obtained were examined for trachoma in both eyes and the worst grade recorded. Prior to lid eversion, faces of children aged 1—9 years were observed for signs of ocular or nasal discharge. A clean face was defined as the absence of both ocular and nasal discharge. One follow-up visit was made to any household with missing residents on the day of the survey.

One female adult respondent was interviewed in each household to determine: presence and use of a household latrine; primary source of water; and the approximate distance to water source estimated by round-trip time of collection. The presence of a latrine was confirmed by direct observation and 'use' was defined as the presence of faeces within the pit. An improved source of water was defined as a covered borehole or well, hand pump or town supply. Participation in antibiotic distribution was assessed by showing each individual (or guardian) an azithromycin bottle and the distinctive pink tablets and asking whether the respondent

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had ever taken this drug for trachoma control, and if so, for how many annual rounds (years) they had taken it. During the separate interview, the respondent was shown the azithromycin bottle and tablet the asked if the household had ever received azithromycin, and if so, for how many years.

2.6. Data processing, presentation and analysis

The data was double-entered and compared using Microsoft Access (Microsoft Corp., Redmond, WA, USA). Discrepancies between data sets were identified and corrected. The variables collected included the community of residence, age, sex, reported years of azithromycin treatment, availability for examination, presence or absence of ocular and nasal discharge, and presence or absence of each individual trachoma grade.

Based on selection methods used, within each district we assumed that the probability of selection was equal and thus the data was self-weighted. Therefore the prevalence estimates presented are unadjusted. 95% confidence intervals for all estimates are adjusted to account for correlation among the data due to clustering through Taylor Expansion using SAS SURVEYFREQ procedures (SAS version 9.1; SAS Institute Inc., Cary, NC, USA).[13,14] Overall estimates are adjusted for the variation between districts. The number of unoperated trachomatous trichiasis (TT) patients was calculated as the sum of the district backlogs, where each district backlog was the product of the total population and the population prevalence of TT for that district.

2.7. Ethical issues

Verbal informed consent to participate in trachoma examination and household interview was obtained from heads of households, each individual or parents of minors according to the principles of the declaration of Helsinki. Participants diagnosed with active trachoma were offered treatment according to national guidelines. Trichiasis patients were referred for free eyelid surgery and their name and contact information was recorded for follow-up.

3. Results

3.1. Inter-observer reliability

Two examiners (number 15 and 18) did not qualify for inclusion as clinical graders and did not participate in the survey. Supplementary Table 1 shows the agreement scores for each examiner against each trachoma sign and their overall agreement, plus the κ statistic.[15]

3.2. Sample characteristics

A total of 79 951 residents in 12 670 households were enumerated, and 74 225 were examined giving a response rate of 92.8%. Children aged 1–9 years ($n = 27\,217$) comprised 36.7% of the examined population and adults aged $\geq$15 years ($n = 37\,964$) were 51.1%. Females ($n = 38\,482$) were 51.8% of the examined population. The gender and age distribution of the examined population did not differ statistically from the enumerated population. Of the 5726 people enumerated but not examined, 45.1% ($n = 2583$) were adult men. Five persons declined to participate and the remainder were not examined due to absence during the surveys.

Characteristics of the 12 679 surveyed households are listed in Supplementary Table 2. The overall mean household size was 6.3 (SEM 0.05) people, range by district 5.3–7.2. The overall estimate of household latrine ownership was 11.6% (95% CI 9.3–13.8%) with a range by district of 1.5–31.0%. An estimated 79.2% (95% CI 75.7–82.7%) of households reported an improved source of water, range by district 49.7–99.3%, with 72.6% (95% CI 69.1–76.2%) reporting a round trip for water collection of $\leq$30 min.

In Category 1 districts, 97.3% (95% CI 95.0–99.6%) of heads of household reported ever receiving antibiotics for trachoma and 73.3% (95% CI 66.0–80.6%) reported receiving antibiotics for 3 or more years. For individuals, 93.1% (95% CI 90.4–95.7%) reported ever taking antibiotics and 57.7% (95% CI 51.4–64.0%) reported taking at least three rounds. In Category 2 districts, 80.7% (95% CI 74.0–87.5%) of households reported ever receiving antibiotics for trachoma and 52.1% (95% CI 43.6–60.6%) reported receiving at least three rounds whilst individuals reported 77.4% (95% CI 70.9–83.9%) and 42.4% (95% CI 35.2–49.7%) respectively. Among Category 3 districts, 74.4% (95% CI 68.6–80.1%) of households reported ever receiving antibiotics and 40.22% (95% CI 34.12–46.22%) reported receiving at least three rounds whilst individuals reported 68.6% (95% CI 63.2–74.1%) and 31.4% (95% CI 26.4–36.5%) respectively.

3.3. Clinical findings

Prevalence estimates for the WHO recommended indicators of trachoma (TF in children aged 1–9 years and TT in adults aged $\geq$15 years) and other indicators of programmatic significance [trachomatous inflammation intense (TI) and clean face in children aged 1–9 years, and trachomatous corneal opacity (CO) in adults] are shown, by district, in Supplementary Table 3. The overall estimate of TF in children aged 1–9 years was 0.84% (95% CI 0.63–1.05%) with a range of point estimates by district of 0.14–2.87%. The prevalence of TI in children was 0.03% (95% CI 0.01–0.05), range by district 0.0–0.26%. The calculated design effect for TF in children aged 1–9 years was 2.87. The majority of children examined in these surveys had clean faces: overall estimate 84.9% (95% CI 83.6–86.3%), range by district 74.0–98.3%.

Figure 2 shows the prevalence estimates of TF or active trachoma (TF and/or TI) from baseline surveys conducted between 2000 and 2003 as reported by the Ghana Health Service alongside the prevalence of TF estimated in this survey.

Considering the entire sample, 118 persons presented with TT, giving an overall prevalence in all ages of 0.16% (95% CI 0.12–0.19%). Among adults aged $\geq$15 years, the overall prevalence of TT was 0.31% (95% CI 0.24–0.38%), range by district 0.0–1.07% (Supplementary Table 3). Women were twice as likely as men to have TT (odds ratio 2.3; 95% CI 1.8–3.4). The overall prevalence estimate of CO in adults

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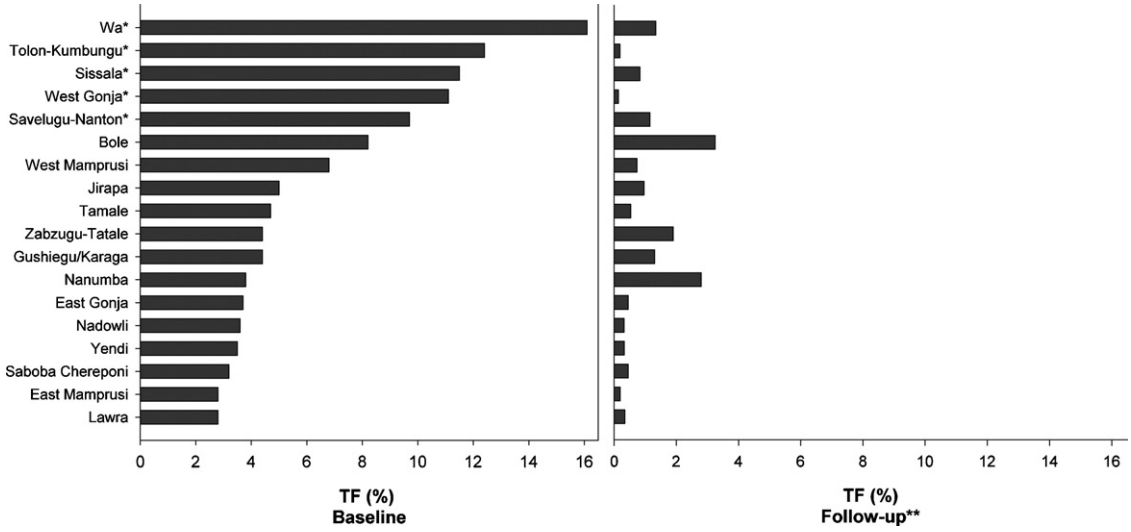

Figure 2 Prevalence of signs of active trachoma in children aged 1—5 years in all districts of the Northern and Upper West Regions of Ghana, 2003[a] and 2008. * Baseline data reported as trachomatous inflammation-follicular (TF) and/or trachomatous inflammation intense (TI) in children aged 1—9 years. ** 2008 active trachoma prevalence corresponds with the age group reported in baseline surveys.

[a] As reported by the Ghana Health Service in the following unpublished documents: Trachoma prevalence survey results: Northern and Upper West Regions 2000 and Trachoma prevalence survey in twelve districts in Northern and Upper West Regions 2003.

was 0.06% (95% CI 0.02—0.09%), range by district 0.0—0.39%. Supplementary Table 4 shows the estimated geographical distribution of the estimated backlog of unoperated TT cases by district. Using the district-specific prevalence estimates and confidence limits of TT in all ages, we estimated a total of 4950 cases of TT remain unoperated with a lower bound of 1139 cases and upper bound of 9090 cases. We did not collect specific information as to whether the TT cases had been approached for surgery or were recurrent cases. Figure 3 shows the estimated age and gender distribution of prevalent TT cases according to the age- and gender-specific rates of TT observed in this survey. An estimated 72.6% are people aged ≥60 years and 71.2% are women. The highest rate of TT (38 cases per 1000 population) occurred in women age ≥70 years.

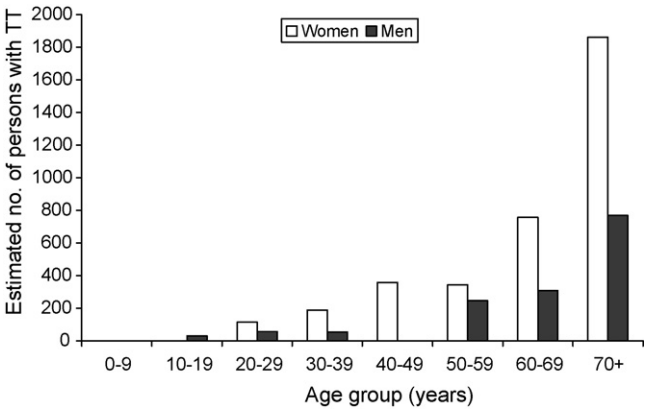

Figure 3 Estimated age and gender distribution of remaining trachomatous trichiasis (TT) cases in Northern and Upper West Regions of Ghana, 2008.

4. Discussion

The results of this survey demonstrate the success of a national programme in implementing the SAFE strategy to control blinding trachoma. Ghana has reached their ultimate intervention goal for the reduction of active trachoma (TF) in children aged 1—9 years to <5.0% in all 18 districts within the endemic regions and is justified in seeking entry to the phase of pre-certification of elimination of blinding trachoma. Under the current criteria for certification of elimination of blinding trachoma, it will be necessary to demonstrate that prevalence of active trachoma (TF) in children aged 1—9 years remains at <5% after interventions to control trachoma have ceased for 3 years.[16] An additional survey should therefore be scheduled for 2010—2011.

The target threshold for elimination of trichiasis is a prevalence of TT <0.1%, i.e. less than 1 case per 1000 persons. Current certification guidelines require that national programmes demonstrate the capacity of the health service to operate on presenting, recurring and incident TT cases in order to meet the elimination target. The population estimate for the endemic areas is projected at 2.93 million, so to reach the elimination threshold of 0.1% the estimated backlog of TT cases (4950) must drop by 2050 or more. In order to actively address the backlog, the programme will need to find and provide surgery for the elderly, particularly elderly women, and this has proved problematic in the past. A programme of active case detection and surgery would require support from the Ghana Health Service and its partners.

Despite the epidemiological rigour of this survey, it did not have the ability to independently confirm the examiners' findings. Advances in digital photography make photographs appealing, but photographing all 74 225 participants encountered by multiple independent teams would have doubled the time and budget required for this survey. In addition,

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reading the photographs would be daunting. In the future it may be possible to frame guidelines for the use of validation photography — whether to photograph all conjunctivae, a random subsample or a systematic sample of positives.

Laboratory testing for ocular *C. trachomatis* using nucleic acid amplification techniques has been suggested as a tool to monitor and evaluate trachoma control programmes and decide when infection has been eliminated.[17,18] However, there are no WHO guidelines for the use and interpretation of such tests, programmatic decision-making thresholds for these diagnostic indicators have not been determined and, currently, there is no standard reference laboratory established for quality control. Adding a well-trained team of swab collectors to the survey to collect a subsample of perhaps 100 swabs per district (1800 in total), and processing the samples would be practical, but the cost prohibitive without external support.

Presence and use of a latrine was confirmed by direct observation in the households, but access to 'improved water source' was not. Reported access to improved water may have been biased upwards by respondents reporting the presence of improved sources, without consideration of whether they were functional.

TI was an extremely rare finding in this survey with <20 cases from the entire sampled population. Compared with TF, TI is associated with a higher prevalence of ocular chlamydial infection and an increased quantity of chlamydial DNA.[19,20] TI is also associated with higher incidence of progression to scarring.[21,22] Assuming that all 15 qualifying examiners did not systematically under-grade TI, the extremely low prevalence suggests that ocular *C. trachomatis* infection is practically non-existent, and that the risk of cicatricial trachoma will probably be reduced.

The Ghana Health Service implemented several years of SAFE interventions (Tables 1 and 2). The most likely explanation for the reduction in trachoma prevalence is that the SAFE strategy was successful. However, there are other possible explanations besides the effect of the activities. At baseline the current guidelines for reporting active and blinding trachoma were under discussion concerning the most appropriate age group in which to report active trachoma. TF and/or TI among children aged 1—9 years was reported in the districts surveyed in 2000 and among children aged 1—5 years in 2003, whilst TT was reported for women aged ≥40 years. Full data sets from the baseline surveys have not continued to the present day, and we were unable to generate prevalence estimates for the baseline data using the current guidelines from the available tables.

The difference between the methods utilized in the baseline survey and the current were minimal. Baseline surveys in 2000 and 2003 were based on the WHO guidelines at the time, which included similar extensive training and validation of examiners using the WHO trachoma grading system, assessment of a large target sample size of 4000 persons per district from at least 20 clusters and selection of households within clusters through random, systematic sampling using household lists.[23]

A secular decline linked to other generalized improvements in access to water, sanitation, and health care as observed in The Gambia, Malawi and Nepal [24—26] is unlikely given the modest improvements of available water and sanitation in northern Ghana during this period.

Ghana has successfully implemented activities to eliminate trachoma in all endemic areas within the country and is thus a leading example in the WHO Global Alliance for the Elimination of Blinding Trachoma by the year 2020. Given the current prevalence of active trachoma, distribution of antibiotics is no longer necessary according to WHO guidelines, and the National Trachoma Control Programme should focus on sustaining health education and providing surgery for incident and remaining TT cases. To sustain the gains achieved, an ongoing strategy co-ordinated by the Ghana Health Service and Ministries of Local Government and Rural Development and Environment to promote hygiene and sanitation, such as an integrated school health curriculum, could be implemented. Whilst the National Trachoma Control Programme will continue to advocate for improvements in sanitation, other health and development initiatives must take the lead. The prevalence of trachoma should be re-evaluated in 3 years, but the process for entering the phase of pre-certification for the elimination of blinding trachoma should begin now. Surveillance activities are needed to monitor active trachoma in children with the capacity to identify any recrudescence above current thresholds and trigger appropriate response activities. Guidelines for designing and implementing such activities are needed. Completing these next steps will position Ghana to become the first sub-Saharan African nation to demonstrate that blinding trachoma can be eliminated through a multisectoral, collaborative partnership, supported by government, non-government and private partners.

Authors' contributions: All authors were involved in the survey design; DY, FA, SW, AA, JDK and OD supervised fieldwork; MOA performed all data management; JDK and MOA analyzed and interpreted data; PME supervised data analysis; DY, JDK and PME drafted the paper which all authors revised. All authors read and approved the final manuscript. MH is guarantor of the paper.

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Conflicts of interest: None declared.

Ethical approval: This study was an evaluation of the National Trachoma Control Programme and approved by the Health Research Unit of the Ghana Health Service. The

survey protocol (079-2006) received approval from the Institutional Review Board of Emory University, Atlanta, GA, USA. The Regional Director of Health Services in each region was responsible for the study whilst the Ophthalmologist in the region supervised the field activities.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.trstmh.2009.02.007.

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