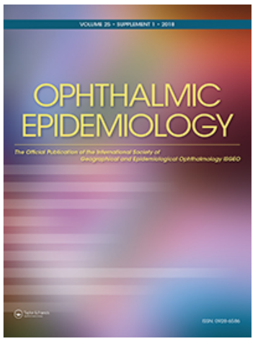

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Prevalence of and risk factors for trachoma in Kwara state, Nigeria: Results of eight population-based surveys from the Global Trachoma Mapping Project

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ABSTRACT

Purpose: To determine the prevalence of and risk factors for trachoma in selected local government areas (LGAs) of Kwara State, Nigeria.

Methodology: Population-based cross-sectional surveys were conducted in eight LGAs of Kwara State using Global Trachoma Mapping Project (GTMP) protocols. In each LGA, 25 villages were selected using probability-proportional-to-size sampling; 25 households were selected from each village using compact segment sampling. All residents of selected households aged ≥1 year were examined by GTMP-certified graders for trachomatous inflammation—follicular (TF) and trichiasis using the simplified trachoma grading scheme. Water, sanitation, and hygiene (WASH) data were also collected.

Results: A total of 28,506 residents were enumerated in 4769 households across the eight LGAs. TF prevalence in children aged 1–9 years ranged from 0.2% (95% CI 0.0–0.3%) to 1.3% (95% CI 0.7–2.1%), while trichiasis prevalence in persons ≥15 years was <0.2% in each LGA. Access to improved water source was the lowest in Edu (62%), while access to improved sanitation facilities was the lowest in Asa (6%) and the highest in Ilorin East (64%). Children aged 1–4 years had 0.63 (95% CI 0.40–0.99) times lower odds of having TF compared to children aged 5–9 years. Children in households with ≥5 resident 1–9-year-old children had 1.63 (95% CI 1.02–2.60) times greater odds of having TF compared to those in households with <5 resident children.

Conclusion: Trachoma is not a public health problem in Kwara State. Provision of adequate water and sanitation services should be a priority here, as a foundation for the health of the population.

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Global Trachoma Mapping Project; sanitation; trachoma; trichiasis; water

Introduction

Trachoma is the principal cause of blindness of infectious origin worldwide.[1] In Africa, where an estimated 171 million people are at risk,[2] trachoma remains a significant public health problem in many areas, but until recently the district-level prevalence data necessary to prompt commitment of resources for interventions were vastly incomplete.[3,4] The Global Trachoma Mapping Project (GTMP)[5] has now supported collection of those data for many more districts.

Infection of the conjunctival epithelium by particular strains[6,7] of the bacterium *Chlamydia trachomatis* stimulates a chronic inflammatory response, which may be sufficient for a diagnosis of the sign trachomatous inflammation—follicular (TF).[8] The principal reservoir of infection is in young children,[9] and this age group is therefore also most likely to have TF. Multiple infections with frequent or constant severe conjunctival inflammation[10–12] may lead to conjunctival scarring and in-turning of the eyelashes. When misdirected eyelashes touch the eyeball, trachomatous trichiasis[8] is present. In some individuals, this results in irreversible visual impairment. The prevalence of trichiasis increases with age.[13,14]

There is no effective vaccine against *C. trachomatis* infection.[15] The World Health Organization (WHO)

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*See Appendix.

supports the use of the SAFE (surgery, antibiotics, facial cleanliness, environmental improvement) strategy against trachoma.[16] To achieve elimination of trachoma as a public health problem,[17,18] community-based trichiasis surgical services should be offered wherever the prevalence of unmanaged trachomatous trichiasis in ≥15-year-olds is ≥0.2%, while the A, F, and E components of SAFE should be implemented wherever the prevalence of TF in 1–9-year-olds is ≥5%.

Nigeria is known to have a substantial burden of trachoma.[19–25] Kwara State, in the west of the country, had a population of 2.4 million in 2006, the year for which the most recent census data are available.[26] Kwara State had not been previously surveyed for trachoma, and it was not known whether interventions would be required here. The purposes of this study were to estimate the district (local government area, LGA)-level prevalence of TF in 1–9-year-olds and of trichiasis in ≥15-year-olds, and to determine the proportion of households with access to improved water and sanitation facilities, in Kwara State. This information was necessary to guide appropriate implementation of the SAFE strategy.[27] Eight LGAs thought to have the greatest trachoma risk (due to their location to the north of the state[24]) were prioritized for survey implementation; decisions on whether or not to proceed with surveys in other LGAs rested on trachoma prevalence in this group of eight.

Methods

Trachoma graders and data recorders were trained and certified according to the standard operating procedures of the GTMP.[28] Version 2 of the GTMP training system[29] was used. Grader trainees were required to pass both a slide-based test of diagnostic accuracy and a live subject-based inter-grader assessment test, while recorder trainees were required to pass an examination testing their data capture accuracy, as described previously.[28]

In each LGA, a separate population-based prevalence survey was conducted according to the same principles and using the same systems. Details of sample-size calculation have been reported elsewhere[28]; briefly, each survey was powered to estimate an expected TF prevalence in 1–9-year-olds of 10%, with an absolute precision of 3% and a design effect of 2.65, giving a desired minimum sample size of 1019.

Household selection

In each of the eight LGAs, 25 villages were selected using a systematic, probability-proportional-to-population-size methodology.[27] In selected villages, 25 households were selected using compact segment sampling.[30,31]

Data collection

All members of selected households aged ≥1 year were eligible to be included. Graders used ×2.5 magnifying loupes to examine both eyes of all consenting eligible individuals for trichiasis, TF, and trachomatous inflammation—intense (TI), defined according to the criteria of the WHO simplified grading system.[8] In accordance with a WHO global strategy,[32,33] collection of water, sanitation, and hygiene (WASH) data was integrated into the survey format, with household-level WASH data generated through interviews with household members and assessment of sanitation facilities. All data were entered into the LINKS-GTMP app running on Android smartphones, which also automatically collected global positioning system coordinates for each household.[28] Data were uploaded to a secure cloud-based server once the phones were within range of a suitable network.[28,34]

Data analysis

Village-level proportions of children with TF were adjusted for age in 1-year age bands using 2006 census data.[26] Village-level proportions of adults with trichiasis were adjusted for gender and age in 5-year age bands using 2006 census data.[26] LGA-level prevalence was calculated as the means of the adjusted village-level proportions. Confidence intervals (CIs) were determined by bootstrapping adjusted cluster-level proportions, with replacement, over 10,000 replications.

We defined water sources and sanitation facilities as "improved" using the criteria established by the WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation, as reported up to 2015.[35]

Univariable and multivariable risk factor analyses were conducted using R 3.3.3 (2017; R Foundation for Statistical Computing, Vienna, Austria). We used a multilevel hierarchical model to account for clustering of TF in 1–9-year-olds at the village level. Additional adjustment for clustering at the LGA level did not significantly improve the model (likelihood ratio test (LRT), p = 0.1901). Prior to conducting multivariable analyses, we used Mantel–Haenszel tests of association to examine collinearity between explanatory variables, but this was not an absolute exclusion criterion. Univariable associations found to be statistically significant were included in the multivariable model (LRT, p < 0.10). Age and gender were included in the multivariable model *a* *priori*, and a stepwise inclusion approach was used to retain further variables in the final model if found to be statistically significant (LRT, $p < 0.05$).

Ethical considerations

Ethical approval was provided by the National Health Research Ethics Committee of Nigeria (NHREC/01/01/2007) and the ethics committee of the London School of Hygiene & Tropical Medicine (reference 6319). Consent was obtained verbally and documented electronically. Consent for individuals aged <15 years was given by a parent or guardian. Subjects noted to have active trachoma were given a course of 1% topical tetracycline eye ointment,[36] and those with trichiasis were referred to the nearest certified[37] trichiasis surgeon.

Results

A total of 28,506 residents were enumerated in 4769 households across the eight LGAs, which are shown in Figure 1. In this population, 14,932 (52.4%) residents were female (Table 1). Graders examined

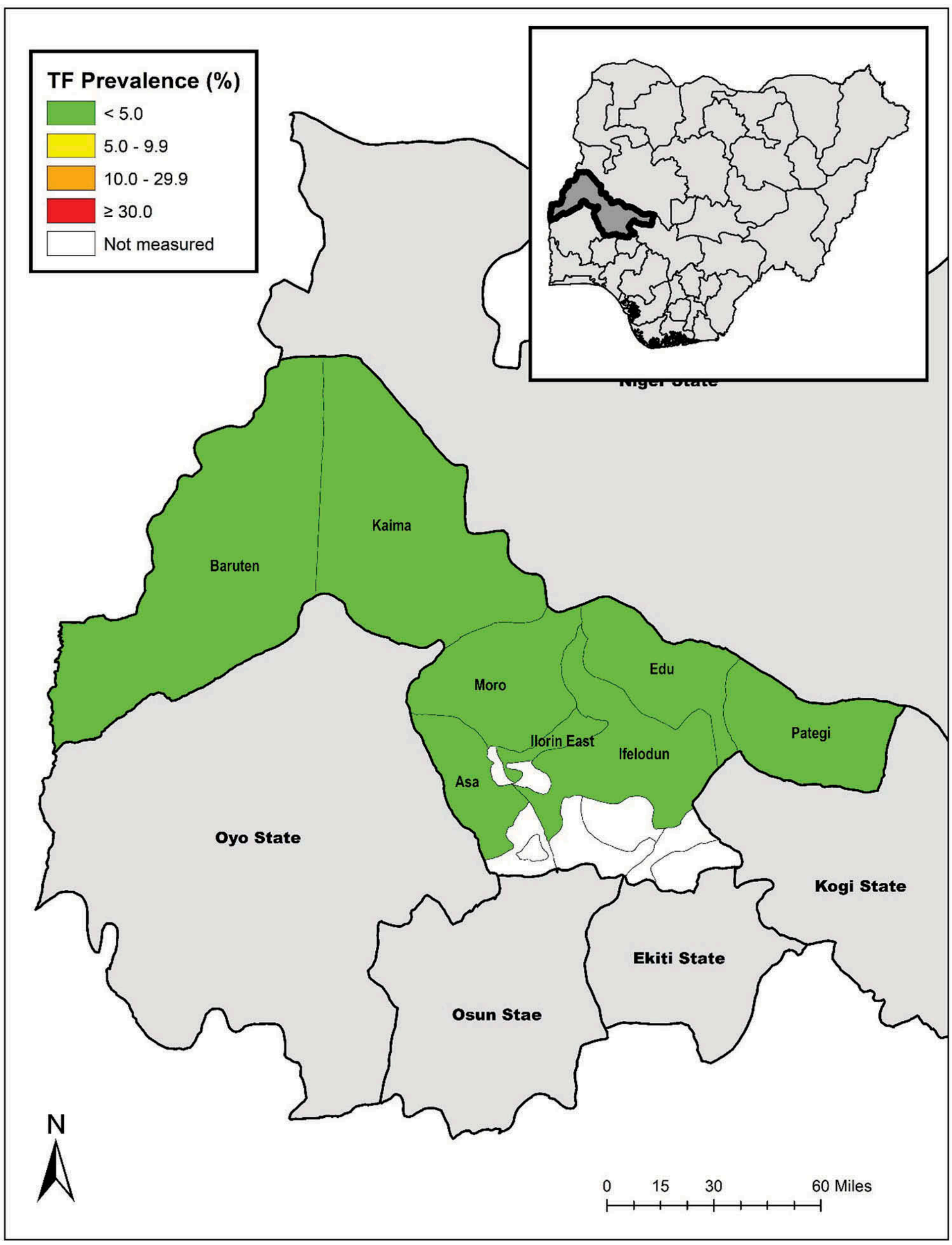

Figure 1. Local Government Areas (LGAs) surveyed, and prevalence of trachomatous inflammation—follicular (TF) in 1–9-year-olds, by LGA, Global Trachoma Mapping Project, Kwara State, Nigeria, June and July, 2014.

Table 1. Number of 1–9-year-old and number of ≥15-year-old resident, examined, absent, and refused; prevalence of trachomatous inflammation—follicular (TF); and prevalence of trichiasis; by Local Government Area (LGA), Global Trachoma Mapping Project, Kwara State, Nigeria, June and July, 2014.

		1–9-year-olds					≥15-year-olds				
LGA	Number of villages sampled	Resident	Examined	Absent	Refused	TF prevalence[a] (95% CI)	Resident	Examined	Absent	Refused	Trichiasis prevalence[b] (95% CI)
Asa	25	1546	1518	10	18	0.5 (0.1–0.9)	1489	1355	113	20	0.1 (0–0.2)
Baruten	25	1933	1892	16	24	0.9 (0.4–1.3)	1714	1593	88	33	0.2 (0–0.3)
Edu	25	1746	1732	2	12	0.2 (0–0.6)	1624	1428	173	23	0
Ifelodun	25	1513	1496	1	16	0.3 (0–0.7)	1432	1374	53	4	0.1 (0–0.2)
Ilorin East	25	1656	1631	10	15	0.7 (0.2–1.2)	1456	1317	124	15	0.1 (0–0.2)
Kaiama	25	1745	1728	6	11	1.3 (0.7–2.1)	1645	1521	105	19	0
Moro	25	1570	1543	16	11	0.3 (0.1–0.6)	1609	1580	25	4	0.1 (0–0.2)
Pategi	25	1903	1895	5	3	0.9 (0.5–1.3)	1470	1395	72	3	0 (0–0.1)
Totals	200	13612	13435	66	110	N/A	12439	11563	753	121	N/A

[a]Adjusted for age in 1-year age bands (see text)
[b]Adjusted for gender and age in 5-year age bands (see text)
CI, confidence interval; N/A, not applicable.

27,406 (96.1%) people in total; 859 (3.0%) people were absent for the examination and 238 (0.8%) people refused examination (Table 1). Of the examined individuals, 14,553 (53.1%) were female.

A total of 13,435 children aged 1–9 years were examined, of whom 6641 (49%) were female. The age-adjusted prevalence of TF in 1–9-year-olds ranged from 0.2% (95% CI 0.0–0.6%) in Edu to 1.3% (95% CI 0.7–2.1%) in Kaiama (Table 1, Figure 1).

A total of 11,563 individuals aged ≥15 years were examined. Of those, 6732 (58%) were female. The highest age- and gender-adjusted prevalence of trichiasis in ≥15-year-olds was 0.17% (95% CI 0.0–0.3%) in Baruten. No individual examined in Edu or Kaiama had trichiasis (Table 1).

In each LGA except Baruten, over 60% of households had access to an improved source of water for face-washing within a 30-minute round trip. Household access to improved sanitation ranged from 6% in Asa to 64% in Ilorin East (Table 2).

A histogram of TF prevalence by age in 1–9-year-olds is shown as Figure 2. For the risk factor analysis with TF as the outcome variable, categorizing age dichotomously (1–4 years v 5–9 years, LRT, p = 0.047) was a better fit for the data than using 1-year age groups (LRT, p = 0.096). We therefore categorized age as 1–4 years and 5–9 years. Results of the univariable analysis are shown in Table 3.

The full results of the multivariable analysis are shown in Table 4. Children aged 1–4 years had 0.63 (95% CI 0.40–0.99) times lower odds of having TF compared to children aged 5–9 years. Children in households with ≥5 children had 1.63 (95% CI 1.02–2.60) times greater odds of having TF compared to those in households with fewer than five children.

Table 2. Household-level access to water and sanitation, by Local Government Area (LGA), Global Trachoma Mapping Project, Kwara State, Nigeria, June and July, 2014.

LGA	Households, n	Improved washing water, n (%)	Washing water source (improved or unimproved) <1km, n (%)	Improved sanitation, n (%)
Asa	593	402 (68)	392 (66)	35 (6)
Baruten	613	392 (64)	365 (60)	86 (14)
Edu	615	379 (62)	522 (85)	204 (33)
Ifelodun	595	538 (90)	506 (85)	142 (24)
Ilorin East	592	535 (90)	500 (84)	378 (64)
Kaiama	599	436 (73)	378 (63)	90 (15)
Moro	581	479 (82)	366 (63)	67 (12)
Pategi	581	450 (77)	416 (72)	102 (18)

Discussion

Trachoma is not a public health problem in any LGA of Kwara State. The LGA-level TF prevalence in 1–9 year-olds was <5%, and the trichiasis prevalence in ≥15-year-olds was <0.2% in each LGA surveyed. That is good news for Kwara and its people. Kogi State, which borders Kwara to the east, also enjoys prevalence of trachoma below those felt to represent a public health problem,[38] reinforcing the impression that deployment of the SAFE strategy for trachoma elimination may be required in the northern half of Nigeria,[24,25,39–46] but not the southern half. Further trachoma mapping in Kwara State is not presently indicated.

Children aged 1–4 years examined as part of these surveys were less likely to have TF than those aged 5–9 years. The older age group includes those commencing primary school, where social interactions become more frequent, and therefore risk of ocular *C. trachomatis* infection from nonfamily members might be higher. However, this is pure speculation, and it is hard to understand why such hypothesized infections

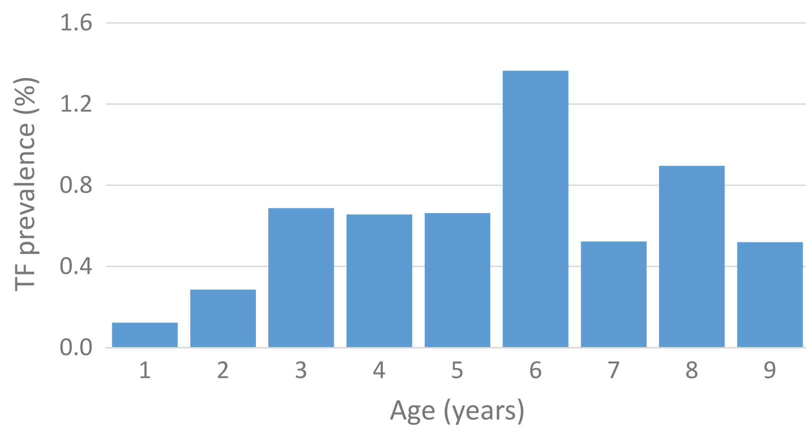

Figure 2. Prevalence of trachomatous inflammation—follicular (TF) by age among 1–9-year-olds, across eight surveyed Local Government Areas, Global Trachoma Mapping Project, Kwara State, Nigeria, June and July, 2014.

Table 3. Univariable analysis of risk factors for trachomatous inflammation—follicular in 1–9-year-olds, Global Trachoma Mapping Project, Kwara State, Nigeria, June and July, 2014.

Variable		Number of cases, N	Univariable OR[a] (95% CI)[b]	*p*-value[c]
Age, years				0.047
	1–4	28	0.6 (0.4–1.0)	-
	5–9	61	-	-
Sex				0.81
	Male	46	1	-
	Female	43	0.9 (0.6–1.4)	-
Children aged 1–9 years in household, n				0.050
	1–4	50	1	-
	≥5	39	1.6 (1.0–2.6)	-
Household sanitation facility				0.83
	Improved	19	1	-
	Unimproved	1	2.1 (0.2–18.1)	-
	Open defecation	69	1.0 (0.6–1.8)	-
Household access to sanitation facility				0.96
	Private	7	1	-
	Shared or public	14	1.1 (0.4–3.0)	-
	No structure	68	1.0 (0.4–2.4)	-
Household drinking water source				0.59
	Improved	64	1	-
	Unimproved	25	1.2 (0.7–2.0)	-
Household water source for face-washing				0.33
	Improved	63	1	-
	Unimproved	26	1.3 (0.8–2.2)	-
Time to main source of drinking water, minutes				0.60
	<30	59	1	-
	≥30	30	1.1 (0.7–1.9)	-
Time to main source of water used for face-washing, minutes				0.95
	<30	60	1	-
	≥30	29	1.0 (0.6–1.7)	-
Hand-washing facility within 15 m of sanitation facility				0.49
	Yes	12	0.8 (0.4–1.6)	-
	No	77	1	-
Water available at the hand-washing facility				0.73
	Yes	10	0.9 (0.4–1.8)	-
	No	79	1	-
Soap or ash available at the hand-washing facility				0.37
	Yes	6	1.6 (0.6–4.0)	-
	No	83	1	-
Altitude, m above sea level				0.43
	<250	42	1	-
	≥250	47	1.2 (0.7–2.0)	-

[a]Univariable random effects regression accounting for clustering at village level.
[b]Wald's 95% confidence interval
[c]Likelihood ratio test
OR, odds ratio; CI, confidence interval

Table 4. Multivariable analysis of risk factors related to trachomatous inflammation—follicular in 1–9-year-olds, Global Trachoma Mapping Project, Kwara State, Nigeria, June and July, 2014.

Variable		Number of cases, N	Multivariable OR[a] (95% CI)[b]	*p*-value[c]
Sex				0.81
	Male	46	1	-
	Female	43	0.95 (0.63–1.45)	-
Age, years				0.048
	1–4	28	0.63 (0.40–0.99)	-
	5–9	61	1	-
Children aged 1–9 years in household, n				0.043
	1–4	50	1	-
	≥5	39	1.63 (1.02–2.60)	-

[a]Multivariable random effects regression accounting for clustering at village level. Multivariable ORs are adjusted for sex, age, and number of children aged 1–9 years in household.
[b]Wald's 95% confidence interval
[c]Likelihood ratio test of inclusion/exclusion of variable in final model.
OR, odds ratio; CI, confidence interval

from classmates would not have been passed on to younger siblings. In any event, at TF prevalence as low as those recorded here, it is difficult to be certain that the follicular inflammation observed in the tarsal conjunctivae of any of our examinees was necessarily associated with *C. trachomatis* infection.[47–50] We did not carry out laboratory tests for *C. trachomatis*.[51] Previous analyses of survey data from Nigeria found no significant difference in the odds of TF in school-going versus nonschool children.[52]

In addition to the above limitation, we note that the work in Kwara State was implemented before the GTMP began to routinely collect data on the presence or absence of conjunctival scar in eyelids noted to have trichiasis; we are therefore unable to report whether the trichiasis we identified was likely to be due to trachoma or to be trichiasis of other etiologies.[53] In any case, the prevalence of all-trichiasis in adults was <0.2% in each LGA, so this omission does not affect our conclusion that elimination thresholds have been surpassed in this population. GTMP approaches are recognized to be of high epidemiological quality,[54,55] and to provide an advance over the more individualized survey designs[56] implemented prior to the inception of the GTMP.

While most households had access to water sources to facilitate hygiene practices like keeping faces clean, access to sanitation was poor. Recent evidence has highlighted the likely importance of full community coverage and use of sanitation facilities for the elimination of trachoma.[57,58] Until adequate sanitation services reach all communities, many will remain at risk for recrudescence of trachoma and for acquiring other infections that flourish in unsanitary environments. Greater efforts are needed here to accelerate progress on universal access to safe and sustainable water and sanitation.

Declaration of interest

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

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Appendix

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