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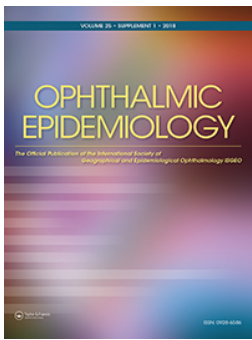
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Prevalence of Trachoma in Senegal: Results of Baseline Surveys in 17 Districts

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ABSTRACT

Purpose: Senegal is endemic for trachoma, an infectious and potentially blinding eye disease. To complete the country's district-level baseline map of trachoma, we conducted population-based surveys in 17 health districts that were suspected-endemic but had yet to be surveyed.

Methods: We randomly selected 30 clusters (villages) per district and 30 households per village, and estimated the district-level prevalences of trachomatous inflammation—follicular (TF) in children aged 1–9 years, and trichiasis in persons aged ≥15 years. Data on household-level water, sanitation, and hygiene variables were also collected. Global Trachoma Mapping Project methods were followed in training, fieldwork, and data handling.

Results: 25,704 children aged 1–9 years and 30,345 adults aged 15 years and above were examined. In children aged 1–9 years, the prevalence of TF was <5% in all 17 districts, with the exception of Saint-Louis (5.1%, 95% CI 3.2–7.5). Trichiasis prevalence in participants aged 15 years and above ranged by district from 0%–1.1% (95% CI 0.7–1.5), with 9 districts having trichiasis prevalences above the elimination threshold of 0.2%. Trichiasis was seen to be significantly less frequent in males than in females (0.17% [95% CI 0.12–0.24] versus 0.49% [95% CI 0.38–0.61], $p < 0.001$). The prevalence of trichiasis rose steeply with age; 62% of cases were observed in people aged 55 years or above.

Conclusions: Active trachoma is not a public health problem in 16 of the 17 surveyed districts, and implementation of the full Surgery (S) – Antibiotics (A) – Facial cleanliness (F) – Environmental improvement (E) strategy is not a programmatic priority. Increased provision of trichiasis surgery is warranted in nine districts.

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Introduction

Trachoma is a chronic keratoconjunctivitis caused by four serovars of *Chlamydia trachomatis*: A, B, Ba, and C.¹ Active trachoma, which is most commonly present in young children, is characterized by chronic, follicular conjunctivitis.^{2,3} Reinfection occurs in situations where individual and group hygiene are poor, and water and sanitation are lacking. Repeated infections result in conjunctival scarring causing entropion (in-turning of the eyelids) and trichiasis (eyelashes touching the eyeball). Corneal opacification resulting from mechanical trauma from in-turned lashes, a dry ocular surface and secondary infection, can ultimately lead to blindness.^{1,4}

Trachoma is responsible for a significant disease burden in low-income countries. Current estimates suggest that 200 million people are at risk of blindness

from trachoma, 1.9 million are already blind or severely visually impaired, and 3.2 million have trichiasis.^{5,6}

Efforts to eliminate trachoma as a public health problem, led by the World Health Organization (WHO) Alliance for the Global Elimination of Trachoma by 2020 (GET2020), rely on a multifaceted approach: SAFE (Surgery for trichiasis, Antibiotics to treat *C. trachomatis* infection, Facial cleanliness and Environmental improvement to reduce transmission). The thresholds for elimination of trachoma as a public health problem are a “trachomatous inflammation—follicular” (TF) prevalence <5% in children aged 1–9 years, and a “trachomatous trichiasis” (TT) prevalence unknown to the health system of <0.2% in adults aged 15 years and above.⁷ To plan interventions at baseline, to assess their impact, and to demonstrate achievement of elimination goals, reliable prevalence data at the district level are required.

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*See Appendix.

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In 1997, it was suggested that trachoma was the second-leading cause of blindness in Senegal, with nearly 25,000 people blind as a result of the disease⁸; its control has therefore been a major focus of the national blindness prevention policy. In line with GET2020, Senegal has set the goal of eliminating trachoma as a public health problem by 2020.⁹ In 2000, prevalence surveys were conducted in eight of the country's then-10 medical regions (i.e., Dakar, Diourbel, Fatick, Kaolack, Louga, Saint Louis, Tambacounda, and Thiès), to determine the prevalence of trachoma. Kolda and Ziguinchor regions were not included in that round of surveys, for security reasons. These surveys were not designed to provide data at the health district level.¹⁰

Four of the country's medical regions were subdivided in 2008, resulting in 14 regions overall and the formation of new health districts.¹¹ Between 2004 and

Table 1. District-level estimates of baseline trachoma prevalence in Senegal generated prior to 2014.

Region	District	Prevalence of trachomatous inflammation–follicular in children aged 1–9 years, %	Prevalence of trichiasis in those aged ≥15 years, % (women only, unless noted)	Year of survey
Diourbel	Diourbel	14.9	4.7	2010
	Mbacké	13.4	1.6	2010
	Touba	15.1	3.1	2011
Fatick	Dioffior	1.4	1.4	2011
	Fatick	1.3	2.0	2011
	Foundiougne	2.4	1.1	2013
	Gossas	11.7	3.3	2011
	Niakhar	4.4	1.7	2013
	Passy	5.4	1.4	2013
	Sokone	4.5	1.0	2011
Kaffrine	Birkélane	13.9	1.4	2010
	Kaffrine	13.9	1.4	2010
	Koungheul	11.5	2.1	2010
	Malem Hodar	11.7	2.9	2011
Kaolack	Guingineo	7.6	2.9	2011
	Kaolack	3.6	1.6	2011
	Ndoffane	12.9	2.5	2011
	Nioro	7.4	1.6	2010
Louga	Coki	9.8	2.3	2012
	Dahra	6.3	0.8	2011
	Darou	8.8	1.6	2008
	Mousty			
	Keur Momar Sarr	2.7	0.8	2012
	Linguère	2.8	0.3	2009
Thiès	Louga	5.1	1.6	2010
	Sakal	9.1	1.6	2010
	Joal	7.8	2.0	2004
	Khombole	11.6	3.6	2004
	Mbour	7.1	1.5	2005
	Mékhé	23.6	4.5	2004
Ziguinchor	Popenguine	6.2	1.9	2005
	Pout	4.8	2.1	2005
	Thiadiaye	6.7	5.2	2005
	Thiès	4.8	2.1	2004
	Tivaouane	28.7	4.5	2004
	Bignona	2.3	1.5 (women & men)	2010
	Diouloulou	2.9	1.1 (women & men)	2010
Thionk-Esyl	2.1	1.7 (women & men)	2010	

2013, district-level baseline surveys were completed in 37 districts (Table 1), using WHO-recommended methods and sampling 30 clusters per district.^{12,13} These surveys were conducted incrementally as funds became available, with priority given to zones that were expected to be at greater risk of trachoma based on the findings of the region-level prevalence surveys.

Based on these findings, and in line with WHO guidance then in effect,¹³ antibiotic mass drug administration (MDA) was progressively introduced from 2005–2014 in 17 of the 18 districts where baseline district (or sub-district) TF prevalence was ≥10% among children aged 1–9 years. The eighteenth district, a highly populous and urbanized area with a seasonally fluctuating population, was resurveyed in 2016 to better target MDA requirements,¹⁴ and initiated MDA in 2017. Facial cleanliness and environmental improvement measures have been implemented periodically in certain districts, but have not been consistently documented. Surgery for trichiasis was initiated in 2006 and has principally been conducted in regions that required MDA.

In order to complete the country's district-level baseline map of trachoma and determine the need for trachoma elimination interventions in those districts suspected to be endemic but not yet mapped, in 2014, we conducted surveys in 17 health districts in collaboration with the Global Trachoma Mapping Project (GTMP).¹⁵

Methods

Ethics statement

The surveys were led by the Ministry of Health and Social Work (MSAS)'s National Eye Health Promotion Program (PNPSO). Ethical clearance was obtained from the MSAS's Planning of Research and Statistics Directorate (Protocole SEN13/66 - N°044 MSAS/DPRS/DR, 21 January 2014), based on the review of the National Ethics Committee for Health Research; and from the ethics committee of the London School of Hygiene & Tropical Medicine (reference 6319).

In each village, the survey team paid a courtesy visit to the village head to explain the purpose of the survey. General information about trachoma was given prior to starting surveys. Verbal informed consent was given by the head of the household for children aged <15 years, and by participants themselves when aged 15 years or above. Consent for trachoma examination and interviews was documented by the field team on the electronic data form in the GTMP-LINKS application.¹⁵ Children found to have

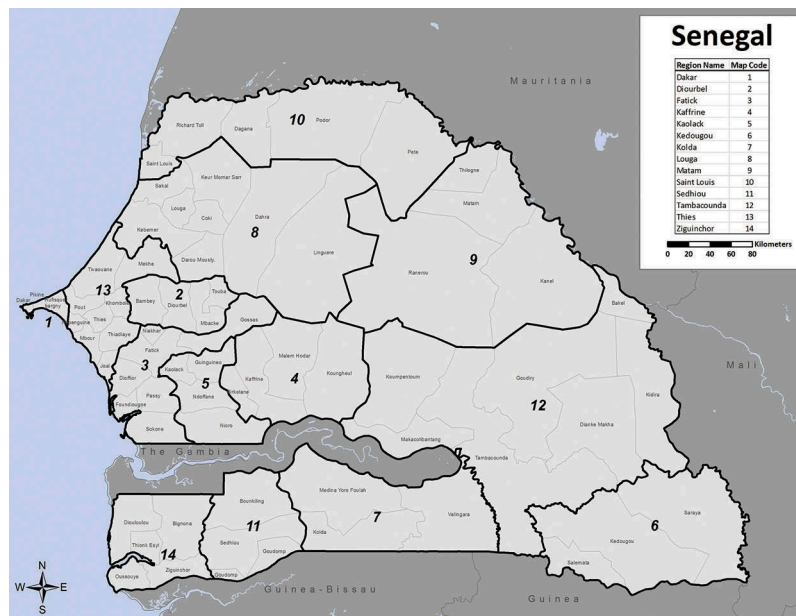


Figure 1. Map of Senegal, showing regions and districts, 2014.

TF were given tetracycline 1% ointment to apply twice daily for 6 weeks. Trichiasis cases were referred for surgery.

Evaluation units

Senegal is divided into 14 medical regions, which are further divided into 76 health districts (Figure 1). The 17 health districts mapped in 2014 were drawn from five medical regions. The two northern regions (Saint Louis and Matam) are bordered by Mauritania, and the three southern regions (Ziguinchor, Séhiou, Kolda)

are bordered by Gambia to the north and by Guinea-Bissau and/or Republic of Guinea to the south (Figure 2). The north is characterized by a hot desert climate, and the south by a tropical wet and dry climate.

All districts in Saint Louis, Matam, Séhiou, and Kolda were surveyed. In Ziguinchor Region, two districts were surveyed; the region's other three districts completed their surveys in 2010 (Table 1).

The population of the districts surveyed ranged from 50,944 to 303,659.

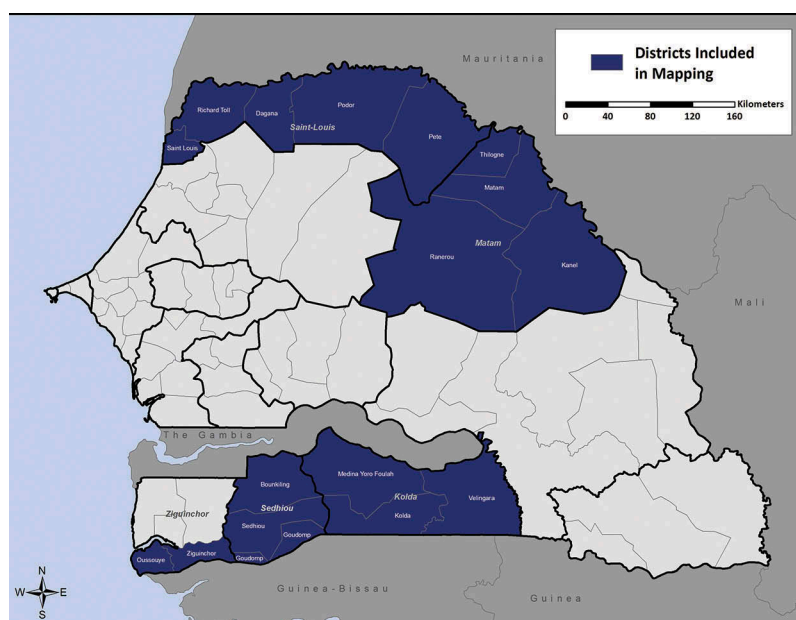


Figure 2. Map of Senegal, showing the 17 districts mapped for trachoma in 2014.

Survey design and sampling

Our work here consisted of a series of community-based cross-sectional surveys designed to assess district-level prevalence of TF in children aged 1–9 years, and trichiasis in adults aged 15 years and above. This involved examination of participants for clinical signs of trachoma using the WHO simplified trachoma grading system,¹⁶ recording each of TT, TF, and trachomatous inflammation-intense (TI) as absent or present; the other signs of the simplified system (trachomatous conjunctival scarring (TS) and corneal opacity (CO)) were not recorded.¹⁷ This was the first time that trachoma baseline surveys in Senegal consistently assessed both females and males for trichiasis; most previous surveys of trichiasis conducted in the country had included women only. Inclusion of males as well as females is in line with the WHO protocol,¹³ and is an important methodological consideration as it avoids the overestimation of prevalence in the overall population resulting from examining females only.¹⁸

A two-stage cluster random sampled design with probability proportional to size was used to select the sample in each district, as recommended by WHO.¹³ Thirty clusters (villages) per district were randomly selected in the first stage. The second-stage selection, witnessed by the head of each selected village, took place in the field. Thirty households per village were randomly drawn from a list of households provided by the village head.¹⁵ If the village had fewer than 30 households, the nearest village was also visited and random selection performed to complete 30 households.

As outlined elsewhere,¹⁵ the sample size for the survey was calculated to estimate with 95% confidence an expected 10% TF prevalence in children aged 1–9 years, with absolute precision of 3% and a design effect of 2.65. With inflation by a factor of 1.2 to allow for non-response, this gave rise to a sample size of 1,222 children in selected households per district, with the expectation that about 1,019 children would be examined.

Training

Eight ophthalmic clinical officers (*Technicien supérieur ophtalmologique* or TSO) working in the Senegalese health system (prospective trachoma graders), and five people with information technology backgrounds (prospective data recorders), underwent a 5-day training program led by a GTMP-certified master grader¹⁵ (Boubacar Sarr) and a GTMP-certified grader trainer¹⁵ (Mactar Sissoko), who also provided field supervision

during the survey. Version 2 of the training system was used.¹⁷ Prospective trachoma graders were trained on examination using the WHO simplified grading system and on standardized procedures for selection of households.¹⁷ A practical test was conducted in a non-survey cluster in Thiès district, with the help of children attending three traditional Koranic schools (*daraas*).

To participate in the survey, prospective trachoma graders had to achieve a kappa score of at least 0.8 in inter-grader agreement with the grader trainer, in identification of TF in children. Data recorders were trained to conduct household interviews and to capture data using Android smartphones (Motorola Atrix 2, Motorola Inc., Schaumburg, IL), and the LINKS application from the Task Force for Global Health, following the GTMP protocol. After training, 4 trachoma graders and 4 data recorders passed their respective tests and were selected to conduct the survey.

Household survey

Each village has a Health Post Head Nurse (*Infirmier Chef de Poste*) whose main responsibilities are to manage the health post (center) and to supervise all health-related activities at village level. Health Post Head Nurses were briefed about the surveys by the Health District Head Doctor (*Médecin-Chef de District*) prior to teams visiting the selected villages. They facilitated contact with the village heads and assisted the survey team in developing a calendar for visits, as well as designating one village resident to serve as a guide. There were four survey teams, each consisting of one grader, one data recorder, one driver, and one guide.

Upon arrival in the village and after meeting with the village head, consent was obtained from the household head of each selected household. Global positioning system (GPS) data were collected at each household. All eligible participants were examined for trachoma signs using a 2.5× magnifying binocular loupe and a torch (flashlight) or sunlight. Household interview questions included, inter alia, the source of drinking water, time needed to fetch water, main source of water for face washing, defecation habits, and sanitation facilities. Some information was collected by direct observation, as described elsewhere.¹⁵

Data management and analysis

Field data collection was performed using the LINKS app on Android smartphones. Data forms were uploaded each day using 256-bit SSL encryption to the GTMP secure server, housed on the Amazon

Elastic Compute Cloud.¹⁹ Prevalences were calculated with gender- and age-adjustment using R 3.0.2 (The R Foundation for Statistical Computing, Vienna, Austria) and Structured Query Language, as described elsewhere,¹⁵ using 2013 Senegal census data as the reference population set.²⁰ The district-level adjusted prevalence was determined by mean of adjusted cluster-level proportions of children with TF. The same method was used to calculate the district-level adjusted trichiasis prevalence, but with adjustment for both gender and age in 5-year age groups. Confidence intervals around prevalence estimates were calculated by bootstrapping the cluster means over 10,000 iterations and taking the 2.5th and 97.5th centiles of all ordered results.

Prevalence was calculated for trichiasis, which can be due to multiple causes,²¹ rather than for TT, because the presence or absence of TS was not recorded in eyes with trichiasis; consensus for recording TS was established after these surveys were conducted.²²

Risk factors associated with active trachoma were investigated using STATA 14 (StataCorp, College Station, TX). Variables were examined in univariate analyses as well as through multiple regression. Risk factor means were generated without sample weights, and standard errors were adjusted for clustering using Taylor linearization.

Results

Study population

Between March and October 2014, a total of 71,493 (25,704 children aged 1–9 years, 36,633 adults aged 15 years and above) individuals were enumerated and 63,716 (25,144 children aged 1–9 years, 30,345 adults aged 15 years and above) were examined for trachoma (response rate of 89.1%) in the 17 districts. Of the 7,777 people not examined, 98.7% were absent and 59.0% were male aged 15 years and above. The mean age of participants included in the study was 21.1 years (sd = 19.8); 54.7% were female (Table 2).

Prevalence of TF and trichiasis, and risk factors

Table 3 summarizes the prevalence of TF and trichiasis in each district. All districts had a TF prevalence below 5% with the exception of Saint-Louis (5.1%, 95% CI 3.2–7.5) (Figure 3). Among children aged 1–9 years sampled, the proportion of males with TF was not significantly higher than that of females (2.9% [375/12,554] versus 2.6% [334/12,441], $p = 0.17$) (Figure 5). The prevalence of trichiasis in individuals aged 15 years

and above ranged by district from 0% to 1.1% (95% CI 0.7–1.5) (Figure 4). We identified no cases of trichiasis in three districts (Matam, Ranérou, Pété). Of the 203 cases identified in the other 11 districts, the proportion of males with trichiasis was significantly lower than that of females (0.3% [58/15,125] versus 0.7% [145/21,305], $p < 0.001$). This difference between prevalence of trichiasis in male and female adults remained significant after adjusting both estimates for age (0.17% [95% CI 0.12–0.24] versus 0.49% [95% CI 0.38–0.61], $p < 0.001$). The prevalence of trichiasis rose steeply with age; 62% of cases were in people aged 55 years or above (Figure 6).

Household-level access to improved water source for face washing ranged by district from 16.6% to 87.0% (Table 2). “Improved” sources of water included piped water into dwelling; piped water to yard/plot; public tap or standpipe; tubewell or borehole; protected dug well; protected spring; and rainwater.^{17,23} Respondents from nearly half the households (47.5%) reported using an unprotected dug well as the main source of water for washing faces. Household-level access to improved latrines ranged by district from 7.3% to 93.1% (Table 2). “Improved” sanitation included flush toilet; piped sewer system; septic tank; flush/pour flush to pit latrine; ventilated improved pit latrine (VIP); pit latrine with slab; composting toilet; and flush/pour flush to unknown place.^{17,23} 67.0% of respondents reported having a round trip to collect water of less than 30 minutes (Table 2). It should be noted that within a given household, responses about availability and use of latrines could be provided by several different respondents.

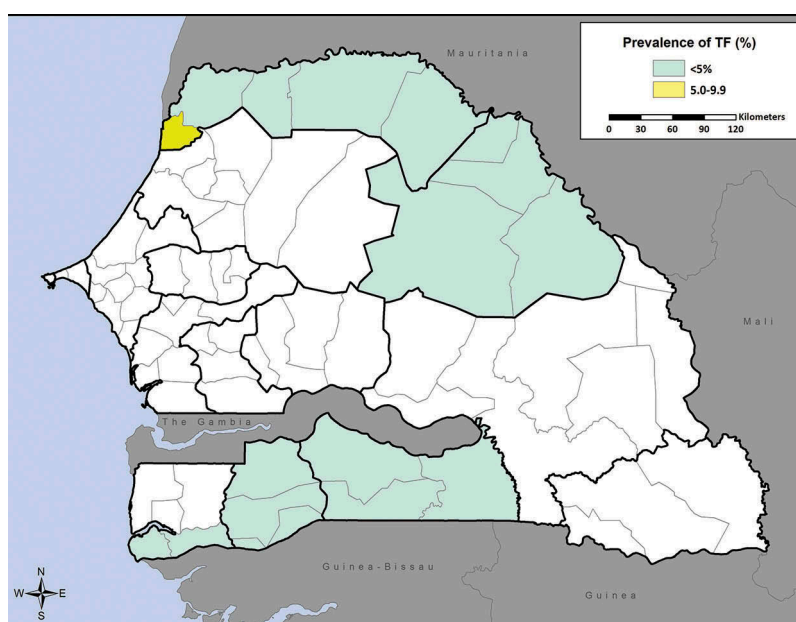
Univariate analysis identified water retrieval time as the only risk factor among those investigated to have a significant ($p \leq 0.05$) relationship to TF in children aged 1–9 years. Specifically, a round-trip of less than 30 minutes to collect water for face washing was associated with lower odds of TF (OR 0.54, 95% CI 0.4–0.7, $p < 0.001$). No significant relationship was observed between TF and self-reported location of defecation by adults aged 15 years and above (using latrines vs. no structure) (OR 1.11, 95% CI 0.8–1.5, $p = 0.504$), having an improved latrine type in the household (OR 1.05, 95% CI 0.8–1.4, $p = 0.723$), or having an improved water source for face washing (OR 1.27, 95% CI 0.98–1.64, $p = 0.065$). Similarly, no significant relationship was found between TF and having a functional handwashing station nearby, specified as one with soap and water within 15 meters (OR 1.67, 95% CI 0.96–2.89, $p = 0.068$).

Table 2. Characteristics of the surveyed population by district, Senegal, 2014.

Region	District	Estimated population	No of clusters surveyed	No of children (1–9 years) enumerated	Participants				Proportion of households (%)			
					Participation rate (%)	Proportion of females (%)	No of adults (≥15 years) enumerated	Participation rate (%)	Proportion of females (%)	Improved water source	Time to collect water <30min	Improved latrine
Kolda	Kolda	259034	30	1656	99	49.2	2122	88.4	56.5	24.1	76.8	52.7
	Médina Yoro Foulah	146058	30	1662	98.4	48.3	2002	88.1	55.1	28.4	72.5	64
Matam	Vélingara	295265	30	1479	97.7	48.2	1999	86.9	57.1	37	71.8	51.5
	Kanel	257330	30	1444	97.1	50.6	2344	81.4	59.1	78.1	59.9	72.5
	Matam	202503	30	1545	95.6	50.6	2028	74.8	57.7	49.2	52.9	43.6
	Ranérrou	53985	30	1564	96.4	52.6	2262	76.9	57.7	65.2	54	64.6
	Thilogne	82710	30	1650	95.5	51.8	1933	72	56.2	32.1	43.8	7.3
Saint-Louis	Dagana	106332	30	1371	99.1	50.9	2204	81.6	57.7	70.6	51.3	63
	Pété	158652	30	1610	98.1	50.4	2205	83.2	60.8	87	45.2	60.1
Sédhiou	Podor	279992	30	1579	97	51.5	2318	83.9	60.7	67.9	52.5	71.2
	Richard Toll	166428	30	1407	99	49.6	2263	80.9	57.5	85.7	70	79
	Saint-Louis	303659	30	1371	98.6	49.4	2185	80.8	60.5	74.2	79.3	93.1
	Boukling	152772	30	1596	98.9	47.2	1894	88.4	61.8	19.7	83.9	67.3
Ziguinchor	Goudomp	166757	30	1678	98.9	47.4	1979	87.4	61.7	19.7	84.8	51.1
	Sédhiou	159288	30	1653	98.5	49.5	2003	88.2	62	16.6	86	50
Ziguinchor	Oussouye	50944	30	1170	97.2	49.6	2446	81.6	56.6	49.3	78.8	72.8
	Ziguinchor	261689	30	1269	98.1	48.2	2446	84.7	57.1	35.2	75.2	91.1

Table 3. Prevalence of trichomatous inflammation–follicular (TF) and trichiasis by district, Senegal, 2014.

Region	District	No of children (1–9 years) examined	TF % (95% CI)	No of adults (≥15 years) examined	Trichiasis % (95% CI) [population ≥15 years]
Kolda	Kolda	1639	3.8 (1.7–6.1)	1876	0.6 (0.3–1.0)
	Médina Yoro Foulah	1636	3.6 (2.0–5.0)	1763	0.2 (0.1–0.4)
Matam	Vélingara	1445	4.0 (2.2–6.0)	1737	0.4 (0.1–0.8)
	Kanel	1477	2.1 (1.2–3.1)	1516	0.1 (0.0–0.3)
	Matam	1507	3.6 (2.2–5.0)	1740	0.0 (0.0–0.0)
	Ranérou	1576	1.9 (1.1–2.8)	1392	0.0 (0.0–0.1)
	Thilogne	1402	3.6 (2.2–5.1)	1907	0.1 (0.0–0.2)
Saint-Louis	Dagana	1358	1.9 (0.9–3.0)	1799	0.1 (0.0–0.1)
	Pété	1579	1.9 (1.0–3.1)	1834	0.0 (0.0–0.0)
	Podor	1531	1.7 (1.0–2.6)	1944	0.1 (0.0–0.1)
	Richard Toll	1393	3.7 (2.3–5.1)	1831	0.1 (0.0–0.2)
Sédhiou	Saint-Louis	1352	5.1 (3.2–7.5)	1766	0.4 (0.1–0.6)
	Boukiling	1579	2.5 (1.1–4.2)	1675	0.7 (0.4–1.1)
	Goudomp	1660	2.7 (1.7–3.8)	1729	1.0 (0.6–1.4)
Ziguinchor	Sédhiou	1628	1.8 (1.0–2.9)	1767	1.1 (0.7–1.5)
	Oussouye	1137	1.4 (0.6–2.0)	1997	0.2 (0.1–0.3)
	Ziguinchor	1245	3.0 (1.8–4.3)	2072	0.6 (0.2–1.0)

**Figure 3.** Prevalence of trichomatous inflammation–follicular (TF) in the 17 districts mapped for trachoma, Senegal, 2014.

The relationship between water retrieval time and TF remained significant when considered in multivariate analysis alongside the other risk factor covariates mentioned in the above paragraph (OR 0.50, 95% CI 0.4–0.7, $p < 0.001$). As in the univariate analysis, none of the other risk factors showed relationships to TF prevalence, though the low prevalence of TF detected in this survey makes the analysis of risk factors more difficult.

When analyses included TF in all age groups, similar results were found, showing a significant, negative relationship between a round-trip of less than 30 minutes to collect water for face washing and TF prevalence (OR 0.53, 95% CI 0.4–0.7,

$p < 0.001$). No other investigated risk factor was found to have a significant relationship with TF.

Discussion

Obtaining prevalence data at the district level is a prerequisite for planning and implementing coherent and efficient interventions for trachoma elimination. The present study, which used methods recommended by WHO for sampling of populations and examination for trachoma, was designed to determine trachoma prevalence in 17 districts in Senegal which had had no prior district-level trachoma surveys.

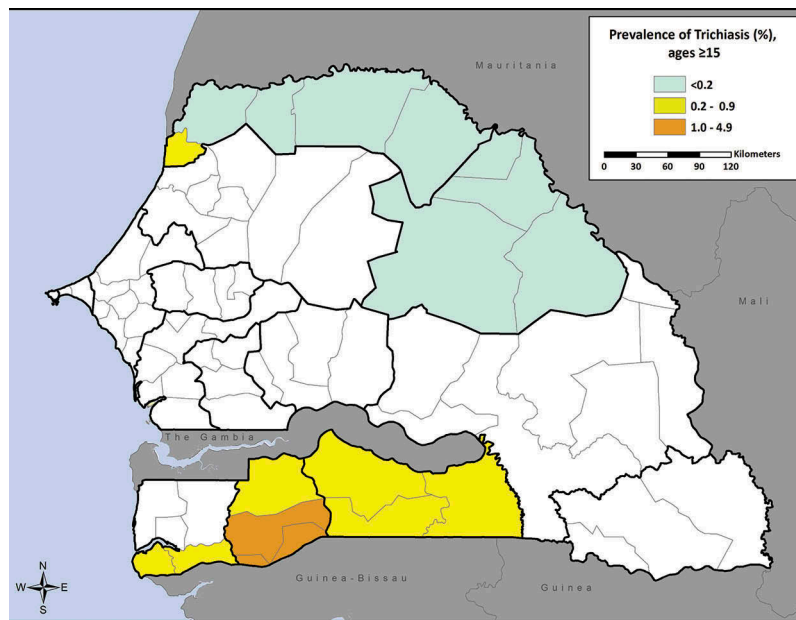


Figure 4. Prevalence of trichiasis in the 17 districts mapped for trachoma, Senegal, 2014.

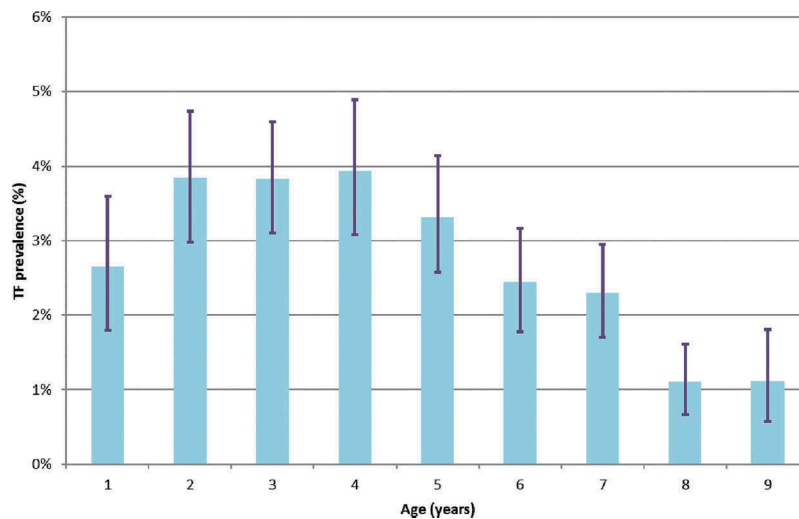


Figure 5. Trichomatous inflammation–follicular (TF) prevalence by age amongst children aged 1–9 years across 17 surveyed districts, Senegal, 2014. Whiskers indicate 95% confidence intervals.

Active trachoma

Based on TF prevalence estimates, implementation of the full SAFE strategy is not warranted in 16 of the 17 districts surveyed. In Saint Louis district, which registered a TF prevalence of 5.1%, a one-year implementation of the SAFE strategy's A, F, and E components, followed by an impact survey, could be considered.²⁴ These prevalences, which are generally lower than those for other districts of Senegal presented in Table 1, are in line with expectations of risk based on the earlier region-level prevalence surveys.

Trichiasis

According to WHO guidelines, TT prevalence $\geq 0.2\%$ in persons aged 15 years or above constitutes a public health problem: the TT threshold for elimination is a TT prevalence of <1 case per 1,000 total population, with an assumption that 50% of the population is aged 15 years or above.^{25,26} Our results show that trichiasis is a public health problem in 9 of the sampled districts (i.e., Kolda, Médina Yoro Foulah, Vélingara, Saint Louis, Bounkiling, Goudomp, Sédhiou, Oussouye, and Ziguinchor); consequently, increased provision of surgical interventions for trichiasis is required in these districts. The prevalences

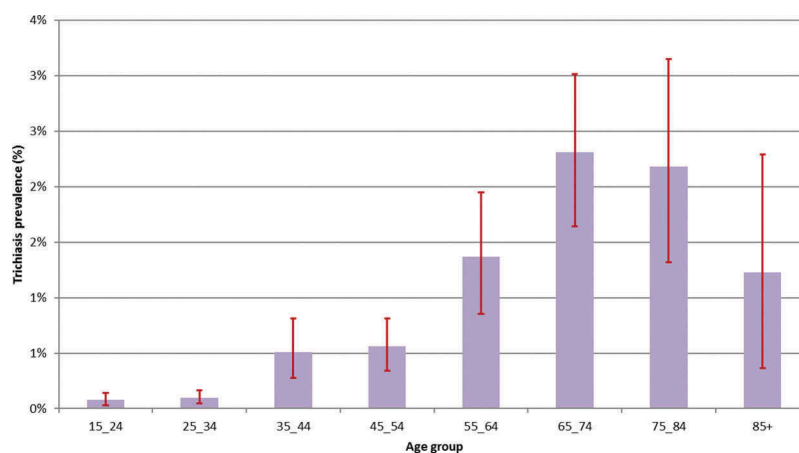


Figure 6. Trichiasis prevalence by age amongst individuals aged ≥ 15 years across 17 surveyed districts, Senegal, 2014. Whiskers indicate 95% confidence intervals.

recorded are generally lower than those presented in Table 1, a result which is in line with expectations of risk based on the earlier region-level prevalence surveys. The inability to distinguish between TT and trichiasis not caused by trachoma was a limitation to our surveys; it is possible that the actual prevalence of TT was lower than surveyed.

The observation, in certain districts, of a high trichiasis prevalence and low TF prevalence likely reflects higher endemicity of active trachoma several decades prior to these surveys. If active trachoma has since become rare, this is likely due to improvement in living conditions, as evidenced by the relatively good access to water and availability of latrines that we demonstrated (Table 2). The finding that trichiasis prevalence was higher among females than males adds weight to the observation made in other contexts that women are more likely to have trichiasis than men, perhaps as a result of their increased contact with young children.¹⁸ However, with nearly 17% (5,417/32,392) of adult males absent compared to 5.8% of adult females (2,257/39,101), caution must be applied, as these absences among males could bias upward the estimated prevalence of trichiasis overall. Our process of age- and gender-standardization of trichiasis prevalence estimates will have partially counterbalanced this potential bias, but it is not possible to estimate the residual magnitude of the effect.

There are approximately 120–130 TSOs in Senegal, and all of them are trained to perform trichiasis surgery. The quality of surgery delivered depends largely on how frequently the TSOs have the opportunity to practice this skill – which, in turn, depends partly on patients’ access to and demand for surgery. To increase access, the MSAS has tried different strategies, such as offering surgery free of charge (with the service paid for by a

partner organization). More aggressive strategies may be warranted to increase demand for surgery, particularly among people who may currently be practicing epilation as an alternative to surgery. One such strategy is known locally as “commando,” whereby TSOs rotate through and focus on performing surgeries in different regions of the country over the course of the year. This strategy would have the added advantage of giving the selected TSOs the opportunity to conduct the procedure more frequently, thereby improving their surgical skills which would help to increase demand for the service. Such a strategy will not be optimal after elimination as a public health problem, when services will need to be integrated into usual health care delivery platforms. Strengthening of the health care system is vital to ensure that this process is not followed by complete loss of capacity to detect trichiasis and deliver trichiasis surgery.

Risk factors

We examined selected potential risk factors for trachoma. The most obvious finding to emerge from our analysis was a significant negative correlation between having active trachoma and requiring less than 30 minutes to retrieve water for face washing. It has been argued that better access to water may reduce the transmission of *C. trachomatis* infection.³ However, previous studies evaluating the association between increased distance to water and prevalence of active disease have delivered inconsistent results.^{27–35}

Others have suggested that the quantity of water brought into the household might be more important than the distance.³⁶ Bailey et al., working in The Gambia, found that after controlling for distance to water and other factors, families with trachoma used less

water for washing children than those without trachoma, irrespective of the amount of available water in the household.³⁷ In the current study, the quantity of water brought was not measured and use of water was not observed, but a round trip of less than 30 minutes to collect water was associated with lower TF prevalence. It would be of interest to study facial cleanliness as a follow-up. Unlike previous studies,^{34,35,38,39} we did not find an association between TF prevalence and reported use of unimproved sanitation by household adults.

Implications for program planning

For the districts surveyed here, the main priorities should be implementation of the S component of SAFE in the nine districts with trichiasis prevalences $\geq 0.2\%$ in adults aged 15 years and above, to prevent worsening of vision in those who are already going blind from trachoma; and a one-year implementation of the SAFE strategy's A, F, and E components in the single district with TF prevalence 5.1% in children aged 1–9 years, followed by an impact survey. MDA in this district is scheduled for 2017.

In 2015, the International Trachoma Initiative, which supplies donated azithromycin (Zithromax®, Pfizer) for MDA against trachoma, notified national programs that it would welcome azithromycin applications for districts with baseline TF prevalence of 5–9.9% among children aged 1–9 years, to be distributed alongside F and E interventions, in an effort to ensure that all districts achieve TF prevalences below 5%.²⁴ A total of nine districts which have not yet initiated MDA for trachoma fall into this category. Of these, one district completed mapping in 2004, three in 2005, one in 2010, two in 2011, one in 2013, and one (which will conduct MDA in 2017, as noted above) as part of the 2014 round of surveys reported here. In collaboration with its partners, Senegal's MSAS is resurveying the eight districts in this category that conducted mapping prior to 2014, and will determine appropriate strategies based on the findings.

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Declaration of interest

None of the authors have any proprietary interests or conflicts of interest related to this submission.

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Appendix

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