Current status of trachoma in India: Results from the National Trachoma Prevalence Survey

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Purpose: In the mid-twentieth century, trachoma was endemic in the northwestern states of India. We aimed to generate recent estimates of prevalence of trachomatous inflammation, follicular (TF) and trachomatous trichiasis (TT) in ten suspected-endemic districts across seven previously hyper-endemic states and union territories for trachoma in India including Delhi, Rajasthan, Haryana, Punjab, Gujarat, Uttarakhand and the Andaman and Nicobar Islands. Methods: Population-based prevalence surveys were undertaken in 10 districts. In each of those districts, two-stage cluster sampling was used to select a sample of 2000 children aged 1–9 years and all adults aged ≥15 years in the enumerated households from a total of 20 clusters per district. Consent was obtained from eligible participants. The surveys used the World Health Organization’s simplified grading system. Data were analyzed at the district level. Results: A total of 13,802 households were surveyed in which 19,662 children were examined for TF and 44,135 adults aged ≥15 years were examined for TT. District-level TF prevalence in 1–9-year-olds ranged from 0.1% in Bikaner (95% CI: 0.01–0.3) to 2.1% in Dholpur (95% CI: 1.6–2.8) and that of trichiasis ranged from 0.7 per 1000 in Pauri Garhwal (95% CI: 0.01–1.4) to 22.1 per 1000 (95% CI: 15.8–28.4) in Car Nicobar. In four districts (Car Nicobar, Dholpur, Hoshiarpur, Tonk), trichiasis prevalence in adults aged ≥15 years was ≥0.2%. Conclusion: TF was not a public health problem in any of the districts surveyed; thus, antibiotic mass drug administration is not needed. However, TT among adults was found to be above 0.2% in four districts; thus, further trichiasis surgery interventions at the public health level are warranted to achieve elimination. These findings will facilitate planning for elimination of trachoma as a public health problem in India.

Key words: Elimination, epidemiology, prevalence, survey, trachoma

Trachoma, a neglected tropical disease, accounts for the maximum burden of blind people in the world due to an infectious cause.[1] It remains a public health problem in some countries of Asia including India, which was known to be trachoma endemic in the fifth and sixth decades of the twentieth century.[2] With improvement in socio-developmental markers and implementation of Surgery, Antibiotics, Facial cleanliness, Environmental improvement (SAFE) interventions, a reduction in burden of active trachoma and trichiasis had occurred by the time that Trachoma Rapid Assessments were conducted in 2006–07 in parts of the northwestern belt of the country.[3]

The World Health Organization (WHO) has recommended a prevalence of trachomatous inflammation, follicular (TF), an indicator of active trachoma, of <5% among children aged 1–9 years and trachomatous trichiasis (TT) prevalence threshold of <2/1000 population aged 15+ years in each formerly endemic evaluation unit (EU) as two of the elimination criteria for trachoma.[4] As population-based prevalence surveys are considered the gold standard to estimate the true prevalence of trachoma, the National Trachoma Prevalence Survey, India was planned and implemented in trachoma-suspect regions of the country to determine whether these elimination thresholds had been attained.

Methods

Study setting

The prevalence surveys were conducted in nine evaluation units of six states, namely, Punjab, Uttaranchal, Haryana, Gujarat, Delhi and Rajasthan during 2014–17. These EUs lie in the northwestern belt of the country previously known to be trachoma hyperendemic (prevalence of TF in 1–9-year-old children more than 50%) in the twentieth century. Nicobar district in the union territory of Andaman and Nicobar Islands was an additional EU identified as trachoma endemic in a rapid assessment conducted in 2010[5] and was included as the 10th EU. Hence, a total of 10 evaluation units (EU) were surveyed [Fig. 1].

Sampling procedure and sample population

The survey methodology adhered to standard cluster sampling approaches recommended by the WHO for national trachoma surveys. Population-based prevalence surveys are considered the gold standard to estimate the true prevalence of trachoma.
programs.\textsuperscript{[6]} Nine districts were randomly selected as EUs from states in the suspected trachoma-endemic northwestern belt; the tenth EU, Nicobar, was purposively selected.\textsuperscript{[7]} Fieldwork was undertaken from May 2014 to February 2017.

Participants were eligible for inclusion if they were one year of age or above and were usual residents of the survey area during the previous six months. Considering the operational definition for trachoma elimination (< 5%), the expected prevalence of active trachoma was taken as 5%, relative precision 25%, design effect 1.5 and response rate 90%. The sample size per EU was calculated as 2000 subjects aged 1–9 years to be examined across 20 clusters in the EU. Taking the population of children aged 1–9 years as roughly 25% of the general population, as per the Census of India, 2011, a cluster of 400 people would yield nearly 100 children. Thus, with 20 clusters randomly selected in an EU, each of population size 400, the total estimated population to be covered was 8000 individuals in one evaluation unit. In Car Nicobar Island, a sample of 800 was taken, as the overall population was approximately 20,000. Based on an expected prevalence of active trachoma infection amongst children aged 1–9 years as 3%, absolute precision 2%, design effect 2.65, finite population correction 6500, and non-response rate as 10%, a minimum sample of 800 children was calculated for this survey.\textsuperscript{[7]} This survey was adequately sized to assess an active trachoma infection prevalence in the range of 1%–5% precisely and was thus appropriate to assess achievement of elimination target of the same. As with the Global Trachoma Mapping Project (GTMP) protocol, loss of precision in the estimate of TT prevalence was considered acceptable.\textsuperscript{[7]}

The sampling frame for selection of clusters was the list of all villages in the EU. Twenty were selected using a probability proportionate to size approach, so that villages of equal population had the same chance of being chosen as a cluster, while villages with larger population size had a proportionately greater chance of being chosen. Once the selected village was known, one compact segment was randomly selected (lottery method using opaque envelopes) to yield a cluster of 400 people after dividing the village into approximately equal-sized segments.

All households in the selected compact segment were visited and all residents were examined, including those residing in households where no eligible child was present. Revisits of locked households and individuals not available during the first visit were done to maximize coverage.

Ethics statement
The survey was conducted in accordance with the principles of the Declaration of Helsinki and ethical clearance for this survey was taken from the Institute Ethics Committee, All India Institute of Medical Sciences (AIIMS), New Delhi, India (IEC/NP-451/2013 RP-27/2013 dated 28th October 2013). Local approval was taken from regional administrative authorities and village heads. Written informed consent was obtained from all eligible adult members of the household before acquiring any information and examination of the household members.

Training of team members
The survey teams comprised of epidemiologists, ophthalmologists, ophthalmic assistants, field supervisors, field workers and volunteers. A three-day training program equipped the survey teams with knowledge on the methodology and operational aspects related to the population-based survey. The team members were trained by senior investigators about data collection procedures, and completion of relevant household and participant information data. The training also guided the study team in the WHO simplified trachoma grading system, and agreement analysis between the ophthalmologists was done as per standard recommendations.\textsuperscript{[7]} All participating ophthalmologists attended the training sessions based on identification of stages of trachoma as per the WHO simplified grading system.\textsuperscript{[8]}

Agreement of the graders with the WHO slide set was conducted, inter-observer agreement analysis was done and Kappa values calculated. The minimum acceptable value was kept at 0.8 between examiners from a training team. The training also included a field visit to orient the survey teams in field-based study procedures. The trained team members from survey teams, further imparted training to the local team members and volunteers before initiating the community-based survey. A total of five training workshops were organized at Dr. Rajendra Prasad Centre for Ophthalmic Sciences (RPC), All India Institute of Medical Sciences, New Delhi, India to cover all the teams conducting survey in the ten EUs.

Data collection and clinical assessment
The survey activities in each cluster were conducted over two days that included enumeration and clinical examination. All the village panchayats were informed about the survey schedule and date and time of survey in their clusters. The local volunteers, Accredited Social Health Activists (ASHAs) and anganwadi workers of the village were identified and trained. Detailed maps of the clusters were prepared with the help of local volunteers.
Data collected included information on total household size, demographic details of enumerated members (name, age, gender, education, occupation, and relationship with head of household), total family income, number of living rooms, and environmental factor assessment. The environmental factors assessed were (i) distance from the water source, and (ii) absence of functional sanitary latrine in the house. Ophthalmic examination was performed using torch light and a 2.5 × binocular loupe using the WHO simplified grading system.

Data entry and statistical analysis
Data entry was performed using Epidata software and double data entry was done to catch and correct data entry errors. The system had in-built validation and consistency checks. Statistical analysis was carried out using Stata 14.0 (Stata Corp., College Station, TX, USA).

The key assessment indicators used were prevalence of active trachoma (TF) in the population aged 1–9 years; age–gender standardized prevalence of TT among the population aged ≥15 years; and prevalence of environmental factors among enumerated households among each EU.

Quality assurance
All the surveys were directly supervised by faculty from RPC, AIIMS, in the field. Daily reporting and checking of survey form for accuracy and incomplete entries was done in the field. The data entry system was designed to have in-built consistency checks to minimize transcription errors. Repeat trainings and inter-observer variation of the survey team were done whenever new ophthalmologists or other staff joined the survey team. Orientation meetings of the survey team were done prior to each EU survey. After completion of each survey, the findings of the supervising faculty were discussed with the survey team to ensure proper feedback and quality assurance.

Results
The population of the selected EUs ranged from 36,842 (Nicobar Island) to nearly 3.12 million (Banaskantha). A majority of the population in these EUs was rural with the exception of East Delhi EU which was largely urban (98.8%) [Table 1].

Study population
Overall, a total of 81,363 individuals of all age groups were enumerated in 13,802 households, of which 51,992 were aged 15 years and above, and 20,929 were aged 1–9 years. The number of children examined for active trachoma was 19,662 (93.9%), and 44,135 (84.9%) individuals were examined for TT (≥15 years). In terms of gender distribution, the male and female population were fairly equally distributed in the examined population for active trachoma (1–9 years) and trichiasis (≥15 years). In the examined population, 53.1% (1–9 years) and 45.9% (≥15 years) were males in the two age groups.

Active trachoma among population aged 1–9 years
A total of 19,662 children were examined for signs of active trachoma. The number of children with TF ranged from 2 to 45 in the ten surveyed EUs. Two children, one each in Car Nicobar and Dholpur were identified with TI. The EU with highest TF prevalence was Dholpur (2.1% [1.55, 2.82]) followed by Nicobar (1.4% [0.75, 2.51]), Mewat (1.18% [0.77, 1.74]), and...

### Table 1: Characteristics of the study population in each evaluation unit, National Trachoma Survey, India, 2014–17

| Evaluation unit | Number of households covered (Census 2011) | Number of residents (Census 2011) | Number of people aged ≥15 years in selected cluster examined (%) | Number of people aged 1–9 years in selected cluster examined (%) | Number of people aged ≥15 years in TT (≥15 years) examined (%) |
|-----------------|------------------------------------------|-----------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Banaskantha     | 31,190,596                               | 1,563,553 (68.1)                  | 70.064                                                        | 1,432                                                         | 83.87                                                        |
| Bikaner         | 2,705,591                                | 1,563,553 (68.1)                  | 70.064                                                        | 1,432                                                         | 83.87                                                        |
| Car Nicobar     | 36,842                                   | 36,842                            | 93.9%                                                         | 19,662                                                       | 93.9%                                                        |
| Dholpur         | 1,208,516                                | 1,208,516                         | 100                                                           | 1,208                                                       | 100                                                          |
| East Delhi      | 1,709,346                                | 1,709,346                         | 93.9%                                                         | 1,526                                                        | 93.9%                                                        |
| Hoshiarpur      | 1,586,695                                | 1,586,695                         | 93.9%                                                         | 1,526                                                        | 93.9%                                                        |
| Mahendragarh    | 1,282,986                                | 1,282,986                         | 93.9%                                                         | 1,202                                                        | 93.9%                                                        |
| Mewat           | 1,307,243                                | 1,307,243                         | 93.9%                                                         | 1,202                                                        | 93.9%                                                        |
| Pauri Garhwal   | 1,241,139                                | 1,241,139                         | 93.9%                                                         | 1,202                                                        | 93.9%                                                        |
| Tonk            | 1,414,720                                | 1,414,720                         | 93.9%                                                         | 1,202                                                        | 93.9%                                                        |
| Total           | 14,143,720                               | 14,143,720                        | 93.9%                                                         | 12,290                                                       | 93.9%                                                        |
Trachomatous trichiasis among population aged 15+ years

A total of 44,135 individuals aged ≥15 years were examined (84.9% response rate) across all the EUs. This included 20,249 males and 23,886 females. Among the examined individuals, 140 (0.32%) had trachomatous trichiasis (TT), of whom 45 (0.1% of all examinees) had trachomatous corneal opacities (TT with CO). The age–gender standardized prevalence rates per 1000 population in each EU were calculated via direct standardization against the 2011 census age–gender distribution of the 15 + population within the EU. The age–gender standardized prevalence of TT ranged from 22.1 per 1000 (15.8–28.4) in Car Nicobar to 0.7 per 1000 (0.01–1.4) in Pauri Garhwal, state of Uttarakhand. The five EUs including Bikaner, Car Nicobar, Dholpur, Hoshiarpur and Tonk had a prevalence rate exceeding the WHO elimination threshold of 2/1000 population in people aged ≥15 years while East Delhi, Banaskantha, Mahendragarh, Mewat and Pauri Garhwal had prevalence within the elimination threshold [Table 2].

Associations of trachomatous trichiasis (TT)

The associations of TT in our dataset are shown in Table 3. The occurrence of TT was positively correlated to increasing age (P < 0.0001), illiteracy (P = 0.04) and access to potable water (P = 0.001). The odds of having TT was nearly twenty times higher in the older population (≥ 40 years) as compared to the participants aged < 40 years (adjusted OR 20.58 [95% CI: 10.53–40.19]; P < 0.001). There were no significant differences with respect to gender and presence of TT (P = 0.086) in this study population. TT was seen more frequently in persons who were less literate (up to primary level education) as compared to those who had received higher education (0.39% versus 0.08%) (P = 0.047).

Environmental associations of trachoma among visited households

During the trachoma prevalence survey, a total of 13,802 households were assessed for environmental factors of trachoma, namely, access to water source, presence of solid wastes and animals within 20 meters of the household, and absence of functional latrine in the house. It was observed that non-availability of water source within a 30-minute walking distance was seen in Mewat with nearly 10.57% of households affected, in Dholpur with 9.2% of households, and in Car Nicobar with 6.7% of households, while excellent access was observed in Banaskantha, Bikaner, East Delhi, Hoshiarpur, Mahendragarh, Pauri Garhwal and Tonk. Poor environmental hygiene was observed across all EUs, with overall 55.4% of households having solid waste or animal present within 20 meters of the household. Good access to functional latrine was observed in Car Nicobar (2.5% lacking access), Bikaner (7.2% lacking access), and Hoshiarpur (9.7%).

Discussion

The National Trachoma Prevalence Survey, India, was implemented in the suspected endemic region of the country to estimate the prevalence of TF and TT. Trachoma prevalence surveys are essential for planning and implementation of the SAFE strategy and setting targets for elimination.43 This survey in India demonstrated that trachoma was not a public
TT continues to be common in certain pockets of the country, and surgical interventions are required to achieve the trachoma elimination goal by 2030. Significant associations for presence of TT in the study population were age and lower educational status. These findings are consistent with risk factors reported in other endemic communities. In an Ethiopian community, adults aged >40 years had twice the risk of having TT and illiterate people reported three times higher odds of trichiasis. Likewise, adults aged >40 years had twenty times more risk of having TT in our study population. The current trichiasis load in the surveyed villages emphasized the need for surgical facilities for managing trichiasis and resultant entropion. Following these interventions, further prevalence surveys for trichiasis will be needed to document attainment of elimination.

The success story of Car Nicobar Island, a tribal reserve area in the union territory of Andaman and Nicobar Islands, India, is heartening. High proportions (49%) of children in Car Nicobar Island were reported to have TF in the Trachoma Rapid Assessment Survey conducted in the year 2010. Annual mass drug administration of azithromycin was offered from 2010 to 2012 to all individuals residing on this island. Cross-sectional prevalence surveys conducted in 2013 and 2017 revealed a reduction of prevalence of TF in children aged 1–9 years from 6.8% in 2013 to 1.6% in 2017. Thus, the island has achieved TF levels below WHO elimination threshold. However, the reported prevalence of TT (including those known to the health system) in 2017 was 2.2%. Sustained efforts and continuous surveillance mixed with adequate programmatic response will be imperative for elimination of trachoma from this island.

The major strengths of our series of surveys were the strong methodologies for estimating prevalence, good geographical sample coverage in each EU, a high participation rate with examination of nearly 65,000 participants, rigorous training and supervision, and standardized approaches to data cleaning and analysis. Our study had some limitations. First, we did not calculate the sample size separately for estimating TT; all household members in the selected compact segment were included in the study. Similar practice of choosing adult members from the same households had also been reported in the Global Trachoma Mapping Project, undertaken in 34
countries.[7] Moreover, our definitions utilized for testing environmental factors were obtained from varying sources and these could vary from one survey to another. However, studying these factors was important, so as to stress on modifiable behavioral change in these communities and institutionalize SAFE interventions in these evaluation units. We also did not implement all elements of quality control and quality assurance now available to national trachoma programs.[13]

The present effort of trachoma control programs in India has reflected the commitment of the National Programme for Control of Blindness and Visual Impairment (NPCB&VI) in eliminating trachoma from the nation. There is a need to develop a strategy for community-based case-finding of patients of trachomatous trichiasis. These cases must be provided free entropion surgery or treatment in local hospitals within the existing health care system. Community-based efforts to generate awareness and encourage uptake of services along with provision of high-quality trichiasis surgical services and program management are imperative. Before India can be validated as having eliminated trachoma, adequate surveillance of the disease must be done. Monthly data on indicators of trachoma surveillance must be regularly sent to the NPCB&VI. A central monitoring team has been constituted to ensure effective implementation of case finding, surgery, preventive and surveillance components of the plan in the country. In the suspected hyperendemic region, trichiasis prevalence surveys have been planned in 200 EUs which will be conducted as per the WHO recommendations.[16]

Conclusion

The findings from these surveys suggest that TF was not a public health problem in any of the EUs, so antibiotic mass drug administration will not be needed for trachoma elimination. However, four EUs need to undertake public-health-level trichiasis surgery interventions to attain elimination of trachoma. The data suggest that with intensive effort and documentation through TT-only surveys, India may soon be able to eliminate trachoma and demonstrate that this has been achieved.

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Conflicts of interest

There are no conflicts of interest.

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