

# Mapping the global distribution of trachoma

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**Objective** We aimed to summarize and map the existing global population-based data on active trachoma and trichiasis. Detailed distribution maps of various infectious diseases have proved a valuable tool in their control. Such maps play an important role in assessing the magnitude of the problem, defining priority areas for control, monitoring changes, and advocacy. Until now, information on trachoma prevalence at within country levels has not been systematically collated, analysed and reported.

**Methods** We gathered the last 18 years' worth of reported data on active trachoma in children aged less than 10 years, and the last 25 years of reported trichiasis in adults aged 15 years and over from 139 population-based surveys in 33 countries. We collated these data into one database using the "district" (second administrative level) as the standard unit of reporting. We used Geographical Information Systems as a database and cartographic tool to generate a global map of the prevalence of trachoma and trichiasis.

**Findings** We obtained data on active trachoma and trichiasis from 18 countries in the WHO African Region, 6 in the Eastern Mediterranean Region, 3 in the South-East Asia Region, 3 in the Western Pacific Region and 2 in the Region of the Americas. In 23 countries suspected of having endemic trachoma no reliable district-level population-based data were available. In China and India, data were limited to a few districts. The data highlighted important regional differences and marked national variations in prevalence of active trachoma and trichiasis.

**Conclusion** This is the first attempt to summarize and map the existing population-based data on active trachoma and trichiasis. The lack of data in many countries remains an important obstacle to trachoma control efforts.

**Keywords** Trachoma/epidemiology; Eyelid diseases/epidemiology; Geographic information systems (source: MeSH, NLM).

**Mots clés** Trachome/épidémiologie; Paupière, Maladies/épidémiologie; Systèmes d'information géographique (source: MeSH, INSERM).

**Palabras clave** Tracoma/epidemiología; Enfermedades de los párpados/epidemiología; Sistemas de información geográfica (fuente: DeCS, BIREME).

## Arabic

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Voir page 917 le résumé en français. En la página 918 figura un resumen en español.

## Introduction

Trachoma is an eye disease caused by infection with the bacterium *Chlamydia trachomatis*. It is the leading cause of infectious blindness globally, being responsible for 1.3 million cases of blindness (1). At a recent WHO meeting it was estimated that trachoma is endemic in 55 countries, mainly in Africa and Asia.

Active trachoma (follicular trachoma, inflammatory trachoma; TF/TI), which occurs most frequently in children, is clinically diagnosed by signs of follicles and papillae on the conjunctival epithelium of the upper lid (2). These occur as a result of the inflammatory response following infection with *C. trachomatis*. Repeated rounds of infection may result in scarring leading to distortion of the eyelids and upper lid entropion (in-turning of the eyelids). As a result of this in-turning, eyelashes rub on the globe, a condition known as trichiasis. Trichiasis can lead to corneal opacity and eventually blindness.

In 1997, WHO formed an Alliance to work towards the Global Elimination of Trachoma by 2020 (GET2020). The

Alliance promotes the use of the SAFE strategy for trachoma control. This involves Surgery to correct trichiasis, Antibiotics to treat infection, Facial cleanliness and Environmental improvement to interrupt transmission of *C. trachomatis*. The appropriate targeting of the SAFE strategy is dependent upon reliable information on the distribution of active trachoma and trichiasis within a country, based specifically upon the district prevalence of the disease (3). Currently, mass treatment of the entire district with antibiotics is recommended in districts with an active trachoma prevalence of 10% or more in children aged 1–9 years. Where the prevalence falls below 10%, treatment is recommended only in those communities with a prevalence  $\geq 10\%$  (3). District-level prevalence estimates derived from population-based surveys are therefore an essential element of trachoma control efforts. Currently, however, there are inadequate epidemiological data on the distribution of trachoma globally (4).

The definition and analysis of the global distribution and limits of disease has yielded valuable information for malaria (5,

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6), onchocerciasis (7) and schistosomiasis (8). Currently available maps of global trachoma distribution indicate the broad areas/countries where endemic trachoma is found; however, they do not provide an indication of the levels of trachoma endemicity within and between countries. Maps displaying reliable epidemiological data can play an important role in: (a) assessing the magnitude of the problem, (b) defining priority areas for control, (c) monitoring progress and change following control efforts, (d) advocacy, and (e) identifying areas where further data are needed.

Using information from published literature and unpublished surveys collated into a single database, this review presents the available trachoma survey data in map format for active trachoma in children and trichiasis in adults. These maps serve to describe the disease prevalence and also to highlight areas for which further information is required.

## Methods

### The database

The information included in the database was derived from two main sources: (a) published surveys identified through computerized literature searches using PubMed, and complemented by reference tracing; and (b) 'grey literature' from unpublished sources collected from a network of contacts of WHO, International Trachoma Initiative (ITI) and London School of Hygiene and Tropical Medicine (LSHTM). Only data from population-based surveys (not hospital data) conducted after 1980 for trichiasis and after 1987 for active trachoma were included. The later cut-off date of 1987 for active trachoma was selected as the new simplified grading system was introduced in this year (2). Data from Trachoma Rapid Assessments (TRAs) were used only to indicate the presence of trachoma, since they are not designed to generate prevalence data. Where more than one reference was found for the same district an average prevalence was calculated. However, if data were part of the same study (such as from a longitudinal or intervention study), the most recent data were recorded.

Active trachoma was recorded for children <10 years only, and trichiasis for adults only as these are the indicators of disease burden (2). Data collection and reporting methods vary considerably so age and gender were recorded in the database enabling age adjustment and stratification if required. For purposes of comparability, an age-adjustment conversion factor was calculated to convert trichiasis prevalence data from 40 years and above to 15 years and above. This factor was calculated using six sets of trichiasis prevalence data from different countries (9–14) where trichiasis prevalence is reported for both >15 years and >40 years age groups. An average of these six conversion factors, weighted according to study population size, was taken to give an overall factor of 2.56.

To limit overinterpretation of the data, which were derived from a range of time periods, using a mixture of survey techniques and reporting methods, prevalence data were banded into broad groups. The following bands were selected for their relevance to WHO control recommendations: for active trachoma in children <10 years 0%, >0% to <10%,  $\geq 10\%$  to <30% and  $\geq 30\%$  (Fig. 1)<sup>a</sup> and for trichiasis in adults >15 years 0%, >0% to <1%,  $\geq 1\%$  to <5% and  $\geq 5\%$  (Fig. 2)<sup>b</sup>.

### Mapping the data

As part of efforts to estimate the global burden of the disease, a list of countries where trachoma was likely to be found was drawn up during the WHO II Global Scientific Meeting on Trachoma, Geneva 2003. For the purposes of the current project the 55 countries included in this list were labelled as endemic for trachoma.

The project sought to assign data where possible to the second administrative level — here defined as the district. This level of stratification was selected because it has direct relevance to WHO recommendations for trachoma control. It is also considered the lowest level of stratification for which data can reasonably be expected to be available. However, in some countries (i.e. Algeria, Australia, Chad, Mali, Mauritania, Niger, Oman and Senegal) data were reported at the regional administrative level.

In areas where no trachoma survey data were identified, likely endemic areas were labelled. In those countries where endemic trachoma was suspected (based on literature and information from experts with experience of working in these areas) but where no recent population-based data on trachoma distribution were identified, the entire country was labelled as suspected endemic. Although prevalence data derived from TRAs were not displayed, the districts where these assessments had been conducted were indicated on the maps.

The WHO Public Health Mapping Programme provided the geographical boundaries for WHO regions. Other country boundaries were downloaded from the following internet sources: (a) [http://www.vdstech.com/map\\_data.htm](http://www.vdstech.com/map_data.htm) (b) <http://www.ga.gov.au> and (c) <http://www.cipotato.org/DIVA/data/DataServer.htm>. Spatial data were displayed using the Geographical Information System ArcView (v3.3, ESRI, CA, USA).

### Trachoma prevalence by climate zone

Within a Geographic Information System (GIS), the distribution of diseases can be overlaid with environmental data, which provides a robust platform upon which to examine environmental correlates of the disease. In this study we used the Köppen climate classification system to calculate mean trachoma prevalence by climate zone (15, 16). The Köppen classification is a widely used system that divides areas into the following five main climatic categories according to annual and monthly averages of temperature and precipitation:

- dry zone — deficient precipitation most of the year;
- tropical moist zone — all months have average temperatures above 18 °C and annual precipitation >1500 mm;
- moist subtropical mid-latitudes zone — warm and humid summers with mild winters;
- severe mid-latitude — warm summers with cold winters;
- polar — year round low temperatures with warmest month <10 °C.

The 'summarize zone' function in ArcView was used to calculate the mean of the active trachoma prevalence figures within each climatic zone. 'Summarize zone' computes a summary statistic for each zone (set of features with same attribute value,

<sup>a</sup> Fig. 1 can be found at <http://www.iceh.org.uk/files/trachomamap2005.pdf>

<sup>b</sup> Fig. 2 can be found at <http://www.iceh.org.uk/files/trachomamap2005.pdf>

Table 1A. Number of surveys and administrative units by country for which data were identified

WHO region	No. of admin. units in country	No. of admin. units with data on trichiasis (%)	No. of admin. units with data on active disease (%)	No. of population-based surveys included	No. of rapid assessments conducted
<b>African</b>					
Algeria <sup>a</sup>	48	0 (0)	1 (2)	1	
Burkina Faso	301	40 (13)	40 (13)	2	
Chad <sup>a</sup>	14	5 (36)	5 (36)	1	
Djibouti	50	4 (8)	0 (0)	1	
Ethiopia	72	6 (8)	10 (14)	10	
Gambia	6	6 (100)	6 (100)	2	
Ghana	110	18 (16)	18 (16)	4	
Guinea	38	9 (24)	9 (24)	1	1
Guinea-Bissau	38	1 (3)	1 (3)	2	
Kenya	70	1 (1)	2 (3)	1	
Malawi	27	2 (7)	2 (7)	3	
Mali <sup>a</sup>	8	8 (100)	8 (100)	2	
Mauritania <sup>a</sup>	13	12 (92)	12 (92)	1	
Mozambique	128	3 (2)	3 (2)	1	
Niger <sup>a</sup>	8	8 (100)	8 (100)	1	
Nigeria	774	41 (5)	41 (5)	4	2
Senegal <sup>a</sup>	10	8 (80)	8 (80)	1	
Togo	30	0 (0)	1 (3)	1	
United Republic of Tanzania	108	20 (19)	20 (19)	7	
Zambia	72	1 (1)	0 (0)	1	
<b>Eastern Mediterranean</b>					
Egypt	27	3 (11)	4 (15)	4	1
Morocco	44	5 (11)	5 (11)	1	
Oman <sup>a</sup>	8	7 (88)	7 (88)	1	
Pakistan	122	0 (0)	0 (0)	0	1
Sudan	26	3 (12)	4 (15)	3	
Yemen	17	4 (24)	4 (24)	1	
<b>South-East Asia</b>					
India	719	0 (0)	4 (1)	2	
Nepal	75	9 (12)	9 (12)	10	
Myanmar <sup>a</sup>	14	3 (21)	3 (21)	3	1
<b>Western Pacific</b>					
Australia <sup>a</sup>	8	2 (25)	3 (38)	35 <sup>b</sup>	
Cambodia	24	0 (0)	0 (0)	0	1
China	2985	1 (0)	1 (0)	1	
Viet Nam	604	22 (4)	22 (4)	2	
<b>Americas</b>					
Brazil	4113	7 (0)	30 (1)	28 <sup>b</sup>	
Mexico <sup>a</sup>	32	1 (3)	1 (3)	1	
<b>Total</b>	<b>10 719</b>	<b>260</b>	<b>323</b>	<b>139</b>	<b>6</b>

<sup>a</sup> The administration unit is the region.

<sup>b</sup> The majority of active trachoma surveys were conducted in school-aged children. In Australia, surveys were mainly conducted in Aboriginal communities.

in this case climatic variables) of a theme, based on the values in another selected theme (in this case trachoma prevalence) that fall within each zone.

## Results

The database included data from 139 population-based surveys. Data on active trachoma were identified in 31, and trichiasis data in 30, of the 55 suspected endemic countries. Data from TRAs exist for a number of countries such as Pakistan and

Nigeria; however, TRAs do not generate prevalence data, rather they identify where population-based epidemiological surveys are required (17). Table 1A and Table 1B show the number of countries and districts for which data were available, and those countries suspected of having disease without recent population-based data.

The distributions of available population-based survey data for active trachoma (TF/TI) by WHO region are shown in Fig. 1, and for trichiasis (TT) in Fig. 2.

## African Region

The highest prevalence of active trachoma and trichiasis was seen in the African Region (Fig. 1c, Fig. 2c). Trachoma data were available from 18 countries with a further eight countries suspected of having trachoma but without data. The disease was predominantly located in the savannah areas of East and Central Africa and the Sahel of West Africa. Data availability varied considerably within the region; national surveys had been conducted in a number of countries, including Gambia, Niger, Senegal, Mali and Burkina Faso.

## Eastern Mediterranean Region

Data were available from five countries with another five being suspected of having active disease and seven having trichiasis (Fig. 1d, Fig. 2d). Very good information was available from Morocco and Oman. Over the last two decades the disease is known to be on the decline in a number of countries in this region (e.g. Morocco, Saudi Arabia and Oman). In Pakistan TRAs have demonstrated endemic disease in a number of districts.

## South-East Asia Region

Active trachoma and trichiasis was thought to be present in India, Myanmar and Nepal (Fig. 1e, Fig. 2e). Little recent data were available on India, while a number of population-based surveys have been conducted in Myanmar and Nepal. Myanmar is known to have had a successful trachoma control programme since the 1960s with disease now limited to foci within the central area of the country. In India the disease was focal, occurring in states such as Rajasthan, but limited data were available.

## Western Pacific Region

Active trachoma and trichiasis was reported from Australia, China and Viet Nam, with the Lao People's Democratic Republic, Cambodia and some of the Pacific islands suspected of having disease (Fig. 1f, Fig. 2f). Very good data were available from Viet Nam and Australia. In Australia, surveys were mainly from Aboriginal communities.

## Region of the Americas

The distribution of trachoma in the Americas was thought to be restricted to three countries: Mexico, Guatemala and Brazil. In Mexico it occurred in only one district (Chiapas) and prevalence was low. No information on the disease in Guatemala could be found. Surveys conducted in Brazil suggested a high prevalence of active trachoma in a number of districts.

## Prevalence by climate zone

The mean trachoma prevalence by climate zone was calculated as follows: dry zone, 24.2%; tropical moist zone, 17%; moist subtropical mid-latitudes zone, 16%; severe mid-latitude and polar, no data and no evidence of trachoma.

## Discussion

This project has systematically collated available data and used a GIS to describe the global distribution of active trachoma and trichiasis at the district level. This has built upon previous global trachoma maps that indicate the broad areas where trachoma is likely to be found.

Table 1B. Countries, by WHO region, suspected to have trachoma where no data was obtained

African	Eastern Mediterranean	Western Pacific	Americas
Benin	Afghanistan	Fiji	Guatemala
Cameroon	Iran (Islamic Republic of)	Kiribati	
Central African Republic	Iraq	Papua New Guinea	
Côte d'Ivoire	Somalia	Lao People's Democratic Republic	
Eritrea	Libyan Arab Jamahiriya	Solomon Islands	
Namibia		Vanuatu	
Uganda			
Zimbabwe			

## Limitations of the study

### Variations in methodology of data collection

Inevitably, there were a number of important sources of variation in the data included in the maps. There was significant variation in methods used for both collection and reporting of the identified data. Data were stratified according to the survey method and only population-based survey methods were included in the final maps; however, among these surveys, the sampling method, sample size, age groups included and date of survey remained highly varied. This has implications for comparability of the data. Data were assigned to broad data bands in an attempt to limit this effect.

### Unit of mapping

The collated data were mapped within defined administrative boundaries to simplify data handling and because of their relevance to control recommendations. The disadvantage of this approach is that it does not take into account the underlying heterogeneity of the disease. It is well established that trachoma is a focal disease, with significant small level (village, subvillage and household) spatial variation (10, 18, 19). In the absence of district-wide surveys, data from a single survey within a district have sometimes been extrapolated to give the district-level prevalence. The fact that these surveys were likely to have been conducted in known high-prevalence foci of the disease results in a likely overestimation of district-level trachoma prevalence.

Further, although it is possible to calculate national average prevalence based on available district prevalence data, these figures would be misleading and this has not been attempted as part of this work. As demonstrated in this study, in some countries only a few prevalence surveys have been conducted, probably in areas with known high prevalence. However, calculations of estimates of numbers at risk from trachoma are currently under way as part of further ongoing and consultative work.

### Chronological limitation

Only data collected after 1980 for trichiasis and after 1987 for active trachoma were included. However, it is likely that in a number of areas prevalence data were collected prior to subsequent control activities. The data shown here are therefore

not necessarily an accurate reflection of the current trachoma situation. An advantage of the use of GIS, however, is that the maps can be easily updated as new data become available.

### Summary

Despite these limitations these maps provide the most detailed picture currently available on the global distribution of trachoma. They are the result of an exhaustive attempt to identify all existing trachoma survey data, achieved largely through contacting people involved in trachoma control efforts throughout the world.

### Trachoma prevalence by climate zone

A basic exploration of active trachoma by climatic zone, using data compiled for this project, found that the mean prevalence was highest in the dry zone. While this analysis was limited, it is in accordance with current understanding about the disease: that active trachoma is associated with poor water availability. However, hot and dry areas are also typically where poorer parts of the world are found and trachoma has also been linked with poverty. Predictive models using correlations between disease and environmental variables have been developed for schistosomiasis, malaria and cutaneous leishmaniasis (20). The possibility of developing models to predict the distribution of active trachoma using temperature, rainfall and elevation data was explored in the current study. However, this analysis was limited by the lack of current reliable epidemiological data, particularly the lack of data confirming where trachoma is absent or where prevalence is below 10%.

### Conclusions

The maps illustrate the variation in trachoma prevalence found within and between countries. According to the available survey data, many districts still have active trachoma prevalence above 30% in children less than 10 years old. The majority of such districts are within Africa, though high prevalence has also been found in some Eastern Mediterranean countries.

The study highlights the range in the amount of population-based survey data that exists within and between countries. Decisions about starting trachoma control activities need to be based upon district-level prevalence estimates (3). Population-based data were available for 33 of the 55 endemic countries, but in some of these the data were limited to a few districts. Of particular importance, China and India potentially contribute

the largest number of active trachoma and trichiasis cases to the overall global burden of the disease (3), yet recent survey data were located for only one or two districts. Encouragingly, a number of countries have undertaken national trachoma surveys including the Gambia (9), Burkina Faso (21), Mali (22) and Senegal (23). Such surveys provide valuable information on the general trachoma situation in these countries.

The process of stratifying the maps of trichiasis data by age and gender demonstrates the variability in data collection methods in trachoma-endemic areas. This variation has implications for control activities that are based on district prevalence. In order to monitor reduction of disease, data need to be collected in a consistent manner (following WHO guidelines), for a uniform age and gender group.

Presenting the existing trachoma data in map form using a GIS has the advantage of highlighting these issues in a clear and accessible way. It is hoped that the published maps will serve as a useful advocacy tool helping to generate interest and action from decision-makers.

### Summary

The results of this study show that trachoma remains highly endemic in many parts of Africa and continues to persist in a number of countries in the Middle East, Asia and Latin America. It highlights the paucity of reliable district-level prevalence data in many trachoma-endemic countries. This remains an obstacle to the efforts underway to move towards elimination of the disease. Development of a simple survey technique to collect reliable prevalence information is a priority. ■

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**Competing interests:** none declared.

## Résumé

### Cartographie de la répartition mondiale du trachome

**Objectif** Il s'agissait de résumer et de cartographier les données mondiales tirées d'études en population concernant le trachome évolutif et le trichiasis. Pour la lutte contre différentes maladies infectieuses, des cartes de distribution détaillées se sont révélées des instruments utiles. Elles sont importantes pour évaluer l'ampleur du phénomène et pour définir les zones où il faut prioritairement lutter contre la maladie, suivre les évolutions et sensibiliser l'opinion. Jusqu'ici, les données sur la prévalence du trachome dans les différents pays n'ont pas fait l'objet d'une exploitation, d'une analyse et d'une notification systématiques.

**Méthodes** On a tiré de 139 enquêtes en population effectuées dans 33 pays les données sur le trachome évolutif relatives aux 18 dernières années chez les enfants de moins de dix ans et les

données sur le trichiasis relatives aux 25 dernières années chez les individus de 15 ans et plus. Ces données ont été regroupées dans une même base de données en utilisant comme unité type de notification le "district" (c'est-à-dire le deuxième niveau administratif). Les systèmes d'information géographique ont servi de base de données et d'outil cartographique pour établir une carte mondiale de la prévalence du trachome et du trichiasis.

**Résultats** Des données sur le trachome évolutif et le trichiasis ont été obtenues auprès des pays suivants : 18 pays de la Région africaine de l'OMS, 6 de la Région de la Méditerranée orientale, de 3 de la Région de l'Asie du Sud-est, 3 de la Région du Pacifique occidental et 2 des Amériques. Dans 23 pays où le trachome est supposé endémique, on ne dispose d'aucune donnée fiable

provenant d'études en population à l'échelle du district. Pour la Chine et l'Inde, on disposait de données pour quelques districts seulement. Les données ont fait ressortir d'importantes différences entre les Régions et des variations notables au niveau national de la prévalence du trachome évolutif et du trichiasis.

**Conclusion** Il s'agit là de la première tentative pour récapituler et cartographier les données fournies par les études en population sur le trachome évolutif et le trichiasis. Le manque de données concernant de nombreux pays oppose un frein important aux efforts de lutte contre le trachome.

## Resumen

### Cartografía mundial del tracoma

**Objetivo** Decidimos resumir y cartografiar los datos disponibles basados en la población mundial sobre el tracoma activo y la triquiasis. Los mapas detallados de la distribución de diversas enfermedades infecciosas han demostrado ser un valioso instrumento para controlarlas. Esos mapas son una importante ayuda para la evaluación de la magnitud del problema, la definición de las áreas prioritarias de control, la vigilancia de los cambios y la promoción. Hasta la fecha no se han compilado, analizado y notificado sistemáticamente los datos sobre la prevalencia del tracoma a nivel intranacional.

**Métodos** Reunimos los datos notificados en los últimos 18 años sobre el tracoma activo entre los menores de 10 años, así como los datos sobre triquiasis correspondientes a los últimos 25 años en la población adulta de 15 o más años, a partir de 139 encuestas basadas en la población de 33 países. Compilamos dicha información en una base de datos utilizando el «distrito» (segundo nivel administrativo) como unidad estándar de notificación.

Empleamos los Sistemas de Información Geográfica como base de datos e instrumento de cartografía para generar un mapa mundial de la prevalencia del tracoma y la triquiasis.

**Resultados** Obtuvimos datos sobre el tracoma activo y la triquiasis en 18 países de la Región de África de la OMS, 6 de la Región del Mediterráneo Oriental, 3 de la Región de Asia Sudoriental, 3 de la Región del Pacífico Occidental y 2 de las Américas. En 23 países con posible tracoma endémico no se pudieron conseguir datos fiables basados en la población a nivel de distrito. En China y la India, los datos se limitaron a unos cuantos distritos. Los datos revelaron importantes diferencias regionales y marcadas variaciones nacionales en la prevalencia del tracoma activo y la triquiasis.

**Conclusión** Este trabajo representa el primer intento de resumir y cartografiar los datos poblacionales disponibles sobre el tracoma activo y la triquiasis. La falta de datos en muchos países sigue siendo un importante obstáculo para las iniciativas de control del tracoma.

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## Arabic

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Sarah Polack et al.

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The maps from this study are available online at: <http://www.iceh.org.uk/files/trachomamap2005.pdf>

A full list of the sources of all the data included in the maps is available from the author on request.