Water, trachoma and conjunctivitis

A. Prost[1] & A.D. Négrel[2]

The incidence of eye infections in a community is generally accepted as an indicator of the adequacy of water supply for their needs. However, discrepancies in the published results from various studies seem to challenge this view. We have reanalysed the published data on trachoma in relation to the most relevant indicators of water accessibility, using prevalence ratios as the single parameter for risk assessment. A definite trend emerges from this review: the incidence of infectious conjunctivitis is not sensitive to differences in water accessibility; on the other hand, a reduction in the risk of trachoma is consistently associated with better access to water. This conclusion may support the efforts of WHO and other multilateral and bilateral agencies to sustain the commitment towards the water supply sector beyond the International Drinking Water Supply and Sanitation Decade.

Conjunctivitis and trachoma, two of the most common eye infections, appear to spread more easily if the quantity of water available for personal hygiene is limited. Most textbooks endorse the assumption made in East Africa by White et al. (*24*) that improvements resulting in sufficient quantities of water for individual use can reduce the incidence of trachoma by 60% and of other types of conjunctivitis by 70%. Very few studies, however, have reported on this impact of water availability and none has investigated the changes in the incidence of trachoma induced by an improvement in water supply. This paper reviews the published data and conclusions concerning trachoma and also briefly discusses acute conjunctivitis, about which information is scarce because it is not a blinding condition.

Trachoma and climate

The geographical approach

It is commonly stated in the epidemiological literature (*6*) that the frequency of trachoma is greater in the drier parts of affected countries (e.g., India, South Africa, Australia and China, which have a variety of climatic zones). Observations in northern Africa suggest that the prevalence and the intensity of trachoma increase with the distance from the sea. Thus, globally trachoma is associated with arid and dusty areas, and generally with a scarcity of water.

However, trachoma has existed and still exists in many areas with different climatic conditions and was prevalent in most European countries up to this century. A special trachoma clinic used to be held in Amsterdam till 1940, and in Finland up to 1949. Trachoma is also present in the humid tropics, especially in Africa and in the Pacific Islands. Mann (*12*) reported severe trachoma from the hot, humid, equatorial islands of the Bismarck archipelago in New Guinea, and also prevalence rates as high as 46% in mainland Papua.

The National Trachoma and Eye Health Program in Australia (*16*) has tested the association of trachoma with six climatic variables: humidity, rainfall, latitude, ultra-violet radiation, evaporation rate, and sunshine hours. Prevalence rates of follicular trachoma are strongly related to humidity, evaporation, sunshine hours, and less strongly to latitude, UV radiation and rainfall. Increasing prevalence is associated with climatic changes towards the brighter and more arid, from cool and moist to hot and dry. Detailed analysis indicates that the main determinant is the evaporation rate. Humidity and rainfall have less but significant force. Latitude has no significant role.

These findings explain the current geographical distribution of trachoma and its association with arid areas. However, aridity is only the main environmental factor in the transmission of the disease. Lack of hygiene, low economic status, crowding, density of contacts, presence of flies, and behavioural attitudes are key epidemiological determinants. Their interactions, for example, would explain observations in Africa, the Middle East, and Australia, that nomadic groups have less severe lesions than settled populations, despite the greater availability of water in the latter. In Western Australia (*12*), the aborigines who have settled in Kimberley have the most severe form of the disease whereas nomadic aborigines in the same region, who have a very limited access to water sources and who never wash, tend to have a very mild trachoma. Similar observations have been reported from Saudi Arabia (*3*).

[1] Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland. Requests for reprints should be sent to this address.

[2] Programme for the Prevention of Blindness, World Health Organization, Geneva, Switzerland.

Table 1: **Summary of published information on trachoma in relation to water accessibility**

Country	Type and size of sample	Indicator for water supply	Observations on trachoma	Comments
Australia (*8*)[a]	73 school children (age 5–15 years)	Provision of washing facilities, 1 daily bath for two months	Cytological examination of conjunctival smears: 43% improved, 13% deteriorated, 44% stationary	Statistically significant despite small numbers; seasonal effect disclaimed; bathing in the same water; one towel for 2 children
Australia (*16*)	Examination of 61 710 aborigines and 38 448 non-aborigines	Communities distributed in four categories, from 1 (limited quantities of water from remote wells) to 4 (unlimited availability within houses) with scoring system to compensate for lack of homogeneity within the settlements	Both follicular and cicatricial trachoma decrease with water availability; prevalence of follicular trachoma in aborigines (age <20) ranges from 3.7% in category 4 to 42.6% in category 1; frequency of follicular trachoma 42 times higher among aborigines in lowest category than in non-aborigines	Water supply cannot be isolated from other variables representative of housing improvement, e.g., waste disposal, sewerage, food storage facilities, and building materials; decrease in prevalence of follicular trachoma strongly associated with improvement of all five indicators
Australia (*21*)	3308 aborigines in Northern Territory (age <21 years)	Three habitat zones. Zone 1: remote camps with mobile tanks or distant bores Zone II: fringe camps with some taps and mobile tanks Zone III: settlements, water accessible	Prevalence of active trachoma decreased from 78% in zone I to 56% in zone II and 25% in zone III	Strong correlation with all living conditions, of which water supply is is only a component
China (Province of Taiwan) (*1*)	Random sample of 33 014 inhabitants	Distance between homes and water sources; type of supply	Prevalence increased with distance, from 18% when water was available *in situ* to 30.5% when water source was beyond 500 m; peak prevalence in 10–14-year age group if water source was >100 m away and in 15–19-year group if water was available within 100 m	Water quality may be a confounding factor: the prevalence of trachoma was 15% in people having home tap supplies and 24% in people having draw-well and hand-pump home supplies
India (*14*)	5% sample of 202 villages in Rajasthan	Distance between homes and water sources in a dry region	56% prevalence of trachoma if water source was >200 m and 39% prevalence if <200 m	Prevalence decreased with rising household *per capita* income, but the effect of distance persisted when results were controlled for income
Indonesia[b]	1265 households in 3 villages	Type of supply: pipe, well, canal	No significant difference in the prevalence of trachoma in relation to the type of supply	No indication that any type of supply resulted in a limitation of the quantities of water
Japan (*13*)	60 307 schoolchildren in Okinawa, distributed into 4 samples of unequal size	Population served with unlimited quantities of good quality water, and population using less water from a limited number of wells	Prevalence of trachoma: urban with water, 4.1%; rural with water, 3.3% urban, water limited, 24.1%; rural, water limited, 41.5%	Major biases impair the validity of the comparison; however, the difference due to water supply is more important than the urban/rural difference

Malawi (*23*)	5356 children (age <6 years)	Distance to the primary source of supply and type of source; frequency of face washing	Prevalence of inflammatory trachoma highest among users of unprotected wells; odds ratio increases with distance for all types of sources up to 2.6 for distances covered in >60 min	Strong association of prevalence with increasing distance; no estimation of quantities used; no effect from face washing
Mexico (*20*)	469 children (age <10 years) in two communities in Chiapas	Frequency of face washing and other hygiene variables	3.1 times more trachoma in children who wash their faces <once per day, compared with ⩾once per day	Frequency of trachoma was not associated with quality of water, use of soap, washing of other parts of the body than the face, etc.
Morocco (*9*)	Random sampling of 200 households with about 1000 persons in four zones	Distance from the main supply of water, volume of water brought daily into households and per capita daily consumption	Incidence of trachoma slightly higher for distance >1500 m (65.5% vs 57.2% for <1500 m); higher prevalence of severe cases associated with the lowest water consumption in all age groups	No relationship between distance and per capita daily consumption in this study
Mozambique (*4*)	Sampling of 100 house-holds in each of two villages differing for water supply variables	Village 1 with municipal supply within 300 m of each household and daily per capita consumption of 14 litres; village 2 with source 4 km away and per capita daily consumption of 8 litres	Overall prevalence of trachoma was 19.2% in village 1 and 38.1% in village 2; prevalence of stage II–IV trachoma was 4.5% in village 1 and 14.6% in village 2	All children in village 1 had a daily bath vs about 39% in village 2; since supply in village 1 was only 18 months old the role of water as the single determinant to account for the difference is doubtful
South Africa (*18*)	2146 persons in two villages in Transvaal	Abundant in village 1, limited and seasonal in village 2; lack of precise data	100% prevalence in both villages: however, prevalence of active cases of trachoma was 44% in village 2 and 6% in village 1	Comparability of results would require adjustment for age (only 50 adults examined in village 2)
Sudan (*11*)	Random sampling of 478 people	Bathing habits	70% prevalence of trachoma in people bathing occasionally, 32% among those bathing daily	
Tunisia (*5*, *15*)	2800 people in two oasis villages	Household supply (well or pipe) or municipal fountain	In both villages, people with household supply have less scarring lesions than people using collective sources; the lack of water in the household was associated with a greater intensity in children aged <5 and with complications in age groups 6–14 and >30 years	Intensity of trachoma and prevalence of complications were higher in village 2 than in village 1 in all categories of water usage; improved socioeconomic conditions responsible for recent decrease of intensity in village 1
USA (*17*)	441 Indians in a reservation in Arizona	32 environmental and sanitation variables	No significant relationship between the incidence of trachoma and any of the sanitation variables	Difficulty of identifying the influence of environmental determinants within a small group

[a] Figures in parentheses are the references to the studies concerned.
[b] See footnote *a*, page 12.

Trachoma and domestic water

Methodological issues

Although many reports assert that the provision of water supply has been instrumental in the control of trachoma, the published literature does not document precisely the effect of such intervention nor does it assess the magnitude of the contribution of the water component to the end result.

Yet, in 1896, long before the agent of trachoma could be identified, Stephenson (*19*) in the USA noted that "epidemic ophthalmia had been shown to be often spread by imperfect washing arrangements". Much later, Bisley (*2*) reported from the northern frontier district of Kenya a 100% prevalence of trachoma in children except in a small primary boarding school where only 30% of the children were suffering from a mild degree of the disease. The striking difference was attributed to the school rule that every pupil should have his face washed in a nearby permanent stream every day before school inspection. However, very few authors have focused on environmental and social factors in eye diseases. Most papers acknowledge their role but seldom establish a relationship between detailed epidemiological observations and selected environmental determinants, among which water availability can be a qualitative (presence/absence) or a quantitative one. Two types of studies are available: intervention studies, in which the same population is examined before and after changes have been introduced in the water sector; and comparison studies using different populations which are presumed to be comparable except for their access to water. Intervention studies provide better clues since they are exempted from most of the biases and from many of the confounding factors which affect comparison studies of the cross-sectional type.

Unfortunately, intervention studies of an acceptable quality are rare. The introduction of hygiene practices in an Australian school (*8*) seems to be the only reliable one. A minimum of scrutiny is sufficient to discard all other studies in this category. Among them is the quotation, widespread in the literature, that in Barabanki, Uttar Pradesh, India, "trachoma morbidity dropped 90 percent following introduction of a piped water supply in 1965"; the original data indicate that the prevalence of trachoma was as low as 3.3 per thousand population even before the intervention, and that the above conclusion derived from a few single cases has no significance (*26*). A similar analysis calls for the rejection of another quotation that "an increase in the availability of water and the increased convenience of a piped supply failed to materially affect the prevalence of trachoma among American Indians living in Blackwater, Arizona"; the data indicate that in 1963, one year after each house had been provided with at least one tap delivering safe water, the trachoma situation in the community was more or less similar to that in 1928 (*7*). However, a sound comparison after 35 years does not seem possible. In both cases, the quotations made in the literature in support of either theory are interpretations which go far beyond the conclusions drawn by the authors themselves.

The material for assessing the impact of water supply on trachoma consists almost exclusively (all but one) of comparison studies. Following an extensive literature search and a critical review of published information, fifteen studies (summarized in Table 1) met the following criteria: precise definition of the population sample; clear indicators for water supply, often allowing an analysis of quantitative relationships; and trachoma diagnosed by specialists.

As regards the epidemiological interpretation of the results, no study was exempt from bias and often the validity of the conclusions could be questioned because of, for example, huge differences in the size of the clusters to be compared (323 and 58 480, or 50 and 2096) (*13*, *18*), or in the age distribution within the clusters (*18*) or of cross-sectional surveys carried out in different places at different dates (*13*), lack of cross-checking for observer's variations (*8*), limited accuracy of the diagnosis of early stages of trachoma (*4*), and uncertainties concerning water utilization (*18*).[a] In all the studies, the main confounding factor was the impossibility to isolate water usage and water availability from other variables associated with income and welfare, those benefiting from greater availability of water tending to enjoy better housing conditions, higher incomes, a socially higher occupation for the head of the household, a higher level of education, and to exhibit better hygiene practices. For these reasons, the present review does not attempt to apportion a share of the benefits to the presence of water in the household environment; and because of differences in the design of the studies which make comparisons difficult, it only attempts to determine for each study the trends in trachoma endemicity in relation to the availability of water for domestic use of the different population subgroups.

The use of a single parameter, whenever possible, makes comparisons easier. In this review, the ratio of the prevalences of trachoma in population groups exposed to different conditions for water

[a] **Delon, P.J.** *Epidemiology and mass treatment of communicable eye diseases in Indonesia* (unpublished document, WHO/SEARO/TRACH/5, 1958).

Table 2: **Prevalence ratios of trachoma cases from various studies, according to five different indicators**

Country	Nature of trachoma lesions	Prevalence ratio (risk estimate)	Definition of exposure variables
1. *Distance from water sources*			
India (*14*)[a]	All stages	1.4	Distance >200 m vs <200 m[b]
China (*1*)	Active cases	1.2	Distant source vs home connection
		1.3	Distance >200 m vs <200 m
		1.4	Distance >500 m vs <500 m
		1.5	Distance >500 m vs home connection
Malawi (*23*)	Inflammatory cases (age <6 years)	1.2	Distance covered in >5 min vs <5 min
		1.4	Distance covered in >30 min vs <5 min
		1.7	Distance covered in >60 min vs <5 min
Morocco (*9*)	Active cases	1.07	Distance >500 m vs <500 m
		1.14	Distance >1500 m vs <1500 m
Morocco (*9*)	Grave cases	1.0	Two definitions (>500 m and >1500 m)
Tunisia (*15*): village 1	Scarring lesions	3.6	Distant source vs home supply
Tunisia (*15*): village 2	Scarring lesions	2.1	Distant source vs home supply
2. *Quantity of water (per capita daily consumption)*			
Mozambique (*4*)	Stages II–IV	3.2	Average 8 litres vs 14 litres
Morocco (*9*)	Active cases (all ages)	1.1	< 5 l vs > 5 l daily
		1.2	<10 l vs >10 l
		1.2	< 5 l vs >10 l
Morocco (*9*)	Active cases (<15 years)	1.0	< 5 l vs > 5 l daily
		1.1	<10 l vs >10 l
		1.1	< 5 l vs >10 l
Morocco (*9*)	Grave cases (>15 years)	1.1	< 5 l vs > 5 l daily
		1.2	<10 l vs >10 l
		1.3	< 5 l vs >10 l
3. *Water quality*			
Indonesia[c]	All cases	1.05	Households using wells vs piped water
		1.03	Households using canals vs piped water
China (*1*)	Active cases	1.5	In-house supply from draw-well vs tap
Malawi (*23*)	Inflammatory cases (age <6 years)	1.2	Supply from unprotected wells vs boreholes
		1.3	Supply from unprotected wells vs river
4. *Personal hygiene*			
Sudan (*11*)	All stages	2.2	Less than 1 bath daily vs daily bath
Mexico (*20*): Naranja	All stages (age 0—10 years)	1.8	Face washing <7 times a week vs >7 times
Mexico (*20*): Chaonil	All stages (age 0–10 years)	2.0	Face washing <7 times a week vs >7 times
Malawi (*23*)	Inflammatory cases (age <6 years)	1.06	Face washing <once/day vs 2 times
5. *Living standards*			
Australia (*16*)	Follicular	11.5	Aborigines in the lowest water access grade vs the best
	Cicatricial	8.2	Aborigines in the lowest water access grade vs the best
	Follicular	8.5	Aborigines in the lowest category for waste disposal vs the best
	Follicular	12.8	Aborigines in the lowest category for sewerage vs the best
	Follicular	10.8	Aborigines in the lowest category for housing vs the best
Australia (*21*)	Active cases (age 0–11 years)	3.1	Aborigines in zone I vs zone III[d]
	Active cases (age 0–21 years)	2.9	Aborigines in zone I vs zone III[d]
Japan (*13*)	All cases	5.9	Urban schoolchildren with limited water supply vs home pipe connection
		12.5	Rural schoolchildren with limited water supply vs home pipe connection

[a] Figures in parentheses are the references to the studies concerned.
[b] Actually 200 yards.
[c] See footnote *a*, page 12.
[d] See Table 1.

accessibility has been calculated from the original published data (Table 2). In many studies, the examination for trachoma of population samples chosen on the basis of water indicators would allow for the determination of the relative risk associated with the relevant exposure. However, the estimation of the relative risk should be based on the incidence, whereas the available surveys report on prevalence rates. Thus, prevalence ratios have been preferred to relative risk estimates and to odds ratios for methodological reasons. For the same reasons, confidence limits could not be calculated.

Results and comments

Four indicators are related to water accessibility: the *distance* between individual households and the source of water, the average *quantity* of water used per person daily, the *quality* of the water, and *hygiene* practices related to water (bathing, face washing). The prevalences of trachoma were compared in population groups with various degrees of exposure as measured by these indicators. In some cases, the influence of each indicator could not be separated from the overall social and economic conditions (*13*, *16*), and the results are presented under the heading of *living standards*. Table 2 provides prevalence ratios of trachoma in countries with various exposure conditions.

Distance. There is a clear advantage in having a water source at home compared with a distant source. The study in Tunisia did not estimate the distance between the water source and the households with no pipe connection, but showed a striking difference in the prevalence of scarring lesions. A distance of more than 500 m in China (Province of Taiwan) and any walking distance in excess of 30 minutes in Malawi seem to be serious risk factors for trachoma. Data also show that the further the water source, the higher the risk of trachoma. Ratios are not comparable for similar distances in different countries; a distance of 200 m seems to carry a greater risk in India than in Taiwan or Morocco. However, in any given situation the frequency of trachoma rises with increasing distance from the water source.

Longer distances are also associated with infection at younger ages. In China, the peak prevalence of active cases was observed in the 10–14-year age group in families using a water source at a distance of 100 m or more; the peak prevalence occurred in the 15–19-year group in families where the water source was less than 100 m. In Tunisia, the intensity was greater in children under 5 years and complications occurred more frequently in the 6–14-year age group in households which had no pipe connection. It is likely that an increased consumption of water, especially for personal hygiene, is the factor limiting the transmission of trachoma.

It appears that when the water source is far away, there may be only a single collection of water per day whereas several trips are likely when the source is closer. However, several studies in our series have failed to demonstrate a relationship between distance and daily consumption (*9*). When water is a limited commodity, mothers may value it too much to use it liberally for hygiene, especially in children. This attitude may persist even though water is provided in sufficient quantities in the vicinity of households, thus reducing the expected impact of water intervention studies. An investigation into this complex relationship in rural Africa (*28*) has shown that water consumption tends to increase when the journey time decreases. However, a plateau is reached when the distance to the water source is covered in less than 30 minutes, which is equivalent to a maximum of about one kilometre. Only when water is supplied in the household does consumption increase further, but then it rises by a factor of three or more.

Quantity. Here the evidence for an impact is not so clear. The differences in water consumption do not induce dramatic changes in the prevalence of trachoma, but the prevalence ratio is consistently greater than unity when the effect of low consumption levels is compared to high levels. In addition, the authors of the Moroccan study concluded that a higher prevalence of severe cases was associated with the lowest water consumption in all age groups (*9*).

The data from Mozambique (*4*) also should not be regarded as conclusive as there was no homogeneity in the samples; the per capita consumption was an average value for the village, including the whole range of consumption patterns. In addition, late stages of trachoma, which could have resulted from infections acquired before the test village was supplied with a new water system 18 months before the survey, were included in the study and may have distorted the conclusions. A most interesting finding of the study is that the water utilization for children's hygiene was most sensitive to changes in the per capita daily availability of water; when the water collection journey time was reduced from five hours to 15 minutes, the total per capita daily consumption of water increased four times, out of which the amount used for bathing children increased 30 times.

Quality. Results from Indonesia and Mexico indicate that the quality of water had no effect on the prevalence of trachoma. The higher risk in China

(Province of Taiwan) and to a lesser extent in Malawi, associated with the use of wells, would require additional supporting evidence that it was independent of the effect of quantity.

Hygiene. There is no doubt that bathing, among other individual hygiene practices, plays a significant role in reducing the incidence of trachoma. Bisley (*2*) suggested in Kenya that daily face washing could reduce both prevalence and intensity in children. Results from Mexico show that this impact was associated with face washing and not with washing of other parts of the body, and that daily washing was necessary to manifest an impact on trachoma. In Australia (*8*), the daily bath of schoolchildren also showed a significant improvement in trachoma assessed by the examination of conjunctival smears. In the Mozambique study (*4*), it is not possible to determine the prevalence of trachoma associated with different bathing frequencies, but the prevalence of trachoma in the village where only one third of the children had a daily bath was two times higher than that in the village where all the children had a daily bath. On the other hand, the Malawi study failed to demonstrate a significant impact from face washing.

Living standards. Water, as one element in an overall welfare situation, is not a discriminant factor for trachoma. Sewerage, housing, and waste disposal seem equally important; income, education, and occupation of the head of the household lead to similar results. In these studies, access to large quantities of water, or even unlimited access to water, is linked to the improvement of a whole set of socioeconomic conditions, all of which contribute to a reduction in the transmission of trachoma. Similar observations in India (*14*) showed a regular decline in trachoma associated with rising household per capita income. However, the same study indicated that the impact of the distance to the water source on trachoma persisted when the results were controlled for income.

Conjunctivitis and domestic water

The assessment of the impact of water supply on acute conjunctivitis is difficult because of the epidemic character of outbreaks resulting from the high infectivity of the bacterial and viral agents, and because of the seasonal pattern of the epidemics. Moreover, epidemiological information is scarce because the absence of debilitating complications makes it a "mild disease". However, conjunctivitis is a disease of public health importance owing to its frequency, the burden on the resources of the health services (representing up to 15% of total outpatient visits in health facilities in rural Africa), and the associated cost to individual patients and the community.

Several studies on the impact of water supply failed to document changes in the incidence of conjunctivitis because of the small number of cases during the study period (*4*) or because of seasonal outbreaks (*10*). Other studies provide results which may appear conflicting. Majcuk (*11*) in Sudan observed that the prevalence of conjunctivitis was significantly lower in people bathing daily compared with people bathing occasionally. Other authors reported no change in the incidence of eye infections during the year following the introduction of water supply systems (*10*, *25*). On the other hand, in Port-au-Prince, Haiti, families faced with an accidental 10-week acute shortage of water did not suffer a higher incidence of conjunctivitis than families unaffected by this breakdown (*22*). Table 3 summarizes the available information from these studies.

In general, the studies seem to show a trend towards a reduced incidence of conjunctivitis when water is available in unlimited quantity. However, this trend never reaches the level of statistical significance. There is also no indication that an improved quality of water can reduce the incidence of conjunctivitis.[b] Although water-borne transmission is known to occur in places such as hospitals and nurseries (*27*), it does not seem to play a major role in the open environment.

A provisional conclusion is that there is no scientific evidence that change in water supply influences the incidence of conjunctivitis. There is no evidence supporting the 70% reduction attributable to water improvements, as reported in textbooks. The nature of the agents, their high infectivity through interhuman contacts, and the epidemiological pattern of these infections make such a reduction unlikely. Thus, the broad category of conjunctivitis cannot be used as an indicator to assess the impact of water in a population.

Conclusions

This review of field studies shows that a decrease in the risk of trachoma is associated with the following: a reduction in the distance between households and water sources, an increase in water consumption (which often depends on the distance to the water source), improvement in personal hygiene (such as face washing), and possibly improvement in water quality. The extent to which trachoma is reduced depends on local circumstances including behav-

[b] See footnote *a*, page 12.

Table 3: **Summary of published information on conjunctivitis in relation to water accessibility**

Country	Type and size of sample	Indicator for water supply	Observations on conjunctivitis	Comments
Guatemala (*25*)[a]	3 years' longitudinal follow-up of 1097 people in one village with improved water supply and 1006 in a control village	Home supply of high quality chlorinated water of unlimited quantity in the 164 homes of the test village. Shallow wells in control village. Per capita daily consumption 69 litres in test village, $2\frac{1}{2}$ times lower in control village	Annual incidence of conjunctivitis and otitis computed together on two-weeks recall experience in each month: in 1973 (before intervention), incidence was 3.5 per 1000 population; in 1976, 4.3 per 1000. No significant change in incidence rates during the seven semesters of surveillance. No difference with control village	True incidence would be higher if based on periods of full months. No change in other health impact indicators. No changes following introduction of health education programmes
Haiti (*22*)	Random sampling of 400 households in each of two areas of Port-au-Prince identical except for water quantity	Accidental water deprivation of part of the city. Comparison of families using <19 litres per person per day and families using more	The 10-week incidence of conjunctivitis was 8% in families in the low-consumption group and 7.2% in the high-consumption group	The 10-week period of water shortage might be too short to induce a difference. Also the occurrence of serious shortages is so frequent that the reported episode may not be exceptional and thus could not have any visible impact
Indonesia[b]	1265 households in three villages	Type of supply: pipe, well, canal	Absence of conjunctivitis in 7% of the households using piped water and in ≤2.5% of those using wells or canals	No statistical significance
Malawi (*10*)	1178 children (age <5 years) in 8 groups of villages surveyed during one year before and one year after introduction of piped-water supply	Community piped-water supply system with public tap. Per capita daily consumption increased from 12.8 to 15.5 litres among users.	4% decrease in incidence of eye infections between baseline year and second half of the year after intervention. At this time, however, no difference between families using new system and families not using it	Outbreak of conjunctivitis during each rainy season. Epidemic character of the disease explains differences which cannot be related to water improvement
Sudan (*11*)	Random sampling of 478 people	Bathing habits	73% prevalence of conjunctivitis in people bathing occasionally and 50% in people bathing daily	

[a] Figures in parentheses are the references to the studies concerned.
[b] See footnote *a*, page 12.

ioural patterns and overall environmental conditions. The extent to which this reduction is measurable depends on selection of appropriate indicators and analysis of confounding factors.

The type of trachoma lesion used by authors as an epidemiological indicator varies, some referring to all cases, i.e., the overall prevalence in the study population, and others to active cases, follicular trachoma and inflammatory cases, as opposed to grave cases or scarring lesions. Some studies refer to the entire population; others use age-specific prevalence rates. These variations in the definition of indicators may be responsible for the discrepancies in impact assessment.

Several studies suggest that a more sensitive indicator relating to water consumption is the intensity of the eye infection, especially the inflammatory reaction (*2*, *5*, *8*, *9*, *15*, *23*), and not the overall prevalence of infection. The accuracy of the analysis is therefore greater if it is based on only the intensity of trachomatous inflammation.

This observation also provides a better understanding of the benefits of water availability. It is unlikely that the provision of water in any quantity can result in the elimination of trachoma from a community because the infection is mainly spread through interhuman contacts, flies, contaminated clothes, etc. Water used for personal hygiene reduces the spread of *Chlamydia*. Therefore, it is possible to assume that providing water to a community will reduce the intensity of the infection, thus leading to fewer complications including blindness. Improving the water supply can therefore change the epidemiological pattern of trachoma from a severe blinding endemic disease constituting a major public health problem to a relatively mild non-blinding infection.

Another important outcome is the evidence that the overall socioeconomic situation of the community (i.e., the living standards) is a much more important risk factor for trachoma than water itself. It means that water is a necessary condition to reduce the risk, but that it is not sufficient to induce marked differences. Changes result from the compounded effect of behavioural and environmental determinants (such as housing conditions, waste disposal, hygiene practices, literacy, income level, etc.), among which water availability is a key factor which interacts positively with all the other elements.

Acknowledgements

We thank Mr Sandy Cairncross, London School of Hygiene and Tropical Medicine, and Dr B. Thylefors, Programme for the Prevention of Blindness in WHO, for their in-depth and critical review of the manuscript.

Résumé

L'eau, le trachome et la conjonctivite

Il est devenu banal de dire que dans une collectivité affectée par le trachome, la maladie décroîtra spontanément si l'eau lui est fournie en quantité suffisante. Cet article tente de retrouver les fondements bibliographiques d'une telle assertion. A cette fin, quinze études concernant le trachome et cinq autres concernant les conjonctivites ont été sélectionnées dans la littérature comme répondant aux trois critères suivants: définition précise de la population étudiée; utilisation de paramètres permettant l'analyse quantitative de la disponibilité et de l'utilisation de l'eau; fiabilité du diagnostic des maladies oculaires.

Le facteur climatique qui associerait trachome et zones arides n'est pas entièrement vérifié. Ni la latitude, ni le nombre de journées d'ensoleillement, ni les radiations ultra-violettes, ni la pluviosité ne sont des déterminants du trachome. Seul le coefficient d'évaporation paraît directement associé à l'extension de l'endémie.

L'étude des relations entre l'usage domestique de l'eau et l'incidence du trachome a nécessité une ré-analyse des données publiées. Pour rendre la lecture homogène et faciliter la comparaison, un rapport de prévalence du trachome (donnant une estimation du risque) a été calculé pour une série de sous-échantillons de population qu'il a été possible d'isoler a posteriori en fonction de leur degré de relation avec l'eau. Ainsi, l'effet de l'eau été évalué selon trois variables quantitatives caractérisant l'accessibilité de l'eau (distance, quantité, qualité), une variable semi-quantifiable d'utilisation de l'eau (hygiène individuelle), et un indicateur composite plus difficile à cerner (qualité de la vie).

Par-delà la disparité des résultats, une tendance très nette se dessine: il y a un moindre risque de trachome quand la distance aux sources d'approvisionnement en eau se réduit, quand les quantités utilisées augmentent, quand certaines pratiques d'hygiène sont plus fréquentes. Il y a surtout une très forte réduction de l'incidence du trachome quand les niveaux de vie s'élèvent et que non seulement l'accès à l'eau s'améliore, mais que l'habitat, l'évacuation des déchets, l'assainissement, le niveau d'éducation etc... sont meilleurs. Toutefois, l'eau reste un élément primordial de cet ensemble puisqu'à revenu égal une moindre consommation d'eau est un facteur de risque pour le trachome.

En revanche, pour les conjonctivites non trachomateuses, aucune influence nette de la dis-

ponibilité en eau ne peut être mise en évidence.

Cette revue de la littérature n'apporte pas de preuve irréfutable confortant l'argument souvent avancé qu'un approvisionnement illimité en eau réduirait de 60% la prévalence du trachome dans les communautés qui en sont atteintes. Si l'on peut dire que la disponibilité de quantités suffisantes d'eau réduit l'incidence du trachome, les observations de terrain ne permettent pas de chiffrer cet impact.

Cela pourrait être imputable à l'absence d'un indicateur à la fois fiable et sensible utilisable dans les enquêtes de terrain. La prévalence du trachome dans l'ensemble de la population n'est à l'évidence pas cet indicateur. Les auteurs suggèrent d'utiliser de préférence l'intensité de la réaction inflammatoire dans un groupe cible, dont l'âge est à définir selon le contexte épidémiologique. L'expérience a montré que cet indicateur était le plus sensible pour mesurer l'impact de l'eau comme celui d'autres programmes d'intervention.

References

1. **Assaad, F.A. et al.** Use of local variations in trachoma endemicity in depicting interplay between socioeconomic conditions and disease. *Bulletin of the World Health Organization*, **41**: 181–194 (1969).
2. **Bisley, G.G.** *A handbook of ophthalmology for developing countries*. Oxford, Oxford University Press, 1973.
3. **Bobb, A.A. & Nichols, R.L.** Influence of environment on clinical trachoma in Saudi Arabia. *American journal of ophthalmology*, **67**: 235–243 (1969).
4. **Cairncross, S. & Cliff, J.L.** Water use and health in Mueda, Mozambique. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **81**: 51–54 (1987).
5. **Dawson, C.R. et al.** Severe endemic trachoma in Tunisia. *British journal of ophthalmology*, **60**: 245–252 (1976).
6. **Reinhards, J.** Aspects actuels et problèmes de l'épidémiologie du trachome. *Revue internationale du trachome*, **47** (3): 213–295 (1970).
7. **Foster, S.O.** Trachoma in an American Indian village. *Public health reports*, **80**: 829–832 (1965).
8. **Hardy, D. et al.** The cytology of conjunctival smears from aboriginal schoolchildren at Yalata, South Australia, after improved hygienic conditions and treatment with oxytetracycline and systematic sulphormetoxine. *American journal of ophthalmology*, **63**: 1538–1540 (1967).
9. **Kupka, K. et al.** Sampling studies on the epidemiology and control of trachoma in southern Morocco. *Bulletin of the World Health Organization*, **39**: 547–566 (1968).
10. **Lindskog, U.** *Child health and household water supply*. (Linköping University Medical Dissertations No. 259.) Linköping, University Press, 1987.
11. **Majcuk, J.F.** A study of trachoma and associated infections in the Sudan. *Bulletin of the World Health Organization*, **35**: 262–272 (1966).
12. **Mann, I.** Correlation of race and way of life in Australia and the territory of Papua and New Guinea with incidence and severity of clinical trachoma. *American journal of ophthalmology*, **63**: 1302–1309 (1967).
13. **Marshall, C.L.** The relationship between trachoma and piped water in a developing area. *Archives of environmental health*, **17**: 215–220 (1968).
14. **Mathur, G.M. & Sharma, R.** Influence of some socioeconomic factors on the prevalence of trachoma. *Indian journal of medical sciences*, **24**: 325–333 (1970).
15. **Messadi, M. et al.** Epidémiologie et histoire naturelle du trachome en Tunisie. *Revue internationale du trachome*, **51** (4): 7–29 (1974).
16. **Royal Australian College of Ophthalmologists.** *The National Trachoma and Eye Health Program of the Royal Australian College of Ophthalmologists*, Sydney, 1980.
17. **Portney, G.L. & Hoshiwara, I.** Prevalence of trachoma among southwestern American Indian tribe. *American journal of ophthalmology*, **70**: 843–848 (1970).
18. **Pratt-Johnson, J.A. & Wessels, J.H.W.** Investigation into the control of trachoma in Sekhukuniland. *South African medical journal*, **32**: 212–215 (1958).
19. **Stephenson, S.** *Epidemic ophthalmia, its symptoms, diagnosis, and management, with papers upon allied subjects*. New York, McMillan & Co., 1896.
20. **Taylor, H.R. et al.** The ecology of trachoma: an epidemiological study in Southern Mexico. *Bulletin of the World Health Organization*, **63**: 559–567 (1985).
21. **Tedesco, L.R.** Trachoma and environment in the Northern Territory of Australia. *Social science and medicine* **14D**: 111–117 (1980).
22. **Thacker, S.B. et al.** Acute water shortage and health problems in Haiti. *Lancet*, **1**: 471–473 (1980).
23. **Tielsch, J.M. et al.** The epidemiology of trachoma in Southern Malawi. *American journal of tropical medicine and hygiene*, **38**: 393–399 (1988).
24. **White, G.F. et al.** *Drawers of water*. Chicago, Chicago University Press, 1972.
25. **Shiffman, M.A. et al.** Field studies on water sanitation and health education in relation to health status in Central America. *Progress in water technology*, **11**: 143–150 (1978).
26. **Misra, K.K.** Safe water in rural areas. *International journal of health education*, **18**: 53–59 (1975).
27. **Salminen, L. et al.** [Ophthalmia neonatorum from contaminated water.] *Duodecim*, **96**: 964–967 (1980) (in Finnish).
28. **Cairncross, S.** The benefits of water supply. In: Pickford, J., ed. *Developing World Water*, Vol. 2. London, Grosvenor Press, 1987, pp. 30–34.

Reprint No. **4943**