WORLD VIEW

Prevalence and risk factors for trachoma and ocular *Chlamydia trachomatis* infection in Niger

A Abdou, B Nassirou, B Kadri, F Moussa, B E Munoz, E Opong, S K West

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See end of article for authors' affiliations

Correspondence to:
Dr S West, Dana Center for Preventive Ophthalmology, Wilmer Room 129, Johns Hopkins Hospital, 600 N Wolfe Street, Baltimore, MD 21205, USA; shwest@jhmi.edu

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Aims: To determine the association of personal and household risk factors for trachoma and ocular *Chlamydia trachomatis* infection in Niger.

Methods: 12 villages were randomly selected. A census of all households was carried out, and 651 children aged 1–5 years were randomly selected and examined. Household and personal characteristics were determined, trachoma was clinically assessed and a swab for ocular *C trachomatis* infection was taken.

Results: The prevalence of trachoma was 43% (95% confidence interval (CI) 39% to 47%) and of infection was 21% (95% CI 18% to 24%). Children aged 3–5 years had a stronger association of clinical signs with infection, compared with those aged 1–2 years. Those with unclean faces were three times more likely to have clinical trachoma or ocular *C trachomatis* infection, compared with those with clean faces (OR 3.1 (95% CI 1.6 to 6.2) and 3.0 (95% CI 1.4 to 6.3), respectively). 75% of compounds were within 30 min of a water source. Flies on the face were a risk factor for trachoma but not for *C trachomatis* infection.

Conclusions: The different association of clinical signs with infection in younger versus older children may be an age-dependent difference in the duration of clinical disease. In Niger, unclean faces are a major risk factor for trachoma. The ready availability of water for washing suggests that further research on the effect of a strong health education campaign promoting clean children is warranted in this area.

The World Health Organization (WHO) has set a target for global elimination of blinding trachoma by the year 2020,¹ and has endorsed the SAFE strategy for trachoma control. SAFE stands for Surgery (for trichiasis), Antibiotics (for active trachoma), Face washing (to decrease transmission) and Environmental change (to interrupt transmission). The determination of hygiene and environmental factors associated with both trachoma and infection may be key to appropriately targeting national programmes. Although risk factors for trachoma have been studied in francophone Africa,² nothing is known about risk factors for infection.

In the context of a community-based clinical trial, we had the opportunity to determine the baseline prevalence of trachoma and *Chlamydia trachomatis*, and risk factors for infection and disease, in 12 randomly selected villages in Maradi, Niger.

METHODS

Baseline data on 12 villages randomised for a community-based trial on the effects of improved water, health education and sanitation on trachoma were collected. The 1995 census of Maradi was used to identify villages containing between 600 and 1200 people (a size range that provided enough children aged 1–5 years to examine, without expending undue resources on large villages). Of a list of 85 villages, 18 were eligible; 20 villages had no census information, 30 had populations <600, 9 villages already had improved water and sanitation programmes, and 8 had populations >1200. Twelve villages were randomly selected.

Trained interviewers conducted a census, collecting data on the presence of a school, market, women's association and distance to the health centre. Each collection of households or compound was visited, and data on distance to a water source, time to walk and to wait at a water source were collected. Interviewers observed the presence of a tin roof, a latrine, an animal pen and garbage inside the compound.

We aimed for a random sample of 60 children aged 1–5 years in each village. A stratified random sampling strategy was used

to select no more than one child per mother to minimise clustering of children within households. In most villages, the 1995 estimate of the population was wrong, and there were insufficient children to sample 60. This was due to the severe famine in Niger, causing child mortality and households to leave the area. Of 679 children selected, we examined 651 (96%).

Before the surveys, the two trachoma graders were standardised against a senior grader (AA), with reliability of $\kappa = 0.65$ for follicular trachoma and for trachoma intense. All people who handled specimens were trained in proper laboratory techniques, using sterile gloves changed between participants.

A child's clean face was defined as the absence of ocular and nasal secretions and food on the face. Flies on the face was coded "yes" if a fly landed anywhere on the child's face within a 3 second window. The face assessment was carried out before the trachoma examination by a team member who did not assess trachoma.

The trachoma grader, wearing 2.5× loupes, assessed each eye for follicular trachoma and trachoma intense using the WHO simplified grading scheme.³ The technician, following careful procedures, rolled the ocular swab three times across the tarsal plate to obtain a specimen. All swabs were kept frozen in the field until transferred to a –20°C freezer. All the specimens were shipped to the International Chlamydia Laboratory at Johns Hopkins, Baltimore, Maryland, USA, and processed for *C trachomatis* using Amplicor qualitative polymerase chain reaction (Roche Molecular Systems, Branchburg, New Jersey, USA). Samples were processed according to the manufacturer's specifications, with positive and negative controls in each run. Swabs were designated as positive or negative according to the manufacturer's specifications. For these analyses, "infection" was defined as a positive laboratory result.

If the child had trachoma, tetracycline ointment and instructions on proper use were provided.

Abbreviation: WHO, World Health Organization

The baseline prevalences of trachoma and ocular *C trachomatis* infection in the villages were calculated, with 95% confidence intervals (CIs). The association of infection with clinical trachoma was tested for uniformity across ages. The clean face variable was constructed as clean, clean but with flies and unclean (with or without flies). Time-to-water variables were categorised as <30 min $v \geq 30$ min. Distance was categorised into three distances, based on logical cut points in the data. Risk factors for trachoma and ocular *C trachomatis* infection were determined using univariate assessments and multivariate logistic models, with CIs adjusted for clustering within villages.

Ethical approval for all protocols and procedures was granted by the Johns Hopkins University Institutional Review Board, and the National Ethical Review Committee of the Niger Ministry of Health.

RESULTS

The overall prevalence of trachoma in these villages was 43% (95% CI 39% to 47%), and that of *C trachomatis* infection was 21% (95% CI 18% to 24%; table 1). We found a considerable variation in active trachoma across villages, from 82% to 3%. In general, villages with high trachoma rates had high infection rates, although in two villages where $>40\%$ of children had trachoma, the rates of infection with ocular *C trachomatis* were low.

Infection was associated with clinical signs of trachoma, with only 9% of those with no follicular trachoma or trachoma intense signs positive for chlamydia (table 2). Children with trachoma intense had the highest rate of infection (56%). We found no difference by grader in this association, suggesting good standardisation (data not shown). However, there were substantial age differences, with children aged 1–2 years much less likely to have infection with follicular trachoma compared with children aged ≥ 3 years.

Children with trachoma were more likely to have unclean faces, or clean faces but with flies (table 3). The time taken to walk to the water source, and wait for collecting water, was <30 min for 75% of households. Children with and without trachoma were equally likely to reside in houses with access to water, as measured by time and distance. Those children in households with an animal pen in the compound were more likely to have trachoma, but this was not statistically significant. Crowding, as measured by number of children aged 1–5 years in the compound, was also associated with trachoma, as was garbage within the compound. Only one village had a market, and all but one village was close to a health centre. Therefore, the only village characteristic studied

was the presence of a women's/village association (three villages had neither association compared with the rest, which had both). However, trachoma rates of children in villages with and without the associations were similar.

An unclean face was also a strong risk factor for infection (table 4). Interestingly, the presence of flies on a clean face was not associated with infection. Garbage in the compound and an animal pen were both, associated with infection. We found no difference by infection in the time to walk or wait to collect water. Children who were aged 3–5 years were more likely to have infection compared with children aged 1–2 years, and crowding was a risk factor for infection. Multivariate analyses showed a consistent association of an unclean face with both trachoma and infection (table 5). Active trachoma, but not infection, was also associated with children whose faces were clean but who also had flies.

DISCUSSION

Niger is on the WHO list of areas endemic with trachoma, and this survey confirms that designation. The prevalence of trachoma in the villages was high, an average of 43% in children aged 1–5 years. This rate is similar to rates from neighbouring Mali, where 50% of pre-school children had trachoma.² Infection was also high (21%) and linked to clinical signs. The association of infection with clinical trachoma was similar to that observed in other studies, with the highest rates in children with trachoma intense.^{4–13} The difference by age in the association of infection with clinical signs was interesting, as the youngest children were almost half as likely to have infection with follicular trachoma and trachoma intense compared with those aged 3–5 years. This finding was also reported by Bird *et al.*⁶ The youngest children may have a longer period of clinical signs without infection, compared with the older children. Bailey *et al.*¹⁴ reported that the duration of trachoma in adults is shorter than in children, and although they examined wider age ranges, our finding suggests that the phenomenon may start at a very young age in hyperendemic areas. Children aged 3–5 years are likely to have experienced more previous episodes of infection compared with children aged 1–2 years, which may improve their ability to clear the clinical signs. Longitudinal studies of disease duration and infection would confirm this cross-sectional finding.

The variability of rates between villages in the same district is similar to variation in trachoma and infection in other settings.^{13 15 16} In one village, the level of trachoma and infection was below the WHO threshold for mass treatment.¹⁷ This village was very different from the others, as it was small, had no

Table 1 Prevalence of trachoma and *Chlamydia trachomatis* in a sample of children aged 1–5 years, by village, in Maradi, Kornaka West district, Niger

Village	Population size (n)	Index children (n)	% Active trachoma (95% CI)	% TI with or w/o TF (95% CI)	% Infection (95% CI)
Dan Faraou Kore	665	59	29 (17 to 41)	5 (0 to 11)	27 (15 to 39)
Dan Dadi	1334	57	51 (37 to 64)	19 (9 to 30)	21 (10 to 32)
Katare	441	58	41 (28 to 54)	22 (11 to 33)	24 (13 to 35)
Guindo	841	55	35 (22 to 48)	7 (0 to 14)	27 (15 to 39)
Zacara	455	58	60 (47 to 73)	31 (19 to 43)	28 (16 to 39)
Bazala	598	57	82 (72 to 93)	46 (32 to 59)	42 (29 to 55)
Gonau	642	54	15 (5 to 25)	0 (0 to 7)	9 (1 to 17)
Maibourgouma	778	57	51 (37 to 64)	21 (10 to 32)	21 (10 to 32)
Dogon Tapki	411	52	35 (21 to 48)	4 (0 to 9)	27 (14 to 39)
Dan Dawey Idi	661	57	44 (31 to 57)	21 (10 to 32)	7 (0 to 14)
Magagin Kore	782	54	54 (40 to 67)	9 (1 to 17)	7 (0 to 15)
Zango Tagaza	253	32	3 (0 to 9)	3 (0 to 9)	3 (0 to 9)
Total	7861	651	43 (39 to 47)	16 (13 to 19)	21 (18 to 24)

TF, follicular trachoma; TI, trachoma intense.

Table 2 *Chlamydia trachomatis* infection according to the clinical signs of trachoma by age in the sample of children aged 1–5 years, Maradi, Niger

Age group	Clinical sign	n	% Infection*
Overall	No TF, no TI	365	9.0
	TF only	172	26.2
	TI	104	55.6
Ages 1–2 years	No TF, no TI	144	8.3
	TF only	62	14.5
	TI	35	34.3
Ages 3–5 years	No TF, no TI	221	9.5
	TF only	110	32.7
	TI	69	66.7

TF, follicular trachoma; TI, trachoma intense.

*Test for trend, significant at $p < 0.001$.

village centre and the compounds were widely dispersed among fields. Thus, the opportunity to spread infection was limited. In addition, a different ethnic group lived in this village compared with the other villages. The two villages with high trachoma rates but low infection rates are puzzling. There were no differences in collection, storage or handling of specimens for

these two villages, and trachoma was assessed by different graders, suggesting that study procedures were an unlikely explanation. The variability among the villages should also be considered in the context of sampling villages within a certain size range. Even more variability may be observed if smaller or larger villages were included in these prevalence estimates. However, we found no effect of population size on estimates of trachoma or infection.

In general, risk factors for trachoma and for infection with ocular chlamydia were similar, as might be expected. Those with trachoma and infection were more likely to be aged 3–5 years, compared with 1–2-year-olds. The 3–5-year-olds are often sent off with older siblings and other children, whereas the 1–2-year-olds are kept close to the mother, until she has another child. Thus, the 1–2-year-olds are less likely to be infected by exposure to other children. No difference by sex was found in this study, similar to findings from Mali and Senegal.^{18–19} Sex differences seem to be more common in east Africa, as reported in Tanzania and Ethiopia.^{15–20}

An unclean face was the most important personal characteristic associated with trachoma and infection. Children whose faces were clean, but who had flies on the face, were more likely to have trachoma compared with children with clean faces and no flies, but there was no association of facial flies with infection. In light of the observation that eye-seeking flies carry *C. trachomatis*,²¹ we expected an association of facial flies with infection. However, the dose of chlamydia imparted by a fly may

Table 3 Percentage of children aged 1–5 years with trachoma, by personal, household and village characteristics

Characteristic	n	% With active trachoma	OR (95% CI)*	p Value
Age (years)				
1	110	40.9		
2	138	39.9		
3	140	45.0	1.06 (0.93 to 1.22)	0.38
4	138	43.5	(per increase of 1 year)	
5	125	46.4		
Sex				
Male	325	40.6	1.00	
Female	326	45.7	1.23 (0.92 to 1.65)	0.16
Facial cleanliness (%)				
Clean	68	22.1	1.00	
Clean, but with flies	258	41.9	2.54 (1.25 to 5.19)	0.01
Unclean	321	48.3	3.30 (1.83 to 5.94)	<0.001
Number of children <8 years (%)				
1–3	198	37.4	1.00	
4–5	153	43.8	1.34 (0.94 to 1.91)	0.10
>5	300	46.7	1.47 (0.94 to 2.28)	0.09
Latrine				
Absent	604	43.0	1.00	
Present	40	45.0	1.09 (0.69 to 1.72)	0.70
Garbage inside compound				
No	246	36.2	1.00	
Yes	401	62.0	1.55 (0.85 to 2.83)	0.15
Time to walk and wait for water				
<30 min for both	487	44.2	1.00	
>30 min to either walk or wait	159	40.3	0.86 (0.48 to 1.55)	0.62
Distance to water source (m)				
≤50	185	40.5	1.00	
51–150	180	53.9	1.72 (1.17 to 2.53)	0.006
>150	280	37.9	0.88 (0.55 to 1.41)	0.59
Animal pen within compound				
Absent	75	38.7	1.00	
Present	569	43.4	1.21 (0.67 to 2.16)	0.53
Village and women's association				
No	167	42.5	1.00	
Yes	484	43.4	1.05 (0.54 to 2.01)	0.89
Village population				
<650	339	43.7	1.00	
≥650	312	42.6	0.98 (0.40–2.36)	0.97

*Corrected to account for clustering within children living in the same village.

Table 4 Percentage of children aged 1–5 years with *Chlamydia trachomatis* infection, by personal, household and village characteristics

Characteristic	n	% With infection	OR (95% CI)*	p Value
Age (years)				
1	107	15.9		
2	134	11.9	1.31 (1.13 to 1.53)	<0.001
3	139	20.9	(per increase of 1 year)	
4	136	27.2		
5	125	29.6		
Sex				
Male	319	20.1	1.00	0.33
Female	322	22.4	1.15 (0.87 to 1.52)	
Facial cleanliness (%)				
Clean	66	5.2	1.00	0.23
Clean, but with flies	254	16.5	1.67 (0.72 to 3.88)	
Unclean	317	27.1	3.14 (1.52 to 6.47)	
Number of children <8 years (%)				
1–3	195	12.3	1.00	0.004
4–5	151	23.6	2.32 (1.32 to 4.09)	
>5	295	25.4	2.39 (1.40 to 4.10)	
Latrine				
Absent	596	21.3	1.00	0.88
Present	39	20.5	0.95 (0.53 to 1.73)	
Garbage inside compound				
No	243	14.4	1.00	0.02
Yes	395	25.3	2.00 (1.11 to 3.61)	
Time to walk and wait for water				
<30 min for both	480	21.5	1.00	0.76
>30 min to either walk or wait	157	19.8	0.90 (0.47 to 1.75)	
Distance to water source (m)				
≤50	180	21.1	1.00	0.77
51–150	179	22.9	1.09 (0.59 to 2.03)	
>150	277	19.9	0.90 (0.44 to 1.84)	
Animal pen inside compound				
Absent	73	17.8	1.00	0.51
Present	561	21.8	1.28 (0.61 to 2.70)	
Village and women's association				
No	168	25.8	1.00	0.47
Yes	484	20.0	0.83 (0.50 to 1.38)	
Village population				
<650	339	18.6	1.00	0.40
≥650	313	23.6	1.34 (0.68 to 2.66)	

*Corrected to account for clustering within children living in the same village.

be insufficient to establish an infection, but may be capable of eliciting the inflammatory response of clinical trachoma, which would be compatible with this observation. Although several other studies have found flies related to active trachoma in children,^{22–25} only one study evaluated flies and the risk of infection, as measured using a direct fluorescent antibody test.²⁶ We found a positive association between infection and flies around the house, but flies on the face were not measured.

Children with an unclean face (with or without flies) were threefold more likely to have trachoma and to have infection, compared with those with clean faces. This finding is similar to many other studies, where unclean faces are a risk for trachoma, and face washing is protective.^{22 24 27 28} These findings further support the association, and argue for the need for education on hygiene in these villages. As most of the households had access to a water source, and did not have a long distance to travel for

Table 5 Multivariate model of risk factors for trachoma and *Chlamydia trachomatis* infection in children aged 1–5 years in Maradi, Niger

Characteristic	Active trachoma OR (95% CI)*	<i>C trachomatis</i> infection OR (95% CI)*
Age (per one year increase)	1.07 (0.93 to 1.24)	1.39 (1.20 to 1.60)
Female	1.18 (0.81 to 1.58)	1.06 (0.85 to 1.33)
Number of children <8 years		
1–3	1.00	1.00
4–5	1.22 (0.87 to 1.71)	2.06 (1.28 to 3.33)
>5	1.27 (0.79 to 2.05)†	2.06 (1.29 to 3.27)
Face status		
Clean	1.00	1.00
Clean, but with flies	2.40 (1.12 to 5.14)	1.45 (0.60 to 3.49)
Unclean (with or without flies)	3.13 (1.57 to 6.24)	2.99 (1.41 to 6.33)
Garbage inside compound	1.43 (0.77 to 2.67)	1.83 (0.97 to 3.42)

C trachoma, *Chlamydia trachoma*.

*Adjusted for clustering of children within village.

†Test for trend $p=0.66$.

Values in bold statistically significant.

water, a strong health communication message about clean faces will not have to labour under unavailability of water for washing. This would make it ideal to further evaluate the effect of health education on trachoma and infection.

The absence of an association of trachoma or infection with distance to water is similar to that found in The Gambia.²⁹ In our population, as people were sufficiently close to water sources, the relationship of increased trachoma with increasing distance to water, as was seen for example in Tanzania,²² could not be observed.

The household characteristic primarily associated with trachoma was increasing number of children aged 1–5 years in the compound, or crowding. Transmission under such conditions is understandable, and has also been found in other studies.^{15 22 30} Notably, the risk seems to be most pronounced once there are more than three children, with no added risk beyond six children. Moalic *et al*¹⁸ did not find a relationship with sibship size in Senegal, but did not study the size of the compound, but rather only studied the number of children per mother.

There were limitations to our study that might affect the conclusions. Firstly, we limited the size of the villages that were eligible to be included in our survey; most of the villages in Kornaka West either did not have census information, or were smaller than our minimum sample of 600 people. Thus, prevalence rates may be higher or lower for this area as a whole, depending on the prevalences in villages larger or smaller than our sample. Secondly, although we attempted to conduct a census on all compounds in the village, we probably missed compounds that the village leadership did not choose or did not know to tell us about. The fact that the census was always less than that observed in 1995 suggests that some compounds may have been missed. On the other hand, the severe famine and mortality/household movement associated with it can also explain this difference, as Maradi was the epicentre of that disaster. As the 2005 census is not available, we cannot check our counts against the latest government figures. Secondly, we observed the children at the time of the ocular examination, although we tried to mitigate the effect of “washing for visitors” by not using the trachoma grader (seen as the senior team member) as the observer. The fact that more than half the children had unclean faces suggested that our efforts were at least partially successful, although the true rate of unclean faces may be even higher. Thirdly, there were so few compounds with latrines (4%) that the “observation” of latrines may reflect insistence by the head of the compound that one existed rather than a true observation. The absence of a difference by latrine status with trachoma or infection, contrary to what others have found,^{22 31} suggests that misclassification may be an issue.

In summary, efforts to improve cleanliness of faces in this environment may have a strong effect on trachoma and infection with *C. trachomatis*. Hsieh *et al*²⁷ found that improved facial cleanliness over a 6-year period was associated with a decline in trachoma at follow-up,²⁷ and a clinical trial of hygiene intervention resulted in less severe trachoma in children who had sustainable clean faces.³² Thus, this area of Niger should consider a health communication programme directed at improving hygiene behaviours. Such a programme could take advantage of the village and women’s associations as communication networks because these are relatively common.

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Authors’ affiliations

A Abdou, B Nassirou, B Kadri, F Moussa, Programme National de Lutte Contre la Cécité, Niamey, Niger

B E Munoz, S K West, Dana Center for Preventive Ophthalmology, Johns Hopkins University, Baltimore, Maryland, USA

E Opong, World Vision, Washington, DC, USA

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