Articles

Role of flies and provision of latrines in trachoma control: cluster-randomised controlled trial

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Summary

Background Eye-seeking flies have received much attention as possible trachoma vectors, but this remains unproved. We aimed to assess the role of eye-seeking flies as vectors of trachoma and to test provision of simple pit latrines, without additional health education, as a sustainable method of fly control.

Methods In a community-based, cluster-randomised controlled trial, we recruited seven sets of three village clusters and randomly assigned them to either an intervention group that received regular insecticide spraying or provision of pit latrines (without additional health education) to each household, or to a control group with no intervention. Our primary outcomes were fly-eye contact and prevalence of active trachoma. Frequency of child fly-eye contact was monitored fortnightly. Whole communities were screened for clinical signs of trachoma at baseline and after 6 months. Analysis was per protocol.

Findings Of 7080 people recruited, 6087 (86%) were screened at follow-up. Baseline community prevalence of active trachoma was 6%. The number of *Musca sorbens* flies caught from children's eyes was reduced by 88% (95% CI 64–100; p<0·0001) by insecticide spraying and by 30% (7–52; p=0·04) by latrine provision by comparison with controls. Analysis of age-standardised trachoma prevalence rates at the cluster level (n=14) showed that spraying was associated with a mean reduction in trachoma prevalence of 56% (19–93; p=0·01) and 30% with latrines (–81 to 22; p=0·210) by comparison with the mean rate change in the controls.

Interpretation Fly control with insecticide is effective at reducing the number of flies caught from children's eyes and is associated with substantially lower trachoma prevalence compared with controls. Such a finding is consistent with flies being important vectors of trachoma. Since latrine provision without health education was associated with a significant reduction in fly-eye contact by *M sorbens*, studies of their effect when combined with other trachoma control measures are warranted.

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Introduction

Trachoma, caused by conjunctival infection with *Chlamydia trachomatis*, is responsible for 15% of all blindness worldwide, and is the leading cause of preventable blindness.[1] The disease is endemic in the poorest countries, where an estimated 6 million people are blind and 148 million have active infections.[2] Despite this toll, trachoma has mostly been a forgotten disease of forgotten people, causing dependency and impeding development.[3,4] However, attitudes are now changing. A WHO global alliance and the International Trachoma Initiative have made major efforts to rid the world of blinding trachoma by 2020. These efforts are based on the SAFE strategy, which consists of trichiasis surgery for those at immediate risk of blindness, antibiotic distribution (supported through donation of patented pharmaceutical by Pfizer), promotion of facial cleanliness, and environmental improvement.[2] SAFE implies more than a drug distribution programme, and the complete strategy needs to be implemented to reduce transmission and to clear current infections.[5,6] Implementation of the full strategy is hampered by gaps in the knowledge about transmission, which hinders policy makers and programme managers, who need to make evidence-based decisions.

We did this study to respond to the need for a strengthening of the evidence base for environmental control of trachoma and to build on the findings of our pilot study[7] and other evidence associating the presence of flies on the face with active trachoma.[8–10] The pilot study compared insecticide spraying with no intervention in two pairs of villages and showed a 61% (95% CI 23–80) reduction in trachoma prevalence associated with fly control but lacked statistical power[11] and was unmasked.[12] We aimed to test the hypothesis that eye-seeking flies are trachoma vectors.

The Bazaar fly *Musca sorbens* is the most likely trachoma vector since it is strongly attracted to human eyes.[13,14] Studies on its ecology have shown that it breeds preferentially in exposed human faeces, but not latrines.[15,16] We tested whether latrine provision, without additional health education, would result in fewer *M sorbens* contacting eyes, and hence reduce trachoma.

Methods

Study population, recruitment, and randomisation

We did our study in the North Bank and Central River divisions of The Gambia between September, 1999, and September, 2001. These divisions were known to have a high trachoma endemicity.[17] Since fly control is best achieved at the community level, rather than by household or individual, the trial was randomised by cluster, each of which consisted of one or more closely neighbouring rural communities, to give a total population of 300–550. Clusters were at least 1·5 km apart but were not matched since this would have reduced the interpretability and statistical power

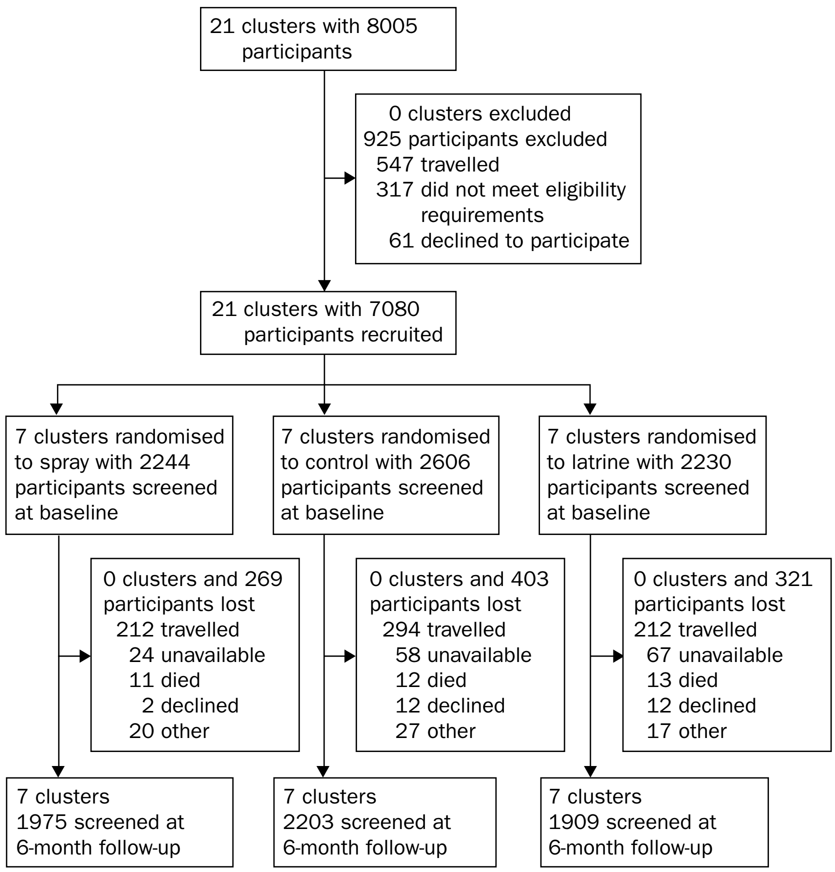

Figure 1: **Trial profile**

of the study. They were recruited in sets of three and randomly assigned to insecticide spray, latrines, or control by drawing from a hat at a meeting of village heads held at the district chief's office. Sets of three clusters were introduced into the study on a step-wise basis separated by 2 months to cover all seasons and aid logistics. After standardised sensitisation procedures, we undertook a census of the number of current residents and surveyed the household. Everybody over 4 months of age was recruited to the study provided that informed consent was obtained and they intended to stay in the village for 6 months. Households were surveyed for potential risk factors for trachoma by use of methods described elsewhere.[18] The joint ethics committee of The Gambia Government and Medical Research Council approved the study protocol, and we obtained informed consent from the villagers and guardians of children.

	Treatment group		
	Spray (n=1975)	Control (n=2203)	Latrine (n=1909)
Trachoma grade			
N	1483 (75%)	1785 (81%)	1518 (80%)
TF	121 (6%)	92 (4%)	92 (5%)
TI*	20 (1%)	15 (<1%)	14 (<1%)
TS	316 (16%)	296 (13%)	259 (14%)
TT	33 (2%)	13 (<1%)	25 (1%)
CO	2 (<1%)	2 (<1%)	1 (<1%)

Values are number of participants (%). Patients graded according to WHO simplified grading system. *Includes grades TI, TF/TI, and TS/TI.

Table 1: **Results of baseline trachoma survey for participants seen at baseline and at 6-month follow-up**

Interventions

Fly control

Flies were controlled for 6 months by space-spraying with water-soluble permethrin (Aqua-Resilin, Agrevo Environmental, UK, applied at 3·75–5·0 g/ha with Hudson Portapac, Hudson Manufacturing, Chicago, IL, USA, or Micronair AU8000, Micron, Bromyard, UK spray equipment). Fly control was based on an attack phase of spraying every 2 days for 2 weeks to kill the adult population followed by a maintenance phase of spraying twice a week.

Latrines

Gambian improved household pit latrines (non-ventilated) were provided without additional health education by use of the established government infrastructure. One latrine was allocated per household, or 20 people, whichever allowed the most latrines. Communal labour for pit digging and casting the ferro-reinforced cement latrine slabs was organised by the village development committees. Individual households were responsible for constructing a super-structure around their latrines. A cash donation of 120 Dalasi (about US$7) was given per latrine to the village development committees after all latrines for that community were complete and inspected. Latrines were located in consultation with each recipient household head and were less than 6 m from the household, further than 30 m from water sources, and not adjacent to a kitchen or footpath. Latrine uptake was monitored by visual inspection once a week for the first month, and once a month thereafter. The presence of adequate screening, faeces in the pit, flies around the slab, and a path worn to the latrine were used as indicators of use. All participating communities received latrines after the second trachoma survey.

Outcome measures

The primary outcome measures were fly-eye contact and prevalence of active trachoma.

Fly-eye contact

We monitored fly-eye contact once every 2 weeks in each cluster by use of eight 15 min hand-net catches of eye-seeking flies from the faces of volunteer children younger than 5 years of age. A contact was defined by the feet or proboscis of a fly touching the eye, lid margin, or lashes. The fly making the contact was caught in a hand-net; which was passed to an assistant who transferred the fly to a tube. Flies were identified by magnification. To ensure that environmental conditions (which affect fly behaviour) were similar between treatment groups, catches were done on the same day for each set of three clusters between 0800 h and 1100 h and the same location used each time.

Active trachoma

All study participants were screened for trachoma at baseline and after 6 months by one of us (KOL) by use of

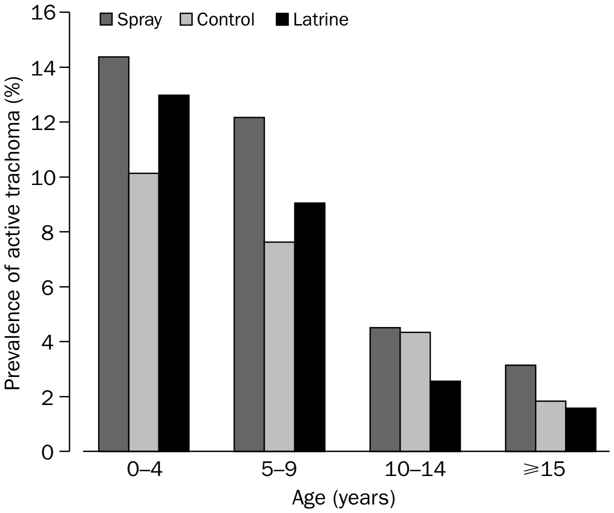

Figure 2: **Active trachoma at baseline by intervention and age-group**

the WHO simplified scheme.[19] Both eyes were inspected for trichiasis and the right eyelid everted and examined with ×2·5 magnification. If trachomatous follicles were present that did not qualify as grade TF (fewer than five, or <0·5 mm in diameter) then the left eyelid was also examined. A single photograph using either slide film (Fujichrome 100ASA) or a digital image (696×405 pixels) of the everted eyelid was taken to verify field grades. Three visits were made to each community per survey. Participants with intense symptomatic active trachoma (grade TI) were offered treatment with 1% tetracycline eye ointment or azithromycin (20 mg/kg) at baseline, participants with any sign of active trachoma were offered treatment after the second survey. Community-based lid surgery was offered where indicated.

Blinding

Photographs of eyes from study participants were graded by clinicians who were unaware of the field diagnosis, whether the photograph was from the baseline or follow-up survey, or if the participant was from an intervention or control cluster.

Statistical methods

Individual and household level risk factors were regarded in a series of logistic regression models as predictors of active trachoma at baseline. The mean of the cluster means of household and individual characteristics for each treatment group at baseline were compared with ANOVA.

We compared primary outcome measures between groups with the *t* test.[20] Since clusters were introduced on a step-wise basis to control for seasonal variations the analysis was done on differences in the mean outcomes of pairs of clusters, giving six degrees of freedom (seven pairs minus one for each comparison). Trachoma prevalence rates were age-standardised through the direct method within each set of three clusters into four age-groups: 0–4 years, 5–9 years, 10–14 years, and 15 years or older. Fly catch data were skewed by many zero catches, especially where there was fly control. They were normalised with an adjusted geometric mean for each cluster (one added to all values and subtracted from the calculated geometric mean) and cluster means compared with the *t* test. CIs for percentage changes in fly population were truncated at 100%. Agreement on diagnosis of active trachoma (grade TF or TI) was compared between field grader and photograph by use of Cohen's kappa statistic.[21]

Role of the funding source

The protocol was peer-reviewed by the main sponsors (DfID) and revised in light of their comments. The final protocol described here was approved by the UK Department for International Development, who had no further role in the study, analysis, interpretation or writing of the report.

Results

We surveyed 21 clusters with 8005 people. All 21 clusters were recruited and visited at follow-up; 7080 people were recruited from these clusters, and 6087 (86%) were seen at follow-up (figure 1). The number of participants lost to follow-up did not differ between either the spray and control groups (p=0·08) or between the latrine and control groups (p=0·55). The proportion lost because of travelling also did not differ between these groups (p=0·84 and p=0·57, respectively). Participants with active trachoma at baseline were 1·38 (95% CI 1·01–1·88) more likely to be lost to follow-up than were those without active trachoma, but the proportions with

	Spray (n=191)	Control (n=253)	Latrine (n=205)	p*
Household characteristics				
Sanitation				
No latrine	67·0 (18·9)	67·9 (13·2)	68·8 (14·9)	0·984
Local latrine	25·4 (18·4)	29·0 (11·0)	27·4 (14·2)	0·897
Improved latrine	7·6 (9·1)	3·1 (4·0)	3·5 (2·9)	0·354
Round-trip to water <30 min	82·4 (19·0)	70·0 (12·7)	84·5 (14·7)	0·204
Housing quality				
Iron-sheet roof	11·0 (9·0)	8·6 (4·7)	13·6 (9·6)	0·952
Grass roof and some cement in construction	46·8 (20·7)	49·1 (14·8)	49·5 (15·3)	0·397
Grass roof, mud walls, no cement in construction	42·2 (22·7)	43·3 (17·1)	36·9 (17·6)	0·803
Individual characteristics				
Age of population				
0–4 years	19·4 (3·3)	19·8 (2·1)	21·0 (1·6)	0·484
5–9 years	18·3 (2·7)	18·0 (1·5)	19·5 (2·3)	0·420
10–14 years	15·9 (4·1)	14·6 (2·4)	12·6 (2·0)	0·141
⩾15 years	46·0 (5·7)	47·6 (1·8)	46·9 (2·5)	0·725
Female sex	54·2 (3·2)	56·6 (2·6)	54·0 (5·6)	0·409
Ethnic origin				
Fula	40·2 (46·5)	35·1 (43·5)	43·5 (42·0)	0·938
Mandinka	4·6 (11·3)	7·4 (17·9)	2·1 (5·1)	0·736
Wollof	55·1 (50·9)	55·6 (42·8)	54·4 (42·6)	0·999

Data are mean of cluster means % (SD). *Results of one-way ANOVA.

Table 2: **Baseline characteristics of clusters by intervention group**

	Musca sorbens			*Musca domestica*		
	Spray	Control	Latrine	Spray	Control	Latrine
Triplet						
1	0·27 (–2·87 to 3·41)	2·32 (–3·22 to 7·86)	0·92 (–2·57 to 4·41)	0·00 (0·00 to 0·00)	0·04 (–0·46 to 0·54)	0·06 (–0·81 to 0·93)
2	0·61 (–2·73 to 3·95)	2·92 (–2·79 to 8·63)	1·78 (–2·02 to 5·58)	0·02 (–0·43 to 0·47)	0·33 (–1·34 to 2·00)	0·10 (–0·64 to 0·84)
3	0·19 (–0·88 to 1·26)	2·10 (–2·49 to 6·69)	1·23 (–2·35 to 4·81)	0·03 (–0·50 to 0·56)	0·64 (–1·73 to 3·01)	1·09 (–2·66 to 4·84)
4	0·11 (–0·09 to 0·31)	0·50 (–0·09 to 1·09)	0·48 (–0·76 to 1·72)	0·01 (–1·49 to 1·69)	0·05 (–2·20 to 2·30)	0·19 (–1·96 to 2·34)
5	0·06 (–0·94 to 1·06)	1·55 (–1·61 to 4·71)	1·16 (–2·08 to 4·40)	0·04 (–0·39 to 0·47)	0·22 (–1·30 to 1·74)	0·16 (–1·15 to 1·47)
6	0·16 (–1·96 to 2·28)	1·85 (–0·61 to 4·31)	1·85 (–1·90 to 5·60)	0·00 (0·00 to 0·00)	0·11 (–0·83 to 1·05)	0·09 (–0·56 to 0·74)
7	0·17 (–1·54 to 1·88)	1·95 (–1·36 to 5·26)	1·84 (–2·04 to 5·72)	0·02 (–0·27 to 0·31)	0·18 (–1·56 to 1·92)	0·13 (–1·12 to 1·38)
Mean	0·22 (–0·13 to 0·58)	1·88 (0·42 to 3·35)	1·32 (0·29 to 2·35)	0·02 (–0·04 to 0·10)	0·22 (–0·19 to 0·63)	0·26 (–0·46 to 0·98)

Data are adjusted geometric mean (95% CI) of about 96 fly catches.

Table 3: **Species and geometric mean number of flies caught from the eyes of volunteer children by treatment group and triplet**

active trachoma lost to follow-up did not differ between the spray and control groups (p=0·71) or between the latrine and control groups (p=0·57).

Table 1 shows baseline trachoma survey results for participants screened in both surveys (n=6087). 354 (6%) participants had active trachoma (grades TF, TI or both), 901 (15%) had visible scarring (without entropion), and 73 (1%) had trachomatous trichiasis. Active trachoma was seen in 258 (11%) of the 2345 children aged 0–9 years. Figure 2 shows baseline prevalence by age-group and intervention.

At the individual level, children younger than 15 years had a much greater risk of active trachoma than did those 15 years or older (age 0–4 years, odds ratio 6·40 [95% CI 4·48–9·14], p<0·0001; age 5–9 years, 4·77 [3·46–6·58], p<0·0001; and 10–14 years, 1·84 [1·21–2·79], p=0·004). Ethnic origin and sex were not associated with active trachoma at baseline. At the household level, active trachoma was not associated with presence of any pit latrine, time to collect water, housing quality, or method of refuse disposal.

Table 2 shows characteristics for all 649 households and 6087 individuals. At baseline, 207 (32%) households had a functioning latrine, of which 180 (87%) were the local type (cover made from wood beams and mud) and 27 (13%) were improved (cement cover). The mean proportion of households with or without a latrine was much the same between treatment groups. The mean number of people per household was 12·3 (95% CI 11·7–12·9), with a mean of 2·8 (2·7–2·9) people per sleeping room. All households reported throwing refuse onto a heap or into a hole in the ground (without covering it); no other method of waste disposal was reported. Access to water was good, with 505 (78%) households reporting that a round trip to collect water took less time than it takes to boil rice (about 30 min). Housing conditions were mostly homogeneous, with 570 (89%) households having grass roofs.

All households in the latrine group received a latrine. 192 (98%) of 196 latrines showed signs of use over the 6 months. The mean number of days between latrine construction and presence of faeces being recorded in the pit was 10·6 (SD 19·2).

We did 2009 15-min hand-net collections of eye-seeking flies. All the 3600 flies caught were either *M sorbens* (87%) or *Musca domestica* (13%). Females accounted for 81% of *M sorbens* and 79% of *M domestica*, giving an approximate ratio of four females per male. 70% of flies caught from the eyes of volunteer children were female *M sorbens*.

Insecticide spray substantially reduced the number of *M sorbens* and *M domestica* caught from the eyes of children (table 3): 88% (95% CI 64–100) fewer *M sorbens* in spray clusters than in control clusters (p<0·0001) and 92% (26·1–100) fewer *M domestica* in the spray group compared with controls (p=0·034). Latrine provision reduced the number of *M sorbens* caught from eyes, but had no effect on the number of *M domestica*: 30% (7·2–52·3) fewer *M sorbens* in latrines compared with controls (p=0·04); *M domestica* (p=0·67).

Table 4 shows age-standardised community prevalence of trachoma at baseline and after 6 months, and the change in prevalence. Within each pair of spray and control clusters the prevalence change at follow-up showed a greater reduction in the spray cluster than in the control cluster, with a mean difference of 3·47 cases per 100 population (p=0·005; table 4). Thus, the mean reduction in trachoma between each pair of spray and control clusters was 55·8% (95% CI 18·8–92·7).

The mean difference in the change from baseline to 6-month follow up between the latrine and control groups was 1·26 cases per 100 population (p=0·232; table 4). Of the seven pairs of clusters, the rate change in the latrine cluster was lower than that in the control cluster in four pairs, greater in two, with no difference in one. The mean reduction in the age-adjusted community prevalence of trachoma between the latrine and control groups was 29·5% (80·8% reduction –21·9% increase).

Table 5 shows data for children aged 0–9 years. There was a mean difference of 7·18 cases per 100 population between the spray and control clusters (p=0·005) and of 3·04 cases per 100 population between the latrine and control groups (p=0·264).

	Spray			Control			Latrine		
	Baseline	6 months	Change	Baseline	6 months	Change	Baseline	6 months	Change
Triplet									
1	5·39	4·33	–1·07	2·89	6·27	+3·38	3·57	4·35	+0·78
2	7·46	4·15	–3·31	4·93	5·60	+0·67	3·74	4·61	+0·87
3	11·23	4·16	–7·07	4·04	4·36	+0·33	5·11	2·25	–2·86
4	6·95	1·60	–5·34	8·31	3·66	–4·66	6·20	3·37	–2·83
5	7·26	3·28	–3·98	3·98	2·74	–1·24	9·64	6·53	–3·11
6	3·90	3·89	–0·01	4·43	6·19	+1·76	4·98	1·97	–3·01
7	8·08	4·40	–3·67	6·66	6·30	–0·36	4·21	5·42	+1·21
Mean	7·18	3·69	–3·49	5·03	5·02	–0·02	5·35	4·07	–1·28

Data are number of cases per 100 population.

Table 4: **Age-standardised prevalence of active trachoma for people of all ages**

	Spray			Control			Latrine		
	Baseline	6 months	Change	Baseline	6 months	Change	Baseline	6 months	Change
Triplet									
1	6·86	6·86	0	1·80	9·91	8·11	1·69	8·47	6·78
2	6·90	4·31	–2·59	6·25	9·38	3·13	5·88	5·88	0
3	20·41	8·16	–12·24	3·31	7·44	4·13	12·69	5·97	–6·72
4	17·02	4·26	–12·77	17·00	8·00	–9·00	12·50	7·50	–5·00
5	17·05	6·82	–10·23	9·16	6·87	–2·29	19·64	11·61	–8·04
6	9·85	9·09	–0·76	10·43	13·04	2·61	12·38	4·76	–7·62
7	17·59	10·19	–7·41	15·32	12·90	–2·42	15·32	12·90	–2·42
Mean	13·67	7·10	–6·57	9·04	9·65	0·61	10·54	8·12	–2·43

Data are number of cases per 100 population.

Table 5: **Prevalence of active trachoma in children aged 0–9 years**

Of 5591 eye photographs scored, 3545 (63%) were gradable. Photographs were ungradable because of: poor focus (1192); showing an inadequate view of the tarsal conjunctiva (364); excessive reflected light (429); a problem with the whole roll of film (353); or being too dark (173). Some photographs were ungradable for more than one reason. Kappa values did not differ for the two media used; baseline and follow-up surveys as a whole and for each treatment group (table 6). The kappa values were also similar for each of the treatment groups in both baseline and follow-up surveys: control group at baseline 0·76, follow-up 0·63; spray group, 0·60 and 0·84; latrine group, 0·63 and 0·95, suggesting that there was no systematic bias in the field diagnoses.

Discussion

This cluster-randomised controlled trial was designed to investigate whether eye-seeking flies are trachoma vectors and whether household latrines can be used by trachoma control programmes as a sustainable intervention. Consistent with our pilot study[7] *M sorbens* was responsible for nearly all fly-eye contacts (87%). Insecticide spraying resulted in an 88% reduction in the number of *M sorbens* caught in children's eyes and a 56% reduction in community trachoma prevalence, compared with control clusters. The baseline prevalence of active trachoma was greater in the spray group than in controls and some proportion of the effect seen might have been the result of reverting towards the mean over time. These findings show that eye-seeking flies, specifically *M sorbens*, are vectors of trachoma in Gambian villages.

The provision of basic pit latrines to every household in a village—without additional health education—was effective in reducing fly-eye contact. There were 30% fewer contacts by *M sorbens* in latrine villages compared with controls, which was accompanied by a decrease in trachoma prevalence of 30%. The reduction in trachoma was not significant, but our results show that latrine provision is effective at reducing fly-eye contact which is an additional, and important, public-health benefit of safe disposal of human faeces. Reduced fly-eye contact in the presence of latrines is consistent with the observation that the absence of latrines is linked with increased rates of trachoma.[10,22]

	Number of photographs	Kappa	95% CI
Baseline survey	2518	0·65	0·58–0·72
Follow-up survey	1026	0·67	0·53–0·81
Spray group	1200	0·63	0·53–0·73
Latrine group	1121	0·69	0·59–0·80
Control group	1223	0·63	0·50–0·76
Digital image	986	0·61	0·50–0·72
Slide photograph	2489	0·68	0·60–0·75
All photographs	3544	0·65	0·59–0·71

Table 6: **Cohen's kappa for agreement on diagnosis of active trachoma between photograph and field grades**

The fight against blinding trachoma is being addressed with an integrated strategy of surgery, antibiotic distribution, hygiene promotion, and environmental improvement—the SAFE strategy. At present, country level control strategies rely heavily on antibiotic distribution,[23] and although local eradication of *C trachomatis* is theoretically possible through antibiotic distribution alone,[24] this strategy must be augmented with other measures to control transmission if lasting control is to be achieved.[25–27] Eye-seeking flies are not the only route of transmission and their contribution to transmission will vary in time and space, hence basing trachoma control solely on control of *M sorbens* is unlikely to be successful. Our study was done in a low prevalence area, and other transmission routes that might be in effect in hyperendemic regions could overwhelm any reduction afforded by fly control. In this study we controlled flies and provided latrines in isolation since multiple concurrent interventions would have made it difficult to ascribe any observed effect to a particular intervention. The incremental effect of fly control or latrine provision with antibiotic distribution and the promotion of facial cleanliness[28] needs to be investigated in regions of differing trachoma endemicity before definitive recommendations on latrine provision can be made.

For flies to be effective vectors of trachoma they must pick up *C trachomatis* on their feet or mouthparts and transfer them to the eyes of an uninfected person. Fly-eye contact is required for transmission, not just the presence of flies in the environment, or even on the face. Since *M sorbens*—which is responsible for most fly-eye contacts—was much less abundant than other species of fly such as *M domestica* and *Chrysomya albiceps* in this environment (accounting for just 9% of flies caught in traps in earlier studies[13]) catches of flies from eyes, or observations of flies on eyes, are probably the most sensitive method of measuring fly-eye contact.

Catching eye-seeking flies in hand-nets as we did here has two disadvantages: sampling without replacement and possible catcher bias. Catching a fly and not replacing it prevents multiple contacts in the period of observation, thereby underestimating fly-eye contact. We could not blind the catchers to fly control with insecticide or the presence of latrines, the knowledge that these were in place to reduce flies might have affected their catches. However catcher efficiency seemed to be greater when there were fewer flies since their attention was more focused. The true reduction in fly-eye contact achieved by spraying and latrine provision is thus likely to be greater than that suggested here.

Variation between observers was removed in field diagnosis by using the same grader for all clinical surveys, but this also introduced possible measurement bias. Knowledge of the intervention, recollection of individual study participants or specific households might have subconsciously affected the grader. Kappa scores of agreement on field diagnosis of active disease with photographs examined by a skilled blinded observer were similar between interventions, suggesting that there was no systematic bias. The range of k was 0·61–0·95, which indicates substantial agreement between field and photograph.[21]

Lack of water is associated with increased risk of trachoma.[29–32] In this part of The Gambia, access to water was good, with every village having at least one well. By contrast, access to latrines was poor. Only 32% of households had a latrine at baseline, of which most (180 of 207) were the local type. Instead of reinforced cement the slabs of local latrines were made from sticks and mud. These were frequently precarious and owners often stopped their children from using them because of this danger. The enthusiastic uptake of latrines by the participants revealed a strongly felt need for sanitation. In informal discussion, household heads reported a desire for latrines, but were not able to build them because the only locally available termite resistant timber had become scarce and it was difficult to obtain a permit to cut it. They were afraid that using poor quality timber would result in the latrine collapsing during the rainy season leaving the uncovered pit a danger to children and livestock.

Our results show that *M sorbens* is a trachoma vector in The Gambia and that controlling flies with insecticide spray reduces trachoma prevalence. Although insecticide spraying was very popular with villagers, it would not be suitable as a long-term control measure since the high selection pressure exerted on the flies would lead to the rapid evolution of insecticide resistance. Environmental changes resulting in reduced fly-eye contacts by *M sorbens* can be promoted by trachoma control programmes.

Contributors

P Emerson, S Lindsay, and R Bailey designed the study. P Emerson, S-M Dibba, and K Lowe had primary responsibility for fieldwork assisted by M Bah, R Bailey, S Lindsay, and G Walraven. Analysis was done by P Emerson, N Alexander, R Bailey, and A Ratcliffe. The report was written by P Emerson and S Lindsay, with contributions from all authors.

Conflict of interest statement

We have received research grants from the International Trachoma Initiative, Sight Savers International, and Pfizer. The corresponding author has had full access to all the data and had final responsibility for the decision to submit for publication.

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