

# Blindness and eye disease in Kenya: ocular status survey results from the Kenya Rural Blindness Prevention Project

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## Abstract

A series of eight regional eye surveys were conducted in Kenya as part of the Kenya Rural Blindness Prevention Project. Each survey consisted of clinical examinations of about 1800 individuals selected by a random cluster sampling technique in geographically distinct and culturally homogeneous rural areas; 13 803 examinations were completed in all. Together these surveys provide the basis for national estimates of the prevalence and aetiology of visual loss and ocular pathology. The results showed that 0.7% of rural Kenyans are blind in the better eye by WHO standards, and another 2.5% suffer significant visual impairment. Rates of visual loss tend to increase five-fold in each 20-year age cohort. Females have higher prevalence of visual loss than males over age 20, and certain geographical areas have markedly higher rates. The commonest cause of both blindness and visual impairment is cataract, accounting for 38% of all visual loss. Trachoma (a localised problem), glaucoma, macular degeneration, and severe refractive errors follow cataract as leading causes of blindness in the better eye. Trauma, corneal scars of various causes, phthisis, and staphyloma are important causes of monocular blindness. Nutritional eye disease does not appear to be a problem of any magnitude in rural Kenya.

Preventable blindness has long been identified as a global public health problem.<sup>1,2</sup> Approximately 28 million people are blind worldwide and over two-thirds of them live in developing nations.<sup>3</sup> Often blindness rates in poor countries are 10 to 20 times those in industrialised nations,<sup>4</sup> and in certain communities with particular disease problems like onchocerciasis or severe trachoma as much as 30-50% of the population may be affected, especially among the elderly. This occurs not only because of limited access to health services, but also because of environmental or climatic stresses, poor hygiene, and other factors associated with a low standard of living. Approximately 80% of the people who are blind in the developing world suffer from conditions which are avoidable in the sense that their blindness could have been prevented or is surgically correctable.

The true consequences of blindness are difficult to calculate. In addition to the social and psychological isolation of the blind and the stigma attached to their helplessness, in a situation of very limited resources for survival, a blind person can be a tremendous economic burden.

The presence of high rates of blindness in a community implies a significant loss of its productivity, not only because the blind often cannot be productively engaged, but also because others must care for them and generate the resources needed for their survival.

The International Eye Foundation (IEF) has assisted the Government of Kenya in developing preventive and therapeutic ophthalmic services since 1972, when an IEF ophthalmologist was posted to a rural provincial hospital as the government eye specialist. Kenya typifies the health manpower situation in many African nations, in that most of the medical facilities, manpower, and resources are concentrated in large cities, especially the capital city. There are only a few government ophthalmologists assigned to rural facilities, concentrating their efforts on the rural population. A pilot ocular survey among the rural Samburu people<sup>5</sup> confirmed that most blindness in rural Kenya is either preventable or curable. For these reasons the underlying rural needs are better addressed by training clinical and surgical personnel who are not ophthalmologists to provide ophthalmic care, and by eye disease prevention programmes, rather than by the isolated clinical efforts of eye specialists.

Substantial funding from the United States Agency for International Development beginning in October 1976 made possible an IEF sponsored Kenya-wide Rural Blindness Prevention Project (KRBPP).<sup>6</sup> The objectives of this project were to strengthen and extend the capabilities of the established system of therapeutic rural eye care, and to divert the emphasis in rural eye care away from a purely therapeutic approach towards prevention of blindness through health education, screening, and treatment at the primary care level, and early referral of people in need of specialised care. To plan for these objectives it was necessary to define accurately the prevalence and causes of blindness among rural Kenyans.

## Material and methods

### SAMPLE DESIGN

Because of constraints in time and resources a national statistical sample of the rural population was not organised. Instead advantage was taken of the fact that tribes in Kenya traditionally live in defined geographical regions and have not tended to intermingle in their rural homes as they have in the cities. Specific rural areas that represented the major population groups, as well as the ranges of ecological conditions that might

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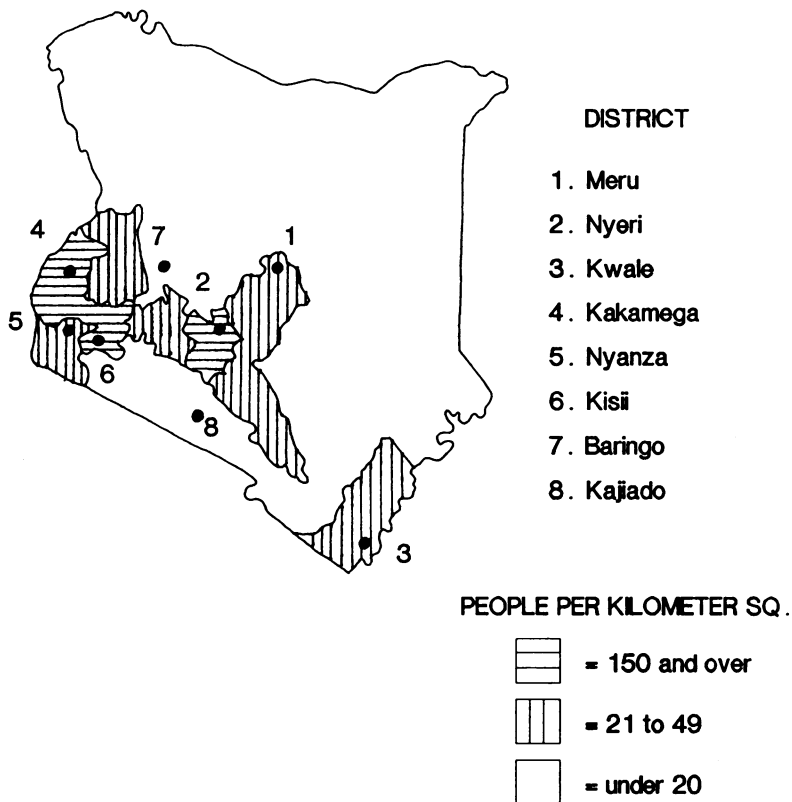


Figure 1: Kenya eye disease surveys: sample areas and population density.

impinge on eye disease, were selected to be surveyed. A series of population based eye disease surveys were conducted in eight rural districts of Kenya (Fig 1). National estimates were inferred from these independent district samples by weighting methods described below.

The methodology used to draw the samples for these surveys has been described elsewhere.<sup>7</sup> Briefly, within the district inhabited by a particular group to be surveyed meetings were held with regional and local officials to identify smaller administrative divisions that were typical of the group and the area. A random cluster sample was then drawn from these administrative divisions by means of a sampling frame based on tax lists, land adjudication records, or, in less settled areas, lists of heads of household assembled by local chiefs.

The cluster sample technique used was similar to the one recommended by the World Health Organisation (WHO) for immunisation surveys.<sup>8</sup> Although sample size was sometimes varied to meet particular objectives, each survey was generally planned to consist of 30 clusters of households. Each cluster was begun at a random starting point selected from the sampling frame and was continued by adding all members of the next nearest household until the total number of eligible residents in the cluster exceeded 60. Examinations in each cluster continued until at least 90% of all eligible persons were examined. Thus there were about 1800 people in the typical regional survey, and 13 803 were examined over the course of the eight surveys.

#### CLINICAL METHODS

The survey teams consisted at a minimum of an ophthalmologist, an ophthalmic clinical officer or ophthalmic assistant, a registrar, and a locally-

hired clerk who was familiar with the survey area and local language. Each survey member was registered, screened for visual acuity, had a history taken by the clinical officer, and was then examined by the ophthalmologist. There were nine separate examiners from the staff of the KRBPP or the Kenya Ministry of Health over the course of the eight surveys, with three primary examiners (RW, LS, PS) involved consistently over the seven years the surveys were conducted.

Each examination was carried out in a centrally located public place or in the homes of survey members, according to a structured clinical protocol. Using a focal handlight, 2× binocular magnifying loupes, and an ophthalmoscope, the ophthalmologist examined the lids, conjunctiva, and cornea of every survey member. In addition, for every survey member with vision less than 6/18 in either eye, and for everyone aged 40 and over, funduscopy was carried out by direct ophthalmoscope, with dilatation of the pupil if necessary. Schiøtz tonometry was performed on all persons aged 40 and over and on anyone below that age when indicated.

The results of examinations were reviewed each evening for accuracy and completeness, and any results about which there were questions were resolved by consensus of the survey ophthalmologists.

**Visual acuity.** With the exception of children unable to understand or co-operate, visual acuity was measured on all survey members with Landholt C-ring optotypes. The procedure was carried out at 6 m in available outdoor light (except in the first survey, when the procedure was performed indoors under incandescent light) with refractive correction by spectacles if available and usually worn. If visual acuity was less than 6/18, it was rechecked with pinhole, and, if there was improvement, this result was recorded as best visual acuity. The visual acuity of infants and children unable to be tested was measured by ability to fix centrally on a moving focal handlight, which was considered to be an adequate indication of normal vision.

Visual acuity was coded according to standard WHO definitions.<sup>9</sup> In this analysis vision less than 6/18 but better than or equal to 3/60 is classified as visual impairment; vision less than 3/60 is classified as blindness; and together these two conditions are referred to as visual loss.

**Diagnosis.** The examining ophthalmologist was required to assign a single principal diagnosis of the reasons for visual loss in each eye with vision less than 6/18. For conditions with multiple causation the examiner assigned the underlying or precipitating cause or the one which accounted for the major component of the visual loss. All reasons for visual loss refer to the cause of the loss in the eye with *better acuity* if vision in the two eyes was unequal, and to the cause in the right eye if both eyes were equally effected.

**Cataract.** Any opacity of the lens visible to the ophthalmologist with direct ophthalmoscopy against the red reflex was classified as a cataract. Cataracts are analysed in three categories depending on whether the eye in which they

TABLE 1 Regional survey area characteristics

District	Tribal group	Sample size	Attributed % of rural population	Geography	Climate and rainfall	Economy
Meru	Meru	1142	16.1	Nyambene Hills northeast of Mt Kenya runoff, scarce water	Temperate to hot; moderate rain but high subsistence farming	Cultivation of miraa (a plant used as a stimulant)
Nyeri	Kikuyu	1825	20.4	Hilly highlands west of Mt Kenya plentiful	Cool temperate, high rainfall, water	Coffee and tea farming, subsistence farming
Kwale	Mijikenda	1342	6.8	Coastal plain and immediate hinterland	Hot, humid, moderate rainfall	Fishing, subsistence farming, tourism
Kakamega	Abaluhya	1651	23.6	Highland plateau west of Rift Valley reliable water	Temperate to hot, moderate rainfall	Cotton farming, some coffee farming, subsistence farming
Nyanza	Luo	1807	11.5	Basin south of Lake Victoria	Hot, humid, rainfall moderate but variable	Cotton farming, fishing, subsistence farming
Kisii	Kisii	1753	6.2	Hilly plateau west of Rift Valley	Temperate, high rainfall; good water	Tea and coffee farming, subsistence farming
Baringo	Tugen Njemps	1182	6.7	Tugen Hills, Lake Baringo plain, Rift Valley north of lake	Varied; temperate to hot; moderate to very low rainfall	Coffee and subsistence farming; livestock herding in arid areas
Kajiado	Pokot Masai	581 596 1924	8.7	1000 m grassland plateau east of Rift Valley	Hot, arid, semidesert; water scarce	Herding cattle, goats

occur had normal visual acuity, visual impairment, or blindness.

**Trachoma.** This paper reports only the basic findings for visual loss due to trachoma and prevalence of trachoma inflammation. Detailed findings on the disease and related ocular pathology will be reported elsewhere. Visual loss was determined as being due to trachoma in three situations: (1) the simultaneous presence of corneal opacities, and entropion or trichiasis; (2) the presence of focal corneal opacity due to secondary bacterial infection or corneal ulcer where there were other clinical signs of trachoma (active inflammation, scarring of the tarsal conjunctiva, corneal or limbal pannus, or Herbert's pits); (3) the presence of trachomatous keratitis that was believed to affect visual acuity. The scoring of trachoma inflammation was based on recommendations<sup>10</sup> of the WHO and coded by a simplified recording system.

**Refraction.** Formal measurement of the type and severity of refractive errors was not carried out. When refractive error was considered to be a possible cause of visual loss, the presence of refractive error was confirmed by lens power readings from the ophthalmoscope or by observed improvements in acuity with pinhole examination.

**Glaucoma.** Visual field testing could not be performed during these surveys for logistic reasons. In the absence of such a definitive test for diagnosis of glaucoma as a cause of visual loss the survey protocol required observation of one of the following: a pathological optic disc (marked pallor of the nerve head, or vertical cupping greater than 0.5) in the presence of raised intraocular pressure (>21 mmHg); markedly raised intraocular pressure (>26 mmHg) without visualisation of a pathological disc; a history of glaucoma surgery or treatment.

Because of the criteria used for identifying the disease, glaucoma as a cause of visual loss is likely to be underestimated in the surveys, but there is no way of determining the extent to which this occurred. Cases of low-tension glaucoma, and those where adequate assessment of the optic disc was not possible (for example, due to the presence of a cataract), were unlikely to be classified as glaucoma. Furthermore, because tonometry and funduscopy were performed

routinely only on persons over 40, early and borderline glaucoma cases in the younger age groups that were not yet sufficiently advanced to affect central vision also may have been missed.

**Retinal disorders.** Age related macular degeneration and other retinal anomalies were diagnosed on clinical grounds alone, as diagnostic laboratory investigations were not feasible.

#### METHODS OF ANALYSIS

Because of the great sensitivity of estimates of the prevalence and causes of visual loss to the distribution of age in a population, a standardisation procedure was carried out to minimise the effects of random differences in the age distribution of the eight regional survey samples. Each survey population was adjusted to the national population age distribution from the 1979 census by weighting age categories according to whether they were over- or undersampled relative to the standard. This procedure allows more appropriate regional comparisons and ensures that national estimates are less influenced by sampling differences.

Because the surveyed regions, and the locations within them, were not selected randomly, there is no unbiased procedure for estimating the true population prevalence of blindness or of other ocular conditions. Within each region, however, an assumption was made that the particular locations from which the sample was randomly drawn were representative of a broader population group, and that estimates of rates from the survey sample would apply to the underlying regional population within reasonable bounds of error.

National estimates were computed by attributing to each regional survey a certain proportion of the national rural population, based on similarity in tribal composition, geography, and climate (Table 1). Observations within each survey were appropriately weighted so that the national estimates reported reflect these attributed proportions.

For the reasons mentioned, and also because the sample was drawn in clusters, there is no unbiased procedure for calculating sampling errors or confidence intervals for the estimates. No standard errors are reported, though it would

TABLE II Visual impairment and blindness by age by sex: percentage by acuity level\*

	Age group				All Kenya
	0-19	20-39	40-59	60+	
<b>Male</b>					
Normal	99.7	98.5	94.3	66.6	97.3
Impaired	0.2	1.0	4.4	26.9	2.1
Blind	0.1	0.6	1.2	6.5	0.6
Weighted N†	(3925)	(1185)	(510)	(304)	(5925)
<b>Female</b>					
Normal	99.7	98.0	89.7	61.4	96.4
Impaired	0.2	1.7	8.6	29.2	2.8
Blind	0.1	0.3	1.7	9.4	0.8
Weighted N†	(4178)	(2227)	(932)	(315)	(7653)

\*All categories refer to acuity in the better eye with available correction. Normal=6/18 or better; impaired=worse than 6/18 but better than or equal to 3/60; blind=worse than 3/60.  
†Weighted according to the proportion of the national rural population represented by each survey region and after adjusting to a standard age distribution based on all surveys combined.

be possible to compute rough estimates based on assumptions of simple random sampling from the information on sample size presented, and to inflate them by an appropriate factor (perhaps 2-4 times) to account for the non-randomised design and clustering.

## Results

### RATE OF BLINDNESS AND VISUAL IMPAIRMENT

The prevalence of blindness and visual impairment by age and sex group is presented in Table II. About 0.7% of all rural Kenyans were blind in their better eye, and another 2.5% had vision which was substantially impaired. Females exceeded males by slight percentages in both these categories.

As expected, the prevalence of visual loss showed a very strong relationship with age, increasing by approximately a factor of 5 in each 20-year age cohort. In the most severely affected group of rural Kenyans, those over the age of 60, about 1 in 12 were blind, and another 28% suffered from visual impairment. Females had a notably higher prevalence of visual loss over the age of 40, and especially in the 40 to 59 year cohort, where total prevalence was nearly double that of males (10.3% vs 5.6%).

There was a fair degree of consistency in the prevalence of impairment and blindness across all the regions surveyed (Table III), with three exceptions. In the two surveys of pastoral groups, among the Masai in Kajiado and among the Pokot and Njemps in Baringo (not separated in Table III from the non-pastoral groups in Baringo) a markedly higher total prevalence of

visual loss was found. However, the highest prevalence of blindness was found in Meru, among a settled agricultural group.

### REASONS FOR VISUAL LOSS

Cataract was the major cause of blindness in rural Kenya, with a prevalence of 2.5 per 1000, accounting for 36% of all blindness (Fig 2). Following cataract in prevalence were trachoma (1.3/1000), glaucoma (0.6/1000), macular degeneration (0.5/1000), and severe refractive errors or amblyopia (0.4/1000). Blindness due to xerophthalmia - nutritional blindness - was estimated to occur at a rate of less than 1 per 10 000 individuals overall in rural Kenya and was not found in any person examined under the age of 20.

Cataracts were also responsible for 39% of all visual impairment (rate of 10.0/1000). It was the most prevalent cause of visual loss in six of the eight survey areas and was second to refractive error in the remaining two (Nyeri and Kisii). Refractive errors and macular degeneration were found to be equally prevalent (4.5/1000) as leading causes for visual impairment after cataract. They were followed in importance by trachoma (3.3/1000) and corneal scars due to causes other than trachoma, trauma, or xerophthalmia (corneal scar/other) (1.2/1000).

The prevalence by age group of the causes of visual impairment (rate of 10.0/1000). It was the Figure 3. Cataract, trachoma, refractive errors, macular degeneration, and glaucoma all show sharp increases in prevalence among those 60 and over, while trachoma and cataract stand out in importance as blinding conditions in the two preceding decades. The relative prevalence of the leading causes of visual loss was found to be similar for men and women in all age groups, except that visual impairment and blindness due to trachoma occur more frequently among women beginning at age 40.

### PREVALENCE OF OCULAR CONDITIONS

Ocular pathologies have as their most important endpoint the inability to see, and the ensuing blindness is not only a health problem but a major socioeconomic problem as well. From a public health perspective, therefore, the most appropriate way to organise diagnoses obtained through prevalence survey is by conditions which affect both eyes or the eye with better vision. However, from the perspective of making decisions related to training health system personnel about common conditions or of public

TABLE III Rates of visual impairment and blindness by regional survey: percentage by acuity level\*

	Regional survey								All Kenya
	Kakamega	Meru	Nyeri	Kwale	Nyanza	Kisii	Baringo	Kajiado	
Normal	98.5	94.5	97.6	97.4	96.8	96.9	96.9	93.3	96.8
Impaired	1.0	4.0	2.1	1.8	2.6	2.7	2.5	5.4	2.5
Blind	0.5	1.5	0.3	0.7	0.6	0.4	0.6	1.3	0.7
Weighted N†	(3174)	(2210)	(2778)	(934)	(1576)	(842)	(902)	(1176)	

\*All categories refer to acuity in the better eye with available correction. Normal=6/18 or better; impaired=worse than 6/18 but better than or equal to 3/60; blind=worse than 3/60.  
†Weighted according to the proportion of the national rural population represented by each survey region, and after adjusting to a standard age distribution based on all surveys combined.

Figure 2: Conditions causing loss of vision in the eye with better visual acuity

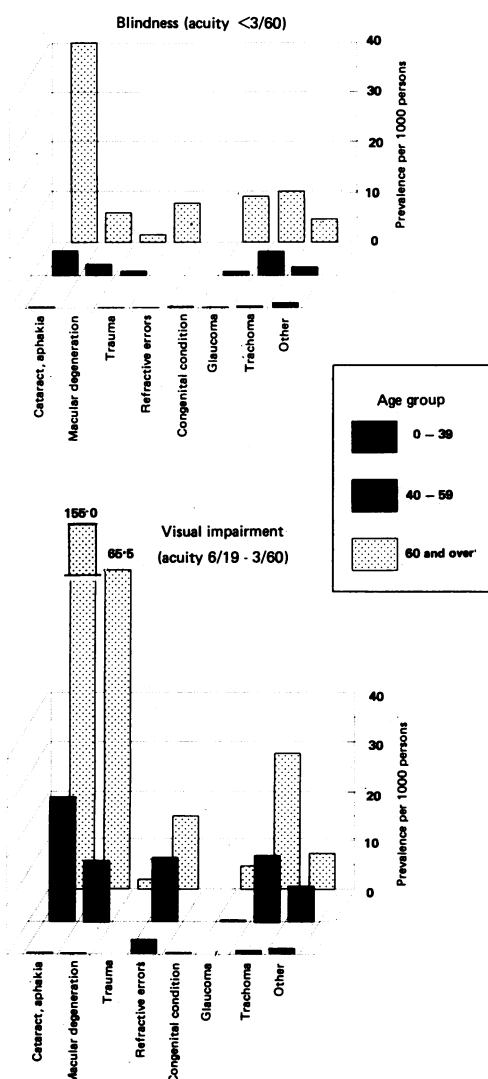
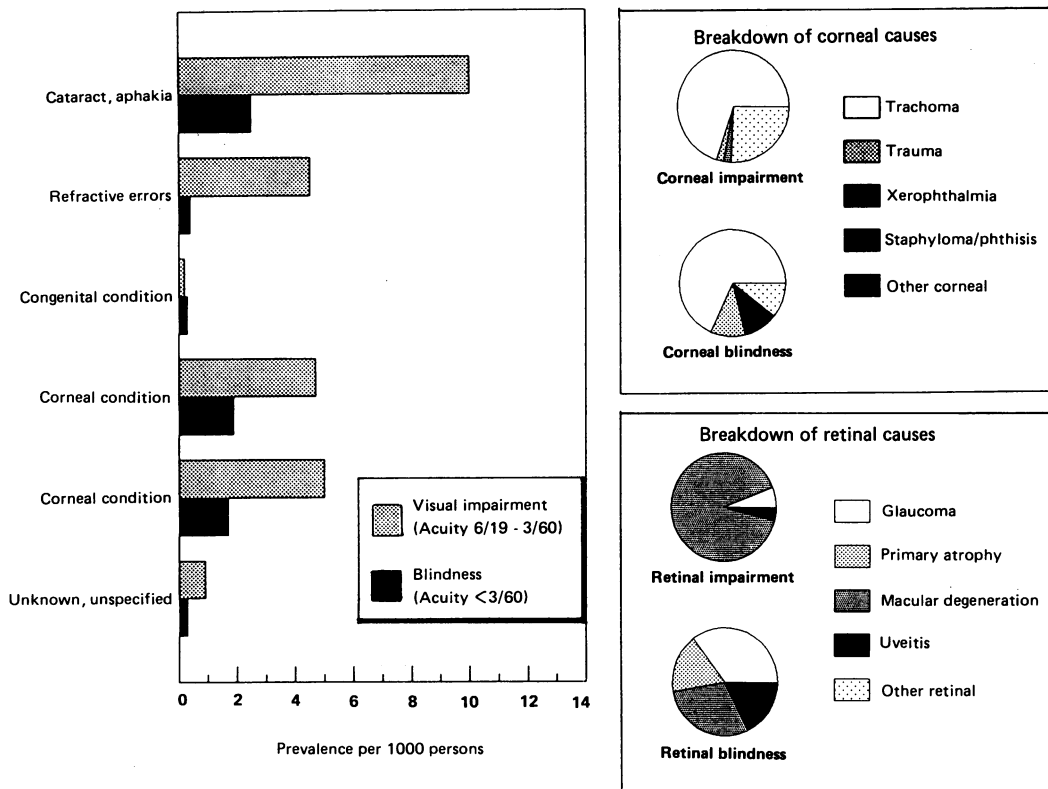


Figure 3: Reasons for loss of vision by age group.

health education, it is also useful to examine the prevalence of sight affecting conditions in either eye (Fig 4).

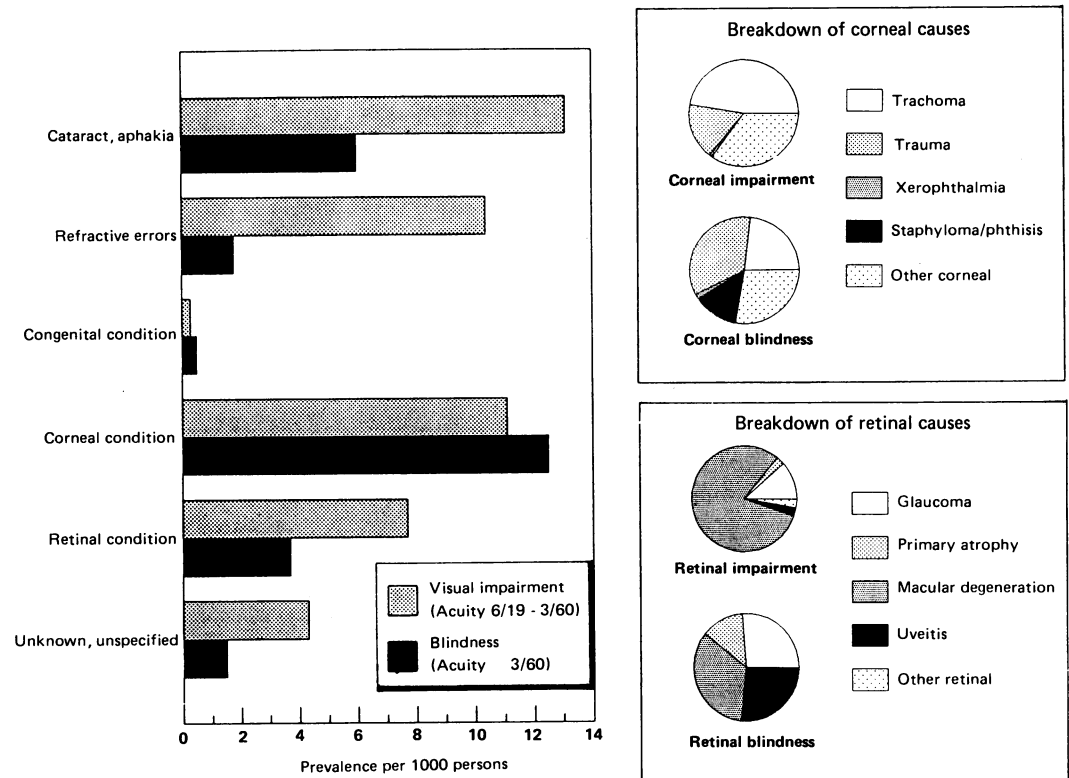
From this perspective cataract is again the major cause of visual loss. Its prevalence as a blinding condition more than doubles (6.0/1000), since many people have at least one eye with a dense cataract even if the other still retained better sight. Trauma, which is most often monocular, assumes a position as the second most prevalent blinding condition (4.3/1000). It is followed in importance by corneal scar due to non-trachomatous infections (3.5/1000) and trachoma (2.9/1000). Phthisis and staphyloma of unknown aetiology (1.7/1000), which are also most often monocular, are nearly equal in prevalence to blinding refractive problems (1.8/1000).

Table IV arrays the prevalence by age group of the most important ocular diseases and conditions from a public health standpoint. Inflammatory trachoma is the most prevalent ocular disease in rural Kenya, with 18.7% of the entire population, and about 1 in 4 children under the age of 10, affected overall. The prevalence in all age groups, but especially among children, varied dramatically among survey areas. Over 80% of those under the age of 10 had active trachoma in Meru and Kajiado; about 50% had active disease among the Pokot in Baringo; 25% in Nyeri and among the Njemps in Baringo; 10% among the Tugen in Baringo; and less than 1% in the remaining survey regions.

The prevalence of visual loss due to sequelae of trachoma varied among survey areas even more sharply - 1.6% of the population in Meru, 1.4% among the affected groups in Baringo, 1.0% in Kajiado, 0.2% in Nyeri, and none in the remaining areas.

There is a very low prevalence of signs of

Figure 4: Conditions causing loss of vision in any eye examined.



potential nutritional eye disease in rural Kenya, especially among children under 5, who are at the highest risk of a nutritional crisis which might precipitate vitamin A deficiency. No cases

of corneal xerosis or active keratomalacia, the two least equivocal signs of current vitamin A deficiency, were found in any of the surveys. Like trachoma, the occurrence of nutritional eye disease appears very localised. Nine of the 10 cases of visual loss due to old xerophthalmia were found in the Baringo survey, and the other was among the Masai in Kajiado.

Glaucomatous cupping was found in 1.1% of the rural population between 40 and 59 years and in 2.8% of those over 60. In addition optic disc pallor or atrophy of the optic nerve, either one of which might indicate the presence of glaucoma, was found in an additional 1.3% of the 40-59-year group and in another 2.5% of those over 60. A raised intraocular pressure (over 21 mmHg) on Schiøtz tonometry, which may indicate open-angle glaucoma, was found in 3.7% of those between 40 and 59 and 7.0% of those over 60, and about half of these individuals were found to have very high (over 26 mmHg) pressures.

## Discussion

A substantial part of the Kenyan rural population, particularly in older people, has been shown to suffer from blinding or visually impairing eye disease. However, without a standard of comparison it is difficult to evaluate the severity of the problem. Relevant population estimates of a similar nature to this one are scarce.

It has been estimated that the prevalence of blindness in the United States is 0.2%,<sup>11</sup> but this is based on a more liberal criterion for blindness (visual acuity equal to or less than 6/60). Although it is impossible to give an exact comparison with this figure because of the way in which acuities were recorded in this series of surveys, it can be estimated that approximately 1.7% of rural Kenyans would have been blind by

TABLE IV Selected ocular conditions by age: percentage with condition in either eye

	Age group			
	0-39	40-59	60+	
<b>Lens opacities:</b>				
With visual acuity >6/18*	0.1	2.3	10.8	
With visual loss or aphakia	0.1	6.1	32.1	
Weighted N	(10439)	(1390)	(609)	
<b>Corneal and globe conditions:</b>				
Ulcer of any origin	0.3	0.4	0.2	
Dystrophy or degeneration	0.2	2.1	7.1	
Nebula, macula, or leucoma	2.2	5.8	11.2	
Phthisis	0.2	0.8	1.9	
Staphyloma	0.1	0.3	0.5	
Weighted N	(11600)	(1449)	(628)	
<b>Disorders of the optic nerve head or macula:</b>				
Glaucomatous cupping	NA†	1.1	2.8	
Optic disk pallor	NA	0.7	1.3	
Optic atrophy	NA	0.6	1.2	
Macular degeneration	NA	3.0	13.9	
Other macular lesions	NA	1.0	10.5	
Pigmentary degeneration	NA	0.1	0.6	
Other retinal lesion	NA	1.5	8.6	
Weighted N	(-)	(1360)	(568)	
<b>Schiøtz intraocular pressure:</b>				
22-25 mm	NA	2.2	3.1	
26+ mm	NA	1.5	3.8	
Weighted N	(-)	(957)	(535)	
	Age group			
	0-4	5-9	10-19	20+
<b>Potential nutritional eye disease:</b>				
Bitot's spots	0.1	0.6	0.3	0.2
Conjunctival xerosis	<0.1	0.3	0.1	0.1
Leucoma from keratomalacia‡	<0.1	<0.1	<0.1	<0.1
<b>Conjunctival inflammations:</b>				
Inflammatory trachoma	27.1	23.8	16.6	14.0
Purulent conjunctivitis	3.1	1.3	0.2	0.4
Tarsal or limbal vernal	0.1	0.2	0.4	0.3
Weighted N	(2541)	(2223)	(3415)	(5843)

\*An individual with cataracts of both types is counted in both categories.

†Ophthalmoscopy and intraocular pressure examination performed only if indicated on persons under 40.

‡No cases of corneal xerosis or active current keratomalacia were found.

this standard, a figure 8.5 times as large as the rate in the USA.

There have been two major recent population based national surveys of eye disease in developing countries, both of which used the same WHO criterion for blindness employed in this study. In Nepal the Ministry of Health/WHO<sup>12</sup> reported a prevalence of 0.9% for blindness and 1.9% for visual impairment. In Saudi Arabia Tabbara and Ross-Degnan<sup>13</sup> reported comparable figures of 1.5% blind and 7.7% visually impaired. In addition to these national studies Chirambo *et al*<sup>14</sup> reported a blindness prevalence of 1.3% in the Lower Shire Valley of Malawi. Rural Kenya, with an estimated 0.7% blind and 2.5% impaired, is therefore quite similar overall to Nepal and much less severely affected than Saudi Arabia. However, the two worst regions in the Kenyan series – Meru and Kajiado – have similar prevalences of blindness to those found nationally in Saudi Arabia, and one might suggest that 1.5% is typical of moderate to severe trachoma environments in the developing world.

It is not surprising that cataract was the leading cause of visual impairment and blindness in rural Kenya. The WHO reports that it is the leading cause of blindness worldwide,<sup>3</sup> despite the fact that it is no longer a leading cause in industrialised nations. Given the primacy of cataract as a cause of visual loss, it is readily seen that the major thrust of any blindness prevention programme in an environment like Kenya should be directed at cataract. Because the supply of ophthalmologists in African countries is typically very limited, cataract programmes are often most productive when they rely on non-ophthalmologists trained to perform simplified cataract extractions by a standardised surgical technique.<sup>15</sup>

Trachoma was the second leading cause of blindness overall in rural Kenya, but the prevalence of both current inflammation and blinding sequelae varied widely among the survey areas. A variety of factors may be responsible for this variability, yet it is impossible to separate their independent effects because of their tendency to vary together in the areas studied.

High in importance in the natural history of blindness from trachoma would certainly be access to adequate supplies of water, since the disease is easily controlled with adequate personal hygiene. People surveyed who live in arid areas of rural Kenya – the Masai in Kajiado and the Pokot and Njemps in Baringo – tended to have a higher prevalence of trachoma in all its manifestations. However, the first two tribes, and to a certain extent the third, also rely on the herding of livestock for economic livelihood and live in quite close proximity to their animals. They are therefore exposed to an additional risk factor, the persistent eye seeking flies which have been implicated in the spread of the disease.

Visual loss due to trachoma occurred with highest prevalence not among these arid area groups, however, but among the Meru. These people live in an area with rainfall adequate for agriculture, but with porous volcanic soil that absorbs water rapidly, passing it directly down to

a deep water table. This makes access to daily supplies of water for hygiene a problem. However, trachoma inflammation and blindness were also found in Nyeri, where people enjoy quite good rainfall, ready access to water and to medical services, and a relatively high level of socioeconomic development for rural Kenya. But trachoma was not found among other rural tribes living in similar circumstances. One must conclude that in Nyeri, and to a certain extent in Meru, it is the cultural pattern of hygiene that is a major factor in the continuing presence of the disease.

In addition to trachoma and cataract many of the other leading causes of visual loss in rural Kenya are preventable or curable. Some conditions are most appropriately addressed by increasing access to prompt and effective treatment by primary care personnel throughout the health system. Much of the visual disability due to trauma and other corneal lesions could be prevented in this manner. In addition, most visual impairment from refractive errors could be alleviated by access to optometric services and spectacles.

A more difficult preventable problem, and an extremely important one given its status as third leading cause of blindness, is that of glaucoma. For the same reasons that open-angle glaucoma is underdiagnosed in field surveys it tends to go unnoticed in the general population. The onset of visual loss from glaucoma is typically slow and insidious, and clinical signs are difficult to recognise and identify reliably. Generally neither the clinical signs nor loss of central visual acuity are apparent until late in the course of the disease.

The best available prevalence estimate for glaucoma in a white population, from the Framingham Eye Study,<sup>16</sup> is 1.9% in people aged 52 and older, an estimate based on very detailed visual field examinations. The comparable group in this age cohort in rural Kenya has a prevalence of 2.1% with visible pathologically cupped optic disc and raised IOP, which represents an extremely conservative estimate of the prevalence of glaucoma disease in all its stages.

One can conclude that glaucoma is probably considerably more prevalent in the Kenyan rural population than in Caucasian populations of industrialised nations, and that it represents a major class of preventable blindness for which there is not yet any clearly defined strategy for diagnosis and treatment. More detailed research on its true prevalence and on the relative efficacy of methods of screening and treatment is clearly indicated.

In summary, blindness and visual impairment have been shown to be much commoner in rural Kenya than in industrialised countries. However, except for certain subgroups, rates of visual disability are lower than those found in the Middle East. The prevalence or visual loss rises sharply with increasing age, and females have a higher prevalence of visual loss than males, especially due to trachoma. Except for age related macular degeneration, the major causes of blindness – cataract, trachoma, glaucoma, refraction, and other corneal opacities – are either preventable or curable.

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