The Nigeria national blindness and visual impairment survey

2005-2007

National Blindness and Low Vision Survey Project

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VELUX STIFTUNG

International Centre for Eye Health

London School of Hygiene & Tropical Medicine

Executive Summary

Overview

- The National Blindness and Visual Impairment Survey in Nigeria was conducted in 2005-2007 (30 months of field work)
- Multi-stage stratified cluster random sampling, with probability proportional-to-size procedures, was used to select a cross-sectional, nationally representative sample of the population
- A total of 13,599 persons aged 40+ were examined across the country (response rate 89.9%).

Prevalence of blindness and visual impairment

- The prevalence of blindness in the sample using presenting vision (PVA) of <3/60 in the better eye was 4.2% (95% CI: 3.8 to 4.6%) and the prevalence of severe visual impairment (SVI) was 1.5% (95 % CI: 1.3 to 1.7%). Using best corrected vision (BCVA) in the better eye, 3.4% (95% CI: 3.0 to 3.8%) were blind, 0.8% (95% CI: 0.7 to 1.0%) had SVI, 5.3% (95% CI: 4.9 to 5.8%) had moderate visual impairment, 4.5% (95% CI: 4.1 to 4.9%) had mild visual impairment while 86% (95% CI: 85.2 to 86.8%) were categorized as normal/near normal.

Associations of blindness and visual impairment with socio-demographic factors

- The prevalence of blindness among those aged ≥50 years was 5.5% (476/8702) and 9.3% (476/5125) among those aged ≥60 years (PVA <3/60 in the better eye)
- The prevalence of blindness (PVA) increases significantly with increasing age, from 0.8% (95% CI: 0.5 to 1.1%) at 40-49 years to 23.3% (95% CI: 20.2 to 26.7%) among those aged ≥ 80 years (p = <0.001)
- Females had a higher prevalence of blindness than males (4.4% vs 4.0%)(p =<0.001)
- Illiterate participants had far higher prevalence of blindness than those who could read and write (5.8% vs 1.5%)(p = <0.001)
- The South West GPZ had the lowest prevalence of blindness (2.8%; 95% CI: 2.2 to 3.5%) and the North East GPZ had the highest (6.1%; 95% CI: 4.7 to 7.9%) (p = <0.001)
- The prevalence of blindness and SVI did not differ by urban/rural place of residence (p=0.18).
- In multivariate analysis, age, gender, GPZ and literacy remained significantly associated with blindness after adjusting for age and gender differences
- It is estimated that 1,130,000 individuals aged ≥40 years are currently blind in Nigeria (95% CI: 1.03-1.25 million). The North West geo-political zone (GPZ) has the largest number of blind adults (28.6%) being the zone with the largest population. A further 2,700,000 adults aged ≥ 40 years are estimated to have moderate visual impairment and an additional 400,000 adults are severely visually impaired. Thus a total of 4.25 million adults aged ≥ 40 years in Nigeria are visually impaired or blind.
- The prevalence of blindness varied across the different ecological zones being highest in the sahel (6.6%) and the lowest in the delta (3.3%)
- The prevalence of blindness in people of all ages was estimated to be 0.78%.

Front cover Participant having his distance visual acuity measured using a reduced logMAR visual acuity chart

Below Survey participants in South West geopolitical zone waiting to be examined by the survey team

Causes of blindness and visual impairment

- Cataract was the commonest cause of severe visual impairment and blindness being responsible for 45.3% and 43.0% respectively. The prevalence of cataract blindness was 1.8% (95% CI: 1.57-2.05)
- Glaucoma was the second commonest cause of blindness (16.7%) (prevalence 0.7%; 95% CI: 0.6-0.9)
- Corneal scarring from all causes was responsible for 7.9% of blindness
- 84% of blindness was due to avoidable causes
- Uncorrected refractive errors were the commonest cause of mild and moderate VI (77.9% and 57.1% respectively) being responsible for visual impairment in 2.46 million adults in Nigeria (i.e. acuity of <6/12-6/60)
- "Operable" cataract (i.e. visual acuity of <6/60) affects 400,000 people and glaucoma has caused blindness in a further 150,000 adults
- By the year 2020 the number of adults with operable cataract will increase by 43% to 600,000 assuming that the incidence of SVI and blindness due to cataract and cataract surgical coverage remain essentially unchanged over the next 12 years.

Cataract surgery and surgical outcomes

- Among all operated eyes, 46.1% had been couched (traditional procedure for cataract)
- Among cataract operated eyes 43.2% had not had an IOL implanted
- Visual outcomes after cataract surgery were poor with 43.2% having a PVA of <6/60
- After correction, nearly 50% with a poor outcome improved to 6/60 or better.

Other findings

- Hypertension Stage 2 occurred in 10.9% of participants (i.e. systolic blood pressure (BP) of ≥160 mmHg and diastolic BP of ≥100mmHg) being more common in females than males and in older than younger participants
- Hypertension Stage 3 occurred in 3.9% (i.e. systolic BP of ≥180 mmHg and diastolic BP of ≥110mmHg) which again was more common in females and which increased with increasing age
- A body mass index of ≥25 affected over a quarter of participants, being more common in females than males (32.8% vs 21.7%)
- Water supplies were unprotected in almost two thirds of households included in the survey (i.e. their water came from an open well or from ponds or streams)
- Diabetes was diagnosed in 7.1% of participants in the normative database (i.e. one in every eight participants; diagnosis was by random blood glucose). 85% were unaware that they had the condition.

Contents

Above Survey team members checking a data entry form

Collaborating institutions

Institution	Principal responsibilities
International Centre for Eye Health London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK	Technical guidance for the survey design, provision of training, external supervision of the survey activities, data analysis and report writing.
Institute of Ophthalmology Bath Street, London, UK	Setting up equipment for the survey, and training survey teams in packing, unpacking and transporting equipment; care of equipment, maintenance and simple repairs.
National Programme for the Prevention of Blindness (NPPB) **Federal Ministry of Health** Abuja, Nigeria	Government institution responsible for the co-coordination planning and implementation of eye care programmes in Nigeria. Primarily involved at the level of the NPPB Zonal Co-ordination offices during the survey.
National Eye Centre Off Nnamdi Azikiwe By-Pass, P.M.B. 2267, Kaduna, Nigeria	Government tertiary specialist eye hospital which was the centre for training survey teams.
Sightsavers International Nigeria Country Office Kaduna, Nigeria	Assisted in recruitment of survey teams, and provided training and support to Resource Manager, particularly with respect to managing the budget.
Sightsavers International Grosvenor Hall, Bolnore Road, Haywards Heath, West Sussex RH16 4BX, UK	International non-government development agency specialising in supporting blindness prevention programmes in developing countries, including Nigeria.

Survey teams

Co-ordinator

Mansur Rabiu

Other Core Team Members

Ophthalmologists: Abdull M Mahdi, Fatima Kyari, Tafida Abubakar, Abdullahi U Imam, O.Bankole
Optometrists: Christian Ezelum, Gabriel Entekume
Finance Manager: Mrs Oye Quaye
Data Entry Team: Mr. Auwal Shehu, Mr Charles Dania

North East	North West	North Central	South East/ South South	South West
Musa Ishaya	Kabir Mailfia	Adedoyin Y Modupe	Mercy O. Okorie	F.I. Fasakin
Late Henry Pero	Late Martha E . Mamman	Abdulrahman S. Mohammed	Victoria Ginikanwa	O.M. Ogunjimi
Hussaini Hong	Bello Buhari	Rebecca K. Hunduh	Felicia Chianakwalam	K.O. Olatunji
Sidi Sheriff	Fati Bukar Abba Gana	Opawoye O. Oluwatoyin	Atim E. Okpo	R.O. Alabi
Fatima Ibrahim	Hadiza Haruna	Magaji Kuku	P.N. Ifepe	C.N. Akomolafe
Aisha Salihu	Ibrahim Moses Dubai	Martin Martha	S.N. Ukeh	O. Animasaun
Dahiru Mohd	Zainab Mahmud	Muhd Yusuf Musa	E.O. Otomere	J.A. Adewale
Margeret Musa	Abdullahi Haro	Yunusa Zarumai	G.O. Apiphen	A.G. Abodunrin
Musa Benjamin	Suleiman D Ibrahim	Yilleng Titus Wiliam	Mary O. Egwu	A.W. Lamidi
Baba Saleh Bukar	Abubakar Kadi	Abiodun F. Comfort	Florence Orukpe	T. Abdul Razaq
Madu H Tilla	Murtala Haruna	Abdulfatai K. Babatunde	Edwin Okolo	A. Adeleke
Ashiru Galadima	Mamuda Kukashenka	Umar Mohd Idris	Gilbert Daminagbo	Opasina
Aisha Hasan Mato	Farouk Sirajo	Rabiu Mohd Sani	Casmir OOnwukwe	T.O. Akinola
Sariga M Ibrahim	Hassan Yusuf Kaura	Zubairu I Babakolo	John Undie	E.O. Adijai
Larry Yusuf Yammai	Isa Abdulkadir	Christiana Adamu	Ugoo Abba	F.A. Adetola
			Hilary Adie	

40 other personnel assisted in the survey: the cooks, drivers and ophthalmic nurses

Acknowledgements

The National Survey of Blindness and Visual Impairment is the biggest ever survey in Africa. No national level estimates existed in Nigeria before the present survey. This gigantic task which took more than three years to complete including 30 months of rigorous field work was only possible because of the special efforts of key individuals. We would like to record our appreciation for these key individuals:

National Programme for Prevention of Blindness (NPPB), Nigeria: Dr J.Jiya (Chairman); Dr O. Olowu (then National Co-ordinator) and Dr U. Onyebuchi (current National Co-ordinator). Professor A. Abiose and Dr Ozemela (then Director of National Eye Centre, Kaduna). Survey team members: Mansur Rabiu (Project Coordinator), Fatima Kyari, Abdull M.Mahdi, Tafida Abubakar, Abdullahi U Imam, O.Bankole (Survey ophthalmologists), Christian Ezelum and Gabriel Entukume (Survey Optometrists). Sightsavers International: Peter Ackland and Catherine Cross (UK office); Elizabeth Elhasan and support staff (Nigeria office) and Hannah Faal (West Africa office). Technical support from ICEH: Professor Allen Foster, Professor Clare Gilbert, Brendan Dineen, GVS Murthy, and Selvaraj Subramaniam. All the other staff who joined the survey teams in each zone, including the cooks and drivers.

We also wish to thank Ms Jyoti Shah for managing the grant; Auwal Shehu and Charles Dania (Data Entry Clerks); Mrs O. Quaye, Finance Administrator ; Pak Sang Lee (Institute of Ophthalmology, London) for setting up equipment and training staff in its handling and use.

We acknowledge the financial support of Sightsavers International, the Velux Stiftung Foundation and CBM.

We record our appreciation for the efforts made by the Federal Government of Nigeria, State Governments and local government authorities for all their support which included board and lodging.

Photography: Members of the Nigerian survey team.

Above All participants had their height and weight measured

Above Survey ophthalmologist measuring intraocular pressure at the slit lamp

Introduction

Purpose of the survey

To determine the prevalence, causes and the magnitude of blindness and low vision in

a) individuals aged 40 years and above and,

b) children aged 10 to 15 years old.

Specific objectives

To obtain information on:

1. Cataract surgical services (i.e. cataract surgical rate; cataract surgical coverage; the visual outcome of different cataract surgical techniques, including that of couching – a traditional surgical procedure)
2. The prevalence of other ocular conditions needing treatment (i.e. glaucoma, and trachomatous trichiasis)
3. The prevalence and type of refractive errors, and estimation of the need for optical services and spectacles
4. The prevalence and causes of conditions requiring low vision services (i.e. those where sight cannot be restored by optical, medical or surgery)
5. Normative data on parameters used in the diagnosis of glaucoma, and for determining optimal intraocular lens power in Nigerian eyes. (Based on a randomly selected sub-group of one in seven participants.)
6. The impact of severe visual impairment and blindness on a) quality of life and b) visual function
7. Gender and socioeconomic differences in health seeking behaviour and barriers to the uptake of services
8. The prevalence of hypertension and obesity, and household access to a protected water supply and sanitation.

Figure 1: States and geo political zones in Nigeria

Background

In 2002 the World Health Organization (WHO) revised estimates of the global magnitude and causes of blindness which revealed a paucity of recent data for most countries in the African region[1]. Though Nigeria is the most populated country in Africa, with a population of 135 million, no national data on the prevalence and causes of blindness exist[2]. Most data used for planning eye care services are generated either from urban areas where the large eye hospitals are situated[3] or from small, focal surveys[4-22].These small studies indicate that blindness is likely to be a public health problem[4-22] but such data cannot be extrapolated to the entire country as the population is culturally, ethnically and geographically diverse. Similarly, national survey results from other West African countries (e.g. Benin, 1990; The Gambia, 1986, 1996, Cameroon, 1996)[23-26] may not be readily comparable to present day Nigeria. Differences in population size, demographic profiles, climate and eye care service accessibility and provision contribute in determining the frequency and distribution of conditions such as trachoma and onchocerciasis as well as other causes of visual loss (e.g. cataract, glaucoma).

Nigeria is the ninth most populous county in the world and the most populated in Africa[27-29]. More than 500 languages are spoken by more than 200 ethnic groups[2]. The population is projected to increase to nearly 210 million by the year 2025[27]. The country is divided into 6 administrative zones (geo-political zones – GPZ), one Federal Capital Territory (FCT) of Abuja and 36 States[31] (Figure 1). Each State is subdivided into Local Government Authorities (LGAs), the smallest administrative division, of which there are 774 in the country[31].

Nigeria has five ecological zones (river delta, rain forest, transition, savannah and sahel) which are shared by 19 other countries with a total population of 345 million people in West and Central Africa. These ecological variations may have an important bearing on the prevalence and causes of blindness. Life expectancy in 2007 was 46.8 years for males and 48.1 for females [30] and 63% of the population lives in rural areas [28]. Adult literacy rate is 68% and the GDP per capita was 1,150 US$ in 2006[31] with 70.2% living in poverty (<1 US$ per day)[2, 29].

Access to eye care services is limited, especially in rural areas and amongst the urban poor. As such it is imperative that existing resources (human, financial, infrastructure and equipment) are used effectively, targeting the major avoidable causes of blindness in order that the goals of VISION 2020 are achieved in Nigeria.

Methodology

Details of the methods used have been published in BMC Ophthalmology[32].

Survey planning started in April 2004 and a consensus meeting was held in Nigeria which was attended by the Federal Government of Nigeria, senior ophthalmologists experienced in population based research and international NGOs. During this meeting the first draft of the protocol was written which was then extensively reviewed by technical experts. Procurement of equipment and recruitment of staff was completed and training of the team for the first phase of the survey was undertaken in January 2005. Training was followed by a pilot survey in two clusters in Kaduna State.

Study protocol

Inclusion criteria: For this survey two separate age groups were recruited, namely adults aged ≥40 years and children aged 10 to 15 years normally resident in the enumerated households. According to the population projections for Nigeria, there were an estimated 24.4 million persons in the adult age group (17.7%), and 20.3 million children (14.8%) aged 10 to 15 years in 2006[33]. The majority of the population live in rural areas (68%) while 32% live in urban zones[28]. Children under the age of 10 years were not included as they would have required specialist equipment, training and expertise. The age group 40 years and above was targeted as the available evidence indicates that most blindness occurs in this age category[34,35]. For example, in the Bangladesh and Pakistan national surveys the prevalence of blindness was very low among participants aged 30-39 years and increased exponentially after the age of 40 years[34,35].

Sample Size

Sample size: Census data available at the time of planning was from 1991. The annual growth rate was estimated to be 2.9%[29]. The target population for the survey was extrapolated from 1991 census data using annual growth rates. 23.6 million of the population were estimated to be aged 40 years and above in 2005, and the number in this age group in each of the 6 GPZs ranged from 16 to 30 million (Table 1).

The following were used to calculate an appropriate sample size: an assumed prevalence of blindness among those aged 40 years and above (based on previous small surveys) of 5%[12-19; 21]; relative precision: 0.5%; confidence limits: 95%; response rate of 85% and a design effect of 1.75. The sample size was calculated to be 15,375 persons aged 40 years or above. A sample size for children was not calculated as children were eligible if they lived in the household of an eligible adult.

Sampling procedure: Multi-stage stratified cluster random sampling, with probability proportional-to-size (PPS) procedures, was used to select a cross-sectional, nationally representative sample of the population. The sample was stratified by place of usual residence (urban / rural). As the proportion of people living in rural areas varied by State this was taken into account during stratification. In each GPZ and in the Federal Capital Territory (FCT) of Abuja, the proportion of clusters sampled was based on the proportion of the national population living in each zone.

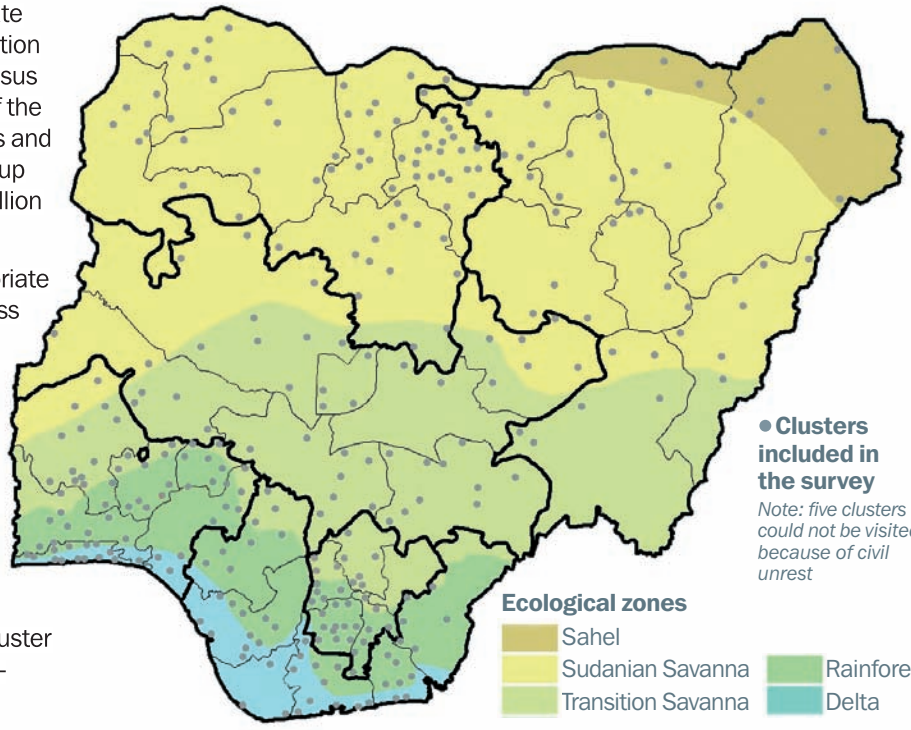
For this survey, a rural cluster consisted of inhabited settlements with a population of <20,000 (village) while an urban cluster comprised a 'ward' in a habited settlement with a population of >20,000. A total of 310 cluster sample sites were selected by PPS, of which 226 (72.9%) were in rural areas and 84 (27.1%) were urban. This sampling strategy was advantageous in terms of time, transport, enumeration and subsequent examination in each cluster.

Table 1: Distribution of Nigeria population based on projections from the 1991 census

Geo political zone	Total population	% of total in each geo political zone	Estimated population ≥ 40 years	% ≥ 40 years	Sample size ≥ 40 years
North Central	18,312, 959	13.7	2,981,514	13.2	2,027
North East	22,211, 520	16.6	3,806,234	16.8	2,588
North West	30,120,187	22.5	5,147,360	22.8	3,499
South East	16,194,215	12.1	2,620,756	11.6	1,782
South South	20,221, 525	15.0	3,290,629	14.6	2,237
South West	26,237,689	19.6	4,657,051	20.6	3,166
Abuja FCT	558,829	0.4	112,335	0.5	76
Total	**133,856,924**	**100.00**	**22,615,879**	**100**	**15375**

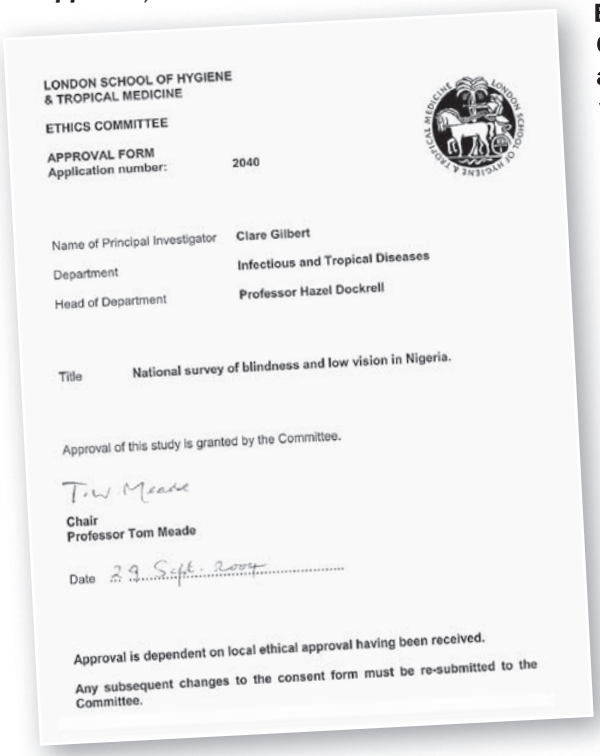
FCT = Federal Capital Territory

Figure 2: Locations of the clusters, by ecological zones



A total of 50 individuals aged 40 years and older were enumerated in each cluster. In small villages, if there were less than 50 eligible adults the nearest village was included and enumerated until the requisite number were identified. The sample of children included those who resided in the households of the adults who had been enumerated for the study. Information was also collected on the causes of blindness among those aged less than 10 years and 16 – 39 years by asking the head of the household.

Figure 3: Ethical approval, LSHTM



LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

ETHICS COMMITTEE

APPROVAL FORM
Application number: 2040

Name of Principal Investigator: Clare Gilbert
Department: Infectious and Tropical Diseases
Head of Department: Professor Hazel Dockrell

Title: National survey of blindness and low vision in Nigeria.

Approval of this study is granted by the Committee.

T.W Meade

Chair
Professor Tom Meade

Date 29 Sept. 2005

Approval is dependent on local ethical approval having been received.

Any subsequent changes to the consent form must be re-submitted to the Committee.

Ethical and Governmental approval: The protocol was reviewed by all the funding agencies (Sightsavers International, CBM and Velux Stiftung). Ethical approval was obtained from the London School of Hygiene and Tropical Medicine. The Federal Government of Nigeria also approved the survey and provided logistic support and advocacy for the study.

A Project Advisory Committee (PAC) was formed to guide the survey. Membership included Federal Ministry of Health officials, the NPPB coordinator, international NGOs based in Nigeria, leading ophthalmologists and academics, the survey team coordinator and ICEH staff. The PAC met periodically to review progress and solve outstanding problems. The SSI Nigeria Country Office provided all the logistic and administrative support for the survey.

Training and Pilot Studies

There were two survey teams who worked concurrently. Each team had two ophthalmologists (designated as a community ophthalmologist and a clinical ophthalmologist) and one optometrist. These "core staff" remained practically unchanged throughout the field work. Other personnel were recruited for each of the 6 GPZs i.e. two ophthalmic nurses, four enumerators, one liaison officer, and one interviewer. Each team had one cook and two drivers who also did not change throughout the survey. A central coordinating team was also drawn up consisting of a National Coordinator, 1 Finance Advisor and 2 data entry clerks.

All survey team members underwent intensive training for two weeks at the start of the survey which was led by technical experts from ICEH. A detailed manual was developed and given to each team member. The manual covered details of all the methods, guidelines for completing the data collection forms, and information on the duties and responsibilities of all survey personnel. Training included diagnostic algorithms for identifying the principal cause of visual impairment, and the importance of quality and of team work. Training was repeated before field work started in each of the six GPZs and included pilot studies in two clusters. Data from the pilot studies were analyzed immediately and fed back to all the team members.

Inter-observer agreement exercises were undertaken for the ophthalmologists, optometrists and the ophthalmic nurses. Wherever agreement was below expectations, personnel were replaced if retraining did not improve agreement. Studies were done in the clinic as well as in the community so that performance could be evaluated in a 'real-life' scenario. Overall agreement between pairs of personnel with similar skills was good.

Survey data collection

Mapping and identification of cluster segment for survey:

Liaison Officers visited survey villages in advance where they met village elders to explain the purpose and procedures of the survey, to obtain consent and to request full participation of all eligible persons.

Enumeration procedures

Meticulous enumeration is of crucial importance in a cross sectional/ prevalence survey, providing the correct denominator for determining blindness and low vision rates. If a house was locked at the first visit by the enumeration team, information was given to the neighbours that the team would return later in the day. Repeat visits were made the same day to gather information about the locked house. If contact could not be established after two visits the household was categorised as a non- responding household. Typically two to three days were required for each cluster.

At the examination site set up in each cluster the interviewer systematically identified one out of every seven adults that reported to the examination site for a detailed eye examination for collecting normative data (yellow card). The purpose of the normative database was to determine the distribution of ocular variables in normal adult Nigerian eyes (e.g. intraocular pressure, cup disc ratio etc) to give a range of values which could be considered normal for this population.

Oral informed consent was obtained from each participant by the enumerators and interviewer. Personal and demographic data were recorded prior to eye examination by a trained interviewer. All subjects had their blood pressure (three readings) height and weight measured. All participants underwent distance visual acuity measurement with a reduced logarithm of minimum angle of acuity (logMAR) tumbling "E" chart[36,37]. The reduced LogMAR E chart was used because of ease

Above The drivers assisted in measuring visual acuity by pointing to the Es on the chart one by one

Above Enumerator visiting a home in South south GPZ

of administration and standardization as well as the relative lack of familiarity with the Roman alphabet in Nigeria. Visual acuities were measured in each eye separately at four metres, and at one metre if necessary, followed by vision with both eyes open. Participants who could not see any letter at one metre were assessed by the community ophthalmologist, for finger counting, hand movements and light perception (PL/NPL) in a darkened room. Participants who did not understand the test or who had communication difficulties were assessed and their vision was recorded as ' believed blind' or 'believed not blind'.

Based on presenting visual acuity, participant s were either marked as a "red card" (visual acuity worse than 6/12 in either eye) or as a "green card" (better than 6/12 in each eye). All then underwent an ophthalmic examination by the ophthalmologist. All participants also underwent automated refraction and biometry. Red card holders were then examined in more detail, which included retesting visual acuity with the autorefraction results placed in a trial lens frame. Red card holders also had a slit lamp examination with dilated fundus examination. Participants also had visual field and fundus photos as per protocol.

Visual function and quality of life questionnaires were also administered.

All participants suspected to have diabetic retinopathy and those selected for the normative database (i.e. the one in seven "yellow cards") had a random blood sugar tested.

A detailed dilated eye examination was done on:

1. Those with a presenting VA of <=6/12 in one or both eyes (red cards)
2. One in seven participants (yellow cards) for the normative data base and
3. Subjects aged 40 years and more, with a CDR of >0.6 or CDR asymmetry of >0.2 or who had splinter haemorrhages on the disc, irrespective of their visual acuity.

Data collection was split into six phases with one GPZ being surveyed in each phase. There was a gap of a few weeks to a few months between each phase to avoid the rainy season when field work was impossible (June to August). Data were collected by the two clinical teams who worked in two different locations concurrently. Each clinical team was supported by a dedicated enumeration team.

Below All data entry was done in Nigeria by trained personnel

Data management and analysis
A record sheet was completed for each eligible enumerated participant, after being cross-checked for errors by the community ophthalmologists in the field and the project coordinator in the office. The data were subsequently entered into a customized database (with built in range and consistency checks) by an experienced data officer and independently crosschecked by a second data officer. Data cleaning and analysis is being done using STATA 10.0 (StataCorp LP, Texas, USA) by a dedicated statistician at ICEH.

The visual fields, autorefractometer readings, and A-scan biometry readings were recorded, printed and attached to the record forms. Fundus images were stored on hard drives of the fundus camera and written on CD plates for reading and grading at the Reading Center, Moorfields Eye Hospital, London.

Descriptive analyses and cross tabulations with calculation of Pearson chi squared tests were performed. Further analyses were undertaken to explore risk factors using logistic regression with generalised estimating equations to adjust for dependency in the data due to clustered sampling. All tests were two sided, and the odds ratios (OR) and 95% confidence intervals (CI) quoted were derived from logistic regression models. To account for differential non-response, the blindness prevalence estimate was standardized by age and gender, using the most recent population estimates. US census bureau data were used when calculating projections for the year 2020.

Quality assurance
Quality was of paramount importance during the survey and was assured by regular training, the use of a detailed Manual of Operations, regular inter-observer agreement studies and supervisory visits to the field, and cross checking of entered data.

Service component
All participants with visual impairment were referred to the nearest eye facility. People with operable cataract were referred to the cataract service centers where free or subsided cataract surgery had been organized for survey participants. A total of 3,620 people had cataract surgery as a direct result of the survey, and 5,800 pairs of reading glasses and over 200 pairs of aphakic glasses were distributed at no cost. Participants with mild ocular or systemic complaints were also treated as were over 30,000 non-survey participants who attended the examination sites with ocular complaints.

Definitions
Household: A household was defined as all those living under the same roof and eating from a common cooking pot routinely. If the head of the household had more than one wife and the wife and children lived in a different compound, they were treated as a separate household.

Normal resident: Individuals who had lived in the cluster continuously for three months prior to the survey.

Eligible respondent: All individuals aged 40 years and above and residing continuously in the cluster for the preceding three months were eligible for inclusion as were children aged 10-15 years living in households which had an eligible adult. If the enumerators determined that a respondent was not going to be available over the following two days (when the survey team would be in the cluster), then the resident and his/her family were deemed ineligible.

Rural cluster: An inhabited village within an LGA with a population less than 20,000 (definition adopted by Nigerian Population Commission).

Urban cluster: A settlement with a population of 20,000 or more. Smaller clusters adjacent to or located within large urban areas were also classified as urban if they had amenities similar to those found in large conurbations.

Blindness: WHO definitions of blindness and visual impairment were used with the addition of "near normal"[38].

Blindness presenting VA (with glasses for distance if normally worn or unaided if glasses for distance not worn) of <20/400 (<3/60) in the better eye.

Severe visual impairment (SVI): presenting VA of <20/200 to 20/400 (<6/60-3/60) in the better eye.

Moderate visual impairment (Mod VI): presenting VA of <20/63 to 20/200 (< 6/18-6/60) in the better eye.

Mild visual impairment (Mild VI): presenting VA <20/40 to 20/63 (< 6/12 – 6/18) in the better eye.

Normal/Near normal (NN): presenting vision ≥ 20/40 (≥ 6/12) in the better eye.

Cataract surgical coverage[39]

CSC (persons)

This measure indicates the extent to which the need for cataract surgical services has been met and it can be calculated for three visual impairment cut-offs: <3/60, <6/60 and <6/18 using the formula: (x + y)/(x + y + z) * 100 where:

x = persons with unilateral pseudo/aphakia and visual impairment in contra lateral eye

y = persons with bilateral pseudo/aphakia, regardless of acuity.

z = persons with <3/60, <6/60 and <6/18 in whom the principle cause was cataract (unilateral or bilateral)

CSC (eyes)

This measure gives an indication of the proportion of eyes with operable cataract that have had surgery in the community at a given point in time.

Calculation of CSC (eyes) was performed for three visual impairment cut-offs: <3/60, <6/60 and <6/18 using the formula: (a/a+b) x100 where

a = all eyes which are aphakic or pseudo/aphakic, regardless of acuity.

b = all eyes with cataract causing an acuity of <3/60, <6/60 or <6/18.

Results

Adult population surveyed

Response rates: The overall response rate was 89.9% (range across GPZs: 88.2 – 91.1%). This high response rate means that the findings can be generalized to the Nigerian adult population across the country. The age and gender distribution of those enumerated and examined showed that women were over-represented in the younger age group (40-49 years) but the gender differences were not significant at other ages (Table 3). The mean age of those examined was 55.9 years (SD ±12.4) being significantly higher for males (56.7; SD ± 12.5) than females (55.2; SD± 12.2) (p = 0.001). The mean age of those enumerated but not examined was 51.5 years (SD ± 10.9). Among those not examined, mean age for males was 51.3 years (SD ±11.2) and 51.6 years (SD ± 10.8) for females.

There were 1,523 individuals who either did not complete the examination, refused to be examined, or were not available (76.5%). The age and gender of those enumerated and those examined were similar (Table 3). There were marginally more younger females enumerated (40-49 years) compared to males (Table3). Similarly enumeration and examination rates were marginally lower for older females compared to males (≥ 80 years).

Prevalence of blindness among adults aged ≥40 years

The revised WHO definition of blindness uses presenting visual acuity which allows estimation of the contribution uncorrected refractive errors make

Above Taking blood pressure using a digital device. The average of three readings was used in the analysis

Table 2: Response rates across the survey clusters (adults ≥40 years)

Geo political zones	Total clusters	% Rural clusters	% Urban clusters	Enumerated	Examined*	Response rate %
North Central	45	66.7 (30)	32.6 (15)	2,287	2,032	88.8
North East	41	74.5 (38)	25.5 (13)	1,959	1,727	88.2
North West	80	75.7 (53)	24.3 (17)	3,949	3,596	88.2
South East	36	80.5 (29)	19.4 (7)	1,778	1,662	91.1
South South	45	73.3 (33)	26.7 (12)	2,074	1,852	89.3
South West	63	68.2 (43)	31.7 (20)	3,075	2,730	88.8
Total	**310**	**72.9 (226)**	**27.1 (84)**	**15,122**	**13,599**	**89.9**

Table 3: Age and gender of the survey population (adults ≥ 40 years)

Age groups	Males				Females				Total			
	Enumerated		Examined		Enumerated		Examined		Enumerated		Examined	
	N	%	N	%	N	%	N	%	N	%	N	%
40-49 years	2,507	35.7	2,084	33.4	3,270	40.4	2805	38.2	5,777	38.2	4889	36.0
50 – 59 years	1,840	26.2	1,649	26.4	2,095	25.9	1928	26.2	3,935	26.0	3577	26.3
60- 69 years	1,405	19.9	1,306	20.9	1,529	18.9	1467	20.0	2,934	19.4	2773	20.4
70 – 79 years	879	12.5	838	13.4	805	10.0	815	11.1	1,684	11.2	1653	12.2
≥ 80 years	400	5.7	369	5.9	392	4.8	330	4.5	792	5.2	699	5.1
Total	**7,031**	**46.5**	**6246**	**46.0**	**8,091**	**53.5**	**7345**	**54.0**	**15,122**	**100.0**	**13591**	**100.0**

Above Old lady who has had cataract surgery having her visual acuity measured. In modern cataract surgery thick spectacles are no longer required

to blindness and visual impairment which was not possible using best corrected visual acuity[38, 40]. In the survey presenting (PVA) and best corrected visual acuity (BCVA) were compared, 81% of participants who were categorised as blind based on PVA could not be improved by best correction after refraction, while 56.7% of those who had SVI and 56.9% of those with moderate VI could be improved (Table 4).

The prevalence of blindness in the sample using PVA was 4.2% (95% CI: 3.8 to 4.6%) (Table 5) and the prevalence of severe visual impairment was 1.5% (95 % CI: 1.3 to 1.7%). Using BCVA, 3.4% (95% CI: 3.0 to 3.8%) were blind, 0.8% (95% CI: 0.7 to 1.0%) had SVI, 5.3% (95% CI: 4.9 to 5.8%) had moderate visual impairment, 4.5% (95% CI: 4.1 to 4.9%) had mild visual impairment while 86% (95% CI: 85.2 to 86.8%) were categorized as normal/near normal. The prevalence of blindness among those aged ≥50 years was 5.5% (476/8702) while it was 9.3% (476/5125) among those aged ≥60 years.

The WHO global data on blindness for the year 2002 categorized Nigeria and other countries in Africa to have an estimated prevalence of blindness of 9% among those aged ≥50 years and 1% for all ages[41]. The present survey found a lower prevalence than has been traditionally used for Nigeria. On the other hand, the Nigeria survey revealed a much higher prevalence of blindness than reported from Rapid Assessment of Avoidable Blindness (RAAB) surveys in other African countries i.e. Western Rwanda[42], Cameroon[43] and Kenya[44].

A recent national survey in Ethiopia of all age groups reported the prevalence of blindness among those aged ≥60 years to be 14.8% [45] which was much higher than among persons of comparable age in Nigeria (9.3%).

The prevalence of blindness among adults in Nigeria (4.2% ≥40 years; 6.5% ≥50 years) was lower than in Pakistan (5.1 % aged ≥40 years; 7% ≥50 years)[46], higher than in Bangladesh (2.3%≥40 years; 3.9% ≥50 years)[47] and similar to India (5.34% ≥50 years)[48]. The surveys in these three large Asian countries used a similar methodology to that in Nigeria and so comparisons are appropriate. Differences in the prevalence of blindness between the countries in Africa and Asia could be due to differences in the causes of blindness between the countries as well as access to eye care services and/or differences in life expectancy.

Age and blindnes: Univariate analysis revealed that the prevalence of blindness based on PVA increased significantly with increasing age, from 0.8% (95% CI: 0.5 to 1.1%) at 40-49 years to

Table 4: Presenting and best corrected visual acuity in the better eye (persons)

Presenting visual acuity	Best corrected visual acuity											
	Normal/ near normal (≥ 20/40)		Mild VI* (< 20/40- ≥20/63)		Mod VI† (< 20/63- ≥20/200)		Severe VI± (< 20/200- ≥ 20/400)		Blindness (< 20/400)			Total
	N	%	N	%	N	%	N	%	N	%	N	%
Normal (≥ 20/40)	10,453	100%									10,453	100%
Mild VI (< 20/40-≥20/63)	766	76.4%	236	23.6%							1,002	100%
Moderate VI† (< 20/63 - ≥20/200)	429	31.4%	347	25.4%	588	43.1%					1,364	100%
SVI± (< 20/200 - ≥ 20/400)	23	11.3%	12	5.9%	80	39.4%	88	43.3%			203	100%
Blindness (< 20/400)	18	3.2%	14	2.5%	54	9.5%	22	3.9%	461	81%	569	100%

*Mild Visual Impairment †Moderate Visual Impairment ±Severe Visual Impairment

23.3% (95% CI: 20.2 to 26.7%) among those aged ≥ 80 years (F-222.72; p < 0.001)(Table 5). This finding is universal[41-48].

Gender and blindness: Significant differences were also observed in relation to gender with females having a higher prevalence (4.4%) of blindness compared to males (4.0%)(F-22.23; p <0.001) but the findings were less dramatic than in South Asia[46-48].

Social status and blindness: Literacy was used to indicate social status and literacy was strongly associated with blindness and visual impairment (Table 5). Participants who could not read or write had a much higher prevalence of blindness (5.8%), compared with those who could read or write easily (1.5%). These differences were statistically significant (F-68.82; p < 0.001).

Geo political zone and blindness: Participants living in the South West had the lowest prevalence of blindness (2.8%; 95% CI: 2.2 to 3.5%) while those in the North East GPZ had the highest (6.1%; 95% CI: 4.7 to 7.9%) (F 6.36; p <0.001).

Place of residence: The prevalence of blindness and severe visual impairment did not differ by urban/rural place of usual residence (F1.62; p=0.1785) (Table 5) though the prevalence of blindness was higher in rural (4.3%) compared to urban (3.8%) areas.

Above Elderly participant being interviewed in her home as she could not attend the examination site

Table 5: Association between socio-demographic variables and presenting visual acuity in the better eye (persons)

	Parameters	Normal/ near normal N (%) [95% CI]	Mild VI N (%) [95% CI]	Mod VI N (%) [95% CI]	Severe VI N (%) [95% CI]	Blind N (%) [95% CI]
Total		10455 (76.9%) [75.8; 77.9]	1002 (7.4%) [6.9; 7.9]	1364 (10.0%) [9.4; 10.7]	203 (1.5%) [1.3; 1.7]	569 (4.2%) [3.8; 4.6]
Age	40 – 49 yrs	4,662 (95.3%)	103 (2.1%)	82 (1.7%)	6 (0.1%) [0.004; 0.3]	37 (0.8%) [0.5-1.1]
	50 – 59 yrs	3,076 (86.0%)	232 (6.5%)	189 (5.3%)	25 (0.7%) [0.5; 1.0]	56 (1.6%) [1.2; 2.1]
	60 – 69 yrs	1,825 (65.8%)	319 (11.5%)	446 (16.1%)	52 (1.9%) [1.4; 2.5]	131 (4.7%) [3.9; 5.8]
	70 – 79 yrs	719 (43.5%)	243 (14.7%)	444 (26.9%)	65 (3.9%) [3.1; 4.9]	182 (11.0%) [9.6;12.6]
	≥ 80 yrs	173 (24.7%)	105 (15.0%)	203 (29.0%)	55 (7.9%) [6.1; 10.0]	163 (23.3%) [20.2; 26.7]
						F 222.72 p <0.001
Gender	Male	5,023 (80.4%)	362 (5.8%)	522 (8.4%)	92 (1.5%) [1.2; 1.8]	248 (4.0%) [3.5; 4.6]
	Female	5,432 (73.9%)	640 (8.7%)	842 (11.5%)	111 (1.1%) [1.2; 1.8]	321 (4.4%) [3.9; 4.9]
						F 22.23 p <0.001
GPZ	South West	2,170 (79.5%)	195 (7.1%)	263 (9.6%)	24 (0.9%) [0.6; 1.3]	76 (2.8%) [2.2; 3.5]
	South South	1,351 (72.9%)	154 (8.3%)	254 (13.7%)	33 (1.8%) [1.2; 2.5]	60 (3.2%) [2.4; 4.4]
	South East	1,159 (69.7%)	174 (10.5%)	218 (13.1%)	34 (2.0%) [1.5; 2.8]	77 (4.6%) [3.6; 5.9]
	North Central	1,648 (81.2%)	126 (6.2%)	144 (7.1%)	35 (1.7%) [1.2; 2.5]	76 (3.7%) [3.0; 4.7]
	North West	2,837 (78.9%)	233 (6.5%)	297 (8.3%)	53 (1.5%) [1.1; 1.9]	174 (4.8%) [4.1; 5.8]
	North East	1,290 (74.6%)	120 (6.9%)	188 (10.9%)	24 (1.4%) [1.0; 2.0]	106 (6.1%) [4.7; 7.9]
						F 6.36 p <0.001
Place of residence	Urban	2408 (78.9%)	210 (6.9%)	272 (8.9%)	44 (1.4%) [1.0; 2.0]	117 (3.8%) [3.1; 4.7]
	Rural	8047 (76.3%)	792 (7.5%)	1092 (10.4%)	159 (1.5%) [1.3; 1.8]	452 (4.3%) [3.8; 4.8]
						F 1.62 p=0.18
Literacy*	Can read and write easily	2626 (89.5%)	115 (3.9%)	134 (4.6%)	16 (0.6%) [0.3; 0.9]	43 (1.5%) [1.0; 2.1]
	Reads and writes with difficulty	2544 (85.2%)	150 (5.0%)	188 (6.3%)	26 (0.9%) [0.6; 1.3]	78 (2.6%) [1.9; 3.5]
	Cannot read or write	5276 (68.9%)	736 (9.6%)	1042 (13.6%)	161 (2.1%) [1.8; 2.5]	446 (5.8%) [5.3; 6.5]

*Literacy Status could not be determined in 12 individuals; GPZ = geopolitical zone

Above Every participant was examined by an ophthalmologist, even those with normal vision

Association of determinants in a multivariate model:
In multivariate analysis, age, gender, administrative zone and literacy remained significantly associated with blindness after adjusting for age and gender differences (Table 6). Individuals aged ≥80 years had a 28 times higher risk (95% CI: 20.7; 38.1) of being blind compared to the youngest participants. Females had a 30% higher risk of blindness compared to males (95% CI: 1.1; 1.6) while people residing in the North East GPZ had a 3.2 (95% CI: 2.2; 4.7) times higher risk compared to those in the South West. Participants who could not read or write, had double the risk of being blind, compared to those who could read and write easily.

Magnitude of blindness among adults:
The magnitude of blindness among adults aged ≥ 40 years and for all ages was estimated (Table 7). Based on the survey findings, it is estimated that 1.13 million individuals aged ≥40 years are currently blind in Nigeria (95% CI: 1.03-1.25 million). The North West GPZ harbours the largest number of blind adults (28.6%) being the zone with the largest population (Figure 4). A further 2.7 million adults aged ≥ 40 years estimated to have moderate visual impairment and an additional

Table 6: Risk factors for blindness

Risk Factors	Blindness	
	N	Adjusted OR* (95% CI)
Age		
40 – 59 yrs	93	Reference
60 – 69 yrs	131	4.5 (3.3; 6.1)
70 – 79 yrs	182	11.3 (8.6; 15.0)
≥ 80 yrs	163	28.1 (20.7; 38.1)
Gender		
Male	248	Reference
Female	321	1.3 (1.1; 1.6)
Geo political zone		
South West	76	Reference
South South	60	1.3 (0.8; 1.9)
South East	77	1.5 (1.1; 2.1)
North Central	76	1.6 (1.1; 2.3)
North West	174	2.5 (1.8;3.4)
North East	106	3.2 (2.2 ; 4.7)
Place of residence		
Urban	117	Reference
Rural	452	1.0 (0.8; 1.4)
Literacy		
Can read and write easily	43	Reference
Can read and write with difficulty	78	1.7 (1.1; 2.6)
Illiterate	446	2.1 (1.4; 3.0)

* Adjusted for age and gender

0.4 million adults are severely visually impaired. Thus a total of 4.25 million adults aged ≥ 40 years in Nigeria suffer moderate or severe visual impairment or blindness (Table 7).

The prevalence of all age blindness was estimated using the prevalence data for those aged 50+ from the present survey and using the WHO estimates for blindness for those aged 0-49 years where Nigeria was categorized along with other sub Saharan countries as the Afro-D region[39]. The prevalence of blindness in the all-age population was estimated to be 0.78%. This was lower than previously estimated for Nigeria by WHO[41].

Ecological zones and blindness

There is a considerable body of evidence that ecological factors such as rainfall, temperature, vegetation, humidity, topography, altitude etc. are associated with eye diseases, particularly those caused by infectious agents. Ultra violet (UV) radiation has been postulated to be a risk factor for cataract and it has been shown that the intensity of UV radiation varies by latitude and altitude[49].

There is significant variation in climatic conditions across the different ecological zones in Nigeria. The mean monthly temperatures vary from 25-28° Celsius in the delta region to 22-33° in the Sahel/Sudan savannah regions[50]. The rainfall pattern is also different across the ecological zones. The delta region has a bimodal pattern of rainfall compared to a unimodal pattern in the Sahel and the Sudan savannah regions. The mean annual rainfall exceeds 2000 mm in the delta region, while the rain forest area has 1200-2000 mm of rain every year. The Sudan savannah and the guinea forest savannah report between 600-1400 mm of rain while the Sahel region typically experiences 400-600 mm of rain annually[50].

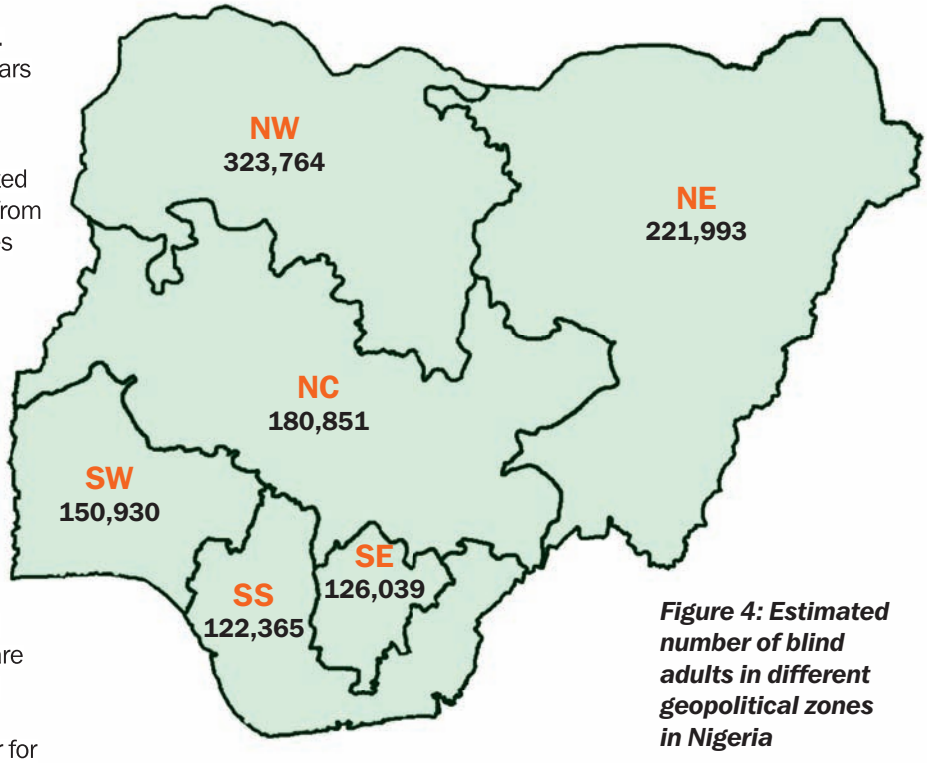


Figure 4: Estimated number of blind adults in different geopolitical zones in Nigeria

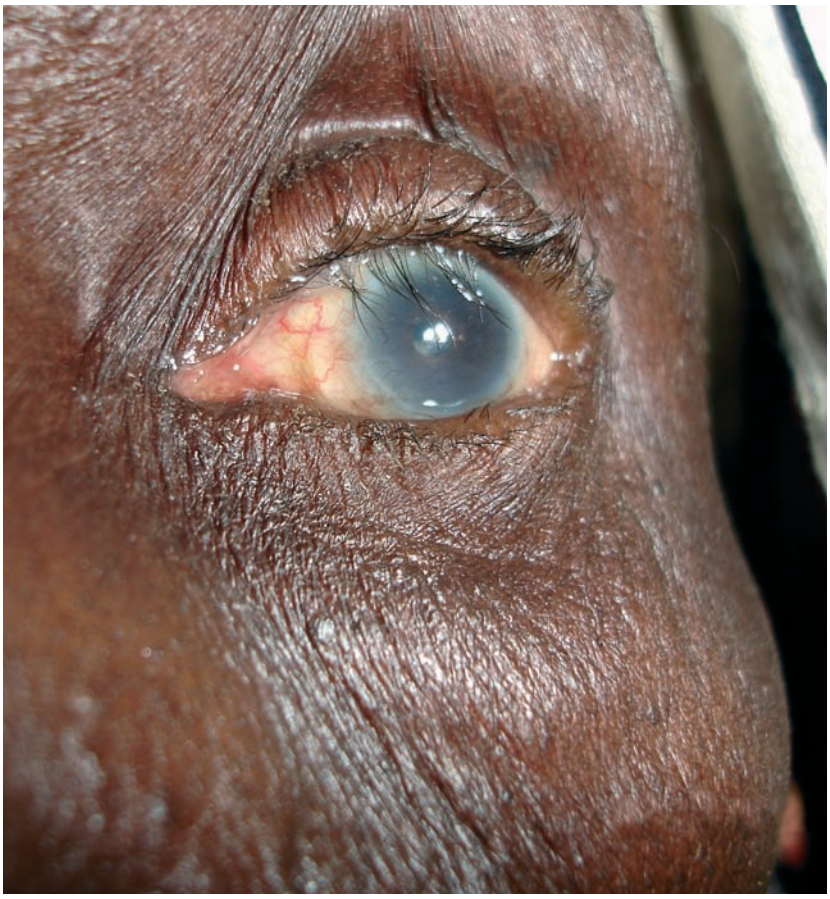
Data were analysed in relation to the different ecological zones in Nigeria. Nigeria has five ecological zones:

1. Sahel: which occupies a small area in the northern part of the country, mostly in the North East geopolitical zone.

Sudan savannah is a large belt in Nigeria and is found in the North East, North West and North Central geopolitical zones.

Table 7: Estimated number of visually impaired and blind persons aged ≥40 years in different administrative zones

	Blindness			SVI			Moderate VI		
Administrative zones	**Prev**	**Estimated No.**	**95% CI**	**Prev (%)**	**Estimated No.**	**95% CI**	**Prev (%)**	**Estimated No.**	**95% CI**
North West	4.84	323,764	270,765 - 385,756	1.48	98,618	74,878 - 129,700	8.27	552,632	483,365 - 630,447
North East	6.14	221,993	171,076 - 286,814	1.39	50,263	34,721 - 72,698	10.89	393,725	330,577 - 466,932
North Central	3.75	180,851	142,916 - 228,376	1.72	83,287	56,973 - 121,189	7.10	342,665	278,107 - 421,023
South West	2.79	150,930	120,813 - 187,991	0.88	47,662	31,422 - 72,054	9.64	522,300	452,371 - 601,898
South East	4.63	126,039	98482 - 160,781	2.05	55,654	39,991 - 77,262	13.12	356,839	298,166 - 424,941
South South	3.24	122,365	89,515 - 166,943	1.78	67,301	47,213 - 95,558	13.71	518,012	444,931 - 600,543
Total Nigeria	**4.19**	**1,132,295**	**1,027,738 - 1,246,808**	**1.49**	**403,965**	**351,595 - 465,187**	**10.04**	**2,714,324**	**2,542,299 - 2,896,598**



Above Elderly women with ingrowing eyelashes from trachoma. She has also undergone unsuccessful couching

2. Guinea forest savannah or tall grass savannah also occupies a large part of the country and is spread across the North Central, North West, South West and South East zones.
3. Rain forest: a small belt of rain forest vegetation mostly occurs in the South West and South East zones.
4. Delta: there is a small delta region in South-south and South west geo-political zones.

The prevalence of blindness varied across the different ecological zones (Table 8) being highest in the sahel (6.6%) and the lowest in the delta (3.3%). Rates of severe visual impairment or moderate visual impairment were similar across the different ecological zones. These differences may reflect differences in access to eyecare services as well as variation in the incidence of disease.

Recent surveys from neighbouring countries in West Africa have shown similarities in the blindness profile in populations residing in the same ecological zones in northern Cameroon, the Volta region of Ghana and Mali[25,51,52]. It is, therefore, possible to use the findings from Nigeria to estimate the need for eye care services for populations in similar ecological zones in West and Central Africa, provided that access to services is similar – however this is not always the case. For example, access to cataract surgical services is reasonably good in the rain forest region of Cameroon[43].

Causes of blindness and visual impairment

All but 9 of the 3,138 individuals with presenting VA < 6/12 in the better eye, underwent a detailed examination to elicit the principal cause of visual impairment. Uncorrected refractive errors were the commonest cause of mild and moderate VI (77.9% and 57.1% respectively) (Table 9). Cataract was the commonest cause of severe visual impairment and blindness being responsible for 45.3% and 43.0% respectively. Overall, 84% of blindness was due to avoidable causes. The avoidable proportion was higher among those with mild and moderate VI (Table 9).

Table 8: Prevalence of blindness and visual impairment across the ecological zones

Eco-logical zones	Examined	Normal/ near normal (≥ 20/40)		Mild VI* (< 20/40-≥20/63)		Mod VI† (< 20/63-≥20/200)		Severe VI± (< 20/200-≥ 20/400)		Blindness (< 20/400)	
		N	% [95% CI]	N	% [95% CI]	N	% [95% CI]	N	% [95% CI]	N	% [95% CI]
Sahel	256	188	73.4 [70.1-76.5]	18	7.0 [4.7-10.3]	29	11.3 [9.1-14.0]	4	1.6 [0.6-4.0]	17	6.64 [4.2-10.4]
Sudan savannah	5,328	4,173	78.3 [76.4-80.1]	350	6.6 [5.8-7.5]	462	8.7 [7.7-9.7]	78	1.5 [1.2-1.8]	265	5.0 [4.3-5.7]
Guinea forest savannah	3,453	2,676	77.5 [75.4-79.4]	258	7.5 [6.5-8.5]	318	9.2 [8.0-10.5]	62	1.8 [1.3-2.4]	139	4.0 [3.2-5.0]
Rainforest	3,220	2,420	75.2 [72.8-77.4]	269	8.3 [7.4-9.4]	390	12.1 [10.6-13.8]	37	1.1 [0.9-1.5]	104	3.2 [2.6-3.9]
Delta	1,334	996	74.7 [71.6-77.5]	107	8.0 [6.5-9.9]	165	12.4 [10.3-14.8]	22	1.6 [1.1-2.4]	44	3.3 [2.4-4.5]
Total	**13,591**	**10,453**	**76.9 [75.8-77.9]**	**1,002**	**7.4 [6.9-7.9]**	**1,364**	**10.0 [9.4-10.7]**	**203**	**1.5 [1.3-1.7]**	**569**	**4.2 [3.8-4.6]**

*Mild Visual Impairment †Moderate Visual Impairment ±Severe Visual Impairment

Table 9: Principal cause among subjects with bilateral blindness, severe, moderate and mild visual impairment

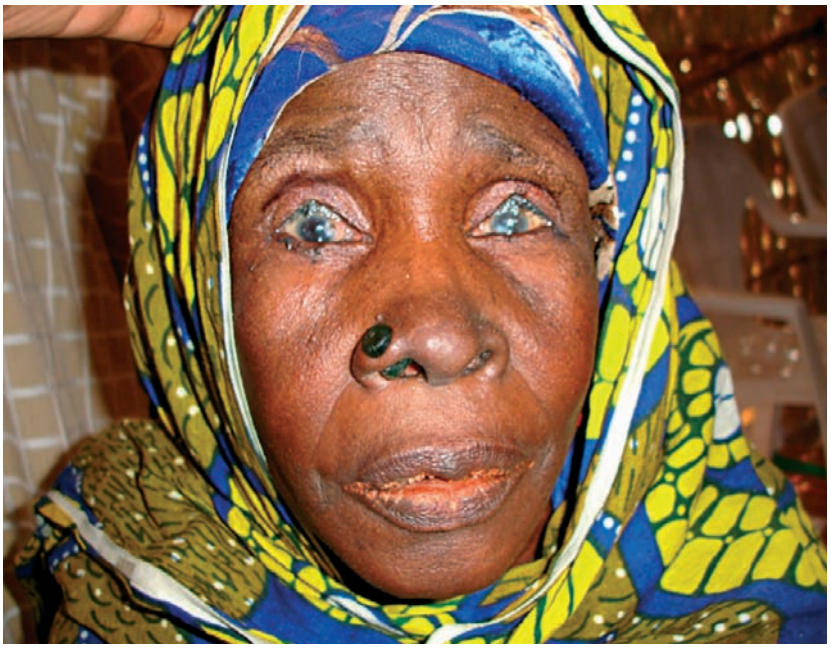
Principal cause	< 6/12-6/18 (Mild VI) N (%)	< 6/18-6/60 (Moderate VI) N (%)	< 6/60-3/60 (Severe VI) N (%)	< 3/60 (Blind) N (%)
Treatable				
Refractive error*	779 (77.9)	776 (57.1)	23 (11.3)	8 (1.4)
Cataract*	123 (12.3)	350 (25.8)	92 (45.3)	244 (43.0)
Uncorrected aphakia*	12 (1.2)	40 (2.9)	32 (15.8)	48 (8.4)
PCO*	1 (0.1)	3 (0.2)	1 (0.5)	1 (0.2)
Glaucoma*	10 (1.0)	28 (2.1)	8 (3.9)	95 (16.7)
Diabetic retinopathy*	4 (0.4)	1 (0.1)	1 (0.5)	3 (0.5)
Pterygium	4 (0.4)	13 (1.0)	0	3 (0.5)
Total treatable	**933 (93.3)**	**1211 (89.2)**	**157 (77.3)**	**402 (70.8)**
Preventable				
Trachoma	6 (0.6)	12 (0.9)	2 (1.0)	24 (4.2)
Other corneal scars	8 (0.8)	19(1.4)	12 (5.9)	45 (7.9)
Onchocerciasis	1 (0.1)	2 (0.1)	0	6 (1.1)
Total preventable	**15 (1.5)**	**33 (2.4)**	**14 (6.9)**	**75 (13.2)**
Total avoidable	**948 (94.8)**	**1244 (91.6)**	**171 (84.3)**	**477 (84.0)**
Unavoidable				
Phthisis/ absent globe	3 (0.3)	4 (0.3)	1 (0.5)	13 (2.3)
Macular degeneration*	10 (1.0)	32 (2.4)	8 (3.9)	10 (1.8)
Optic atrophy	4 (0.4)	14 (1.0)	1 (0.5)	21 (3.7)
Other retina and posterior segment	13 (1.3)	32 (2.4)	17 (8.4)	17(3.0)
Others	0	3 (0.2)	0	2 (0.3)
Total unavoidable	**30 (3.0)**	**85 (6.3)**	**27 (13.3)**	**63 (11.1)**
Undetermined	22 (2.2)	29 (2.1)	5 (2.5)	28 (4.9)
All blindness	**1000 (100)**	**1358 (100)**	**203 (100)**	**568 (100)**

* Age related

Age-related causes were responsible for 41% of mild VI, 60.7% of Mod VI, 75.9% of SVI and 73.2% of blindness. In 56.6% of mild VI, 35.8% of mod VI, 15.8% of SVI and 11.1% of blind, the underlying aetiology was unknown. Measles/ use of traditional eye medicines/ vitamin A deficiency were responsible for 3.7% of blindness. Trauma (1.1%), surgical procedures (2.8%) were also identified among the blind. Toxoplasmosis was responsible for 0.9% of mild and 0.7% of Mod VI. Trachoma was responsible for 4.2% of blindness and Onchocerciasis for 1.1%.

Among persons with corneal scarring (45), infections not due to trachoma or onchocerciasis were responsible for 28.9% (13) while measles/ vitamin A deficiency or use of traditional eye medicines was responsible for 26.7% (12). Trauma was the underlying cause in 11.1% (5) and surgical procedures for 6.7% (3). In a further 26.7% (12) no underlying cause could be determined.

Man blind from corneal scarring



Above This woman has had unsucessful lid surgey in both eyes for trachoma. She is blind in the her left eye and urgently needs surgery to correct the position of her right upper eye lid

The prevalence of cataract blindness was 1.8% (95% CI: 1.57-2.05) (Table 10). Glaucoma blindness was the second most prevalent condition (prevalence- 0.7%; 95% CI: 0.55-0.88). The prevalence of blindness due to uncorrected refractive errors, onchocerciasis, trachoma and diabetic retinopathy were low (Table 10).

Increasing age was associated with increasing prevalence of most of the important causes including cataract and glaucoma. Most cause specific prevalence rates were higher among females.

Participants living in rural areas had a higher prevalence of cataract and corneal pathology compared to those from urban areas. The prevalence of glaucoma and posterior segment pathology was higher among urban residents.

The prevalence of cataract was lowest in the South West and highest in the North East. Participants who were illiterate had a higher prevalence of all cause-specific conditions.

Adjusted association analyses

Each decade increase in age was significantly associated with increasing prevalence of all the common causes. Females had nearly twice the risk of having VA < 6/60 due to cataract compared to males.

Poor literacy was also associated with a higher risk of visual loss from cataract and refractive errors. The prevalence of visual loss from cataract was significantly higher in all five GPZs compared to the South West.

The survey results show that in Nigeria, 84% of all causes of blindness were either preventable or treatable. This is comparable to other reports from Nigeria[3,6,15] and other countries in Africa such as Rwanda[42], Ghana[51], Mali[52], Sudan[53], Tunisia[54], Central African Republic[55], Niger[56], Cameroon[43], Kenya[44] and Ethiopia[45] and in South Asia (Bangladesh[47], Pakistan[57] and India[58]). However, most studies in Africa have been conducted on much smaller samples or in specific population groups. The exception is the national survey in Ethiopia which is located on the eastern side of the African continent. All available evidence from different parts of Africa points to cataract being the single commonest cause of blindness and visual impairment. The difference in the prevalence of severe visual impairment due to cataract between urban and rural areas in Nigeria may be related to access to services.

Previous surveys in Nigeria[59,60] and other locations in Africa[45,53,61] have shown that trachoma is responsible for a significant proportion of blindness in certain areas. However, all these surveys, apart from the national survey in Ethiopia[45] were undertaken in trachoma endemic areas. The present survey included clusters in northern Nigeria where trachoma is endemic[59,60] but in our survey trachoma was not a significant cause of visual loss. However trachoma surveys or rapid assessment in the previously known endemic areas will provide a more accurate evaluation of the trends in trachoma

Table 10: Prevalence of cause specific blindness and severe visual impairment of common blinding conditions

Causes	No. blind	Prevalence (%)	95% CI	No. SVI*	Prevalence (%)	95% CI
Cataract	244	1.8	1.57; 2.05	92	0.68	0.55-0.84
Glaucoma	95	0.7	0.55-0.88	8	0.06	0.03-0.12
Uncorrected aphakia	48	0.35	0.26-0.47	32	0.24	0.16-0.34
Cornea (excluding trachoma)	45	0.33	0.24-0.46	12	0.09	0.05-0.16
Trachoma	24	0.18	0.1 -0.27	2	0.01	0.004-0.06
Optic atrophy	21	0.15	0.1-0.24	1	0.007	0.001-0.053
Phthisis	13	0.1	0.05-0.18	1	0.007	0.001-0.053
Macular degeneration	10	0.07	0.035-0.15	8	0.06	0.03-0.12
Uncorrected refractive errors	8	0.06	0.03-0.12	23	0.17	0.11-0.27
Onchocerciasis	6	0.04	0.014-0.14	0	-	
Diabetic retinopathy	3	0.02	0.007-0.07	1	0.007	0.001-0.053

* SVI: Severe Visual Impairment

Table 11: Age and gender standardized estimated number of adults (⩾ 40 years) in Nigeria with visual impairment (presenting vision)

	Presenting Vision < 6/12 – 6/60 (mild/moderate visual impairment				Presenting vision < 6/60 (severe visual impairment and blindness)			
Cause	Crude prevalence (%)	Standardized prevalence (%)*	2008 estimated number	2020 estimated number	Crude prevalence (%)	Standardized prevalence (%)*	2008 estimated number	2020 estimated number
Cataract	3.48	2.39	630,624	878,209	2.47	1.51	399,041	570,512
Glaucoma	0.28	0.21	56,620	79,159	0.76	0.56	147,064	205,266
Uncorrected aphakia	0.38	0.29	75,711	105,026	0.59	0.38	101,425	142,048
Refractive error	11.45	9.33	2,463,695	3,400,953	0.23	0.19	49,292	67,317
Central corneal opacity (excluding trachoma)	0.21	0.18	47,628	65,871	0.40	0.31	81,191	112,945
Trachoma	0.13	0.12	30,441	40,615	0.19	0.13	33,424	47,146
Posterior segment causes	0.68	0.52	138,281	190,949	0.43	0.33	86,549	120,979
Onchocerciasis	0.02	0.03	6,616	9,035	0.04	0.04	9,611	12,719
All other causes	0.73	0.56	147,936	205,178	0.55	0.45	117,718	163,622
Total	**17.36**	**13.62**	**3,597,552**	**4,974,995**	**5.68**	**3.88**	**1,025,315**	**1,442,554**

Age and gender standardization using Nigeria population for 2008 and projected for 2020 (US Census Bureau)

blindness and visual impairment in Nigeria as a survey on a nationally representative sample may underestimate the true magnitude in trachoma endemic areas.

Onchocerciasis was also not a significant cause of blindness in our survey despite the fact that the sample included clusters from areas where onchocerciasis was known to be endemic in the past. Earlier surveys showed that onchocerciasis was an important cause of blindness in endemic areas of Africa, including Nigeria[3,10,20,55,62,63], and ocular manifestations of onchocerciasis have been recorded in savannah as well as rain forest areas[64,65]. There are several possible explanations for our findings: firstly, both onchocerciasis and trachoma are focal diseases, and the clusters selected even in endemic areas may, by chance, have not included areas with the highest endemicity. Secondly, there may have been misclassification: for example, corneal scarring from trachoma may have been misclassified as non-trachomatous, but this seems unlikely, and corneal opacity, chorioretinitis and optic atrophy may not have been attributed to onchocercaisis. Thirdly, the findings may reflect a genuine decline in blindness from these two diseases, particularly that due to onchocerciasis as a consequence of the Africa Onchocerciasis Control Programme (APOC).

Nigeria is among the ten most populated countries in the world. Despite its size there has been no earlier national estimate of the prevalence and causes of blindness and visual impairment. Data from surveys in special population groups or focal areas cannot be extrapolated to the entire country due to its cultural, economic, ethnic and geographical diversity. For the first time scientifically valid data are available for the entire country.

Number of people with visual loss by cause in 2008 and 2020

Data from the survey can be applied to the whole country indicating that refractive errors are responsible for visual impairment in 2.46 million adults (i.e. acuity of (<6/12-6/60). “Operable” cataract (i.e. visual acuity of <6/60) affects 400,000 people and glaucoma has caused blindness in a further 150,000 adults. By the year 2020 the number with operable cataract will increase by 43% to 600,000 assuming that the incidence of cataract blindness/SVI and cataract surgical coverage remain essentially unchanged over the next 12 years (Table 11).

Below Vision testing was done at six metres, which was carefully measured for each participant. This man is having his vision measured using corrective lenses.

Ophthalmic nurses measuring the vision of an elderly woman who has very poor sight

Causes of blindness in ecological zones

Cataract was the commonest cause of blindness in all ecological zones (Table 12) ranging from 3.7% in guinea forest savannah to 52.9% in the sahel. Both cataract and glaucoma were seen in all ecological zones. Trachoma was most commonly seen in the sudan savannah region (8.3%) while onchocerciasis was only seen in the guinea forest savannah (3.6%) and rain forest (1%) regions in Nigeria. Thus there was a distinct distribution by ecological zone for these two causes. It was also observed that in the sahel 100% of the causes of blindness were avoidable.

Cataract surgical outcomes

364 participants (527 eyes) had undergone procedures for cataract either in one eye (201 participants, 55.2%) or in both eyes (163 participants, 44.8%). A total of 243 (46.1%) eyes had been couched (traditional procedure for cataract). Data were incomplete for 11 participants

Table 12: Principal cause of blindness in ecological zones

	Sahel N (%)	Sudan savannah N (%)	Guinea forest savannah N (%)	Rainforest N (%)	Delta N (%)
Treatable					
Refractive error	1 (5.9)	3 (1.1)	1 (0.7)	2 (1.9)	1 (2.3)
Cataract	9 (52.9)	113 (42.6)	51 (36.7)	48 (46.6)	23 (52.3)
Uncorrected aphakia	2 (11.8)	27 (10.2)	7 (5.0)	8 (7.8)	4 (9.1)
Pco	0	0	0	0	1 (2.3)
Glaucoma	4 (23.5)	35 (13.2)	32 (23.0)	18 (17.5)	6 (13.6)
Diabetic retinopathy	0	0	1 (0.4)	2 (1.4)	0
Pterygium	0	0	3 (2.2)	0	0
Total treatable	16 (94.1)	178 (67.2)	95 (68.3)	78 (75.7)	35 (79.5)
Preventable					
Trachoma	0	22 (8.3)	1 (0.7)	1 (1.0)	0
Other corneal scars	1 (5.8)	24 (9.1)	11 (7.9)	6 (5.8)	3 (6.8)
Onchocerciasis	0	0	5 (3.6)	1 (1.0)	0
Total preventable	1 (5.8)	46 (17.3)	17 (12.2)	8 (7.8)	3 (6.8)
Total avoidable	17 (100)	224 (84.5)	112 (80.6)	86 (83.5)	38 (86.4)
Unavoidable					
Phthisis/ absent globe	0	7 (2.6)	4 (2.9)	1(1.0)	1 (2.3)
Macular degeneration	0	2 (0.7)	5 (3.6)	3 (2.9)	0
Optic atrophy	0	8 (3.0)	7 (5.0)	4 (3.9)	2 (4.5)
Other retina and posterior segment	0	7 (2.6)	0	7 (6.8)	1 (2.3)
Others	0	1 (0.4)	1 (0.7)	2 (1.9)	0
Total unavoidable	0	25 (9.4)	16 (11.5)	17 (16.5)	5 (11.4)
Undetermined	0	15 (5.7)	9 (6.5)	2 (1.9)	2 (4.5)
All blindness	17 (100)	265 (100)	139 (100)	103 (100)	44 (100)

Table 13: Visual outcomes after cataract surgery (modern cataract surgery)– presenting vision

Characteristics	No. of eyes	>= 6/18	< 6/18-6/60	< 6/60
All operated	**273**	**30.8**	**26.0**	**43.2**
IOL implant				
No IOL	160	13.7	23.1	63.1
IOL	113	54.9	30.1	15.0
Age				
40 – 49 y	10	30.0	10.0	60.0
50 - 59 y	36	36.1	33.3	30.6
60 – 69 y	84	36.9	20.2	42.9
70 – 79 y	96	27.1	36.5	36.5
80+	47	23.4	12.8	63.8
Gender				
Female	127	31.5	22.9	38.6
Male	146	30.1	22.6	47.3
Residence				
Rural	172	29.6	26.2	44.2
Urban	101	32.7	25.7	41.6
Geo political zone				
NE	42	21.4	33.3	45.2
SE	51	33.3	29.4	37.2
SS	16	6.2	25.0	68.8
NW	62	38.7	24.2	37.1
SW	51	37.2	27.4	35.3
NC	51	27.4	17.6	54.9
Literacy				
Can read and write easily	54	42.6	25.9	31.5
Read and write with difficulty	50	40.0	14.0	46.0
Cannot read/write	169	24.3	29.6	46.1

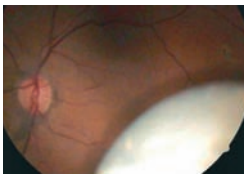
Above Survey vehicle negotiating difficult terrain

on the type or place of surgery and these individuals were excluded from analyses. A total of 118 (43.2%) eyes had no IOL implant while 93 (34.1%) eyes had an IOL implant.

Visual outcomes after cataract surgery (presenting visual acuities) were poor with 43.2% remaining blind after surgery (Table 13). Only 30.8% had a good outcome (i.e. presenting vision of ≥6/18) after surgery. Visual outcomes were significantly better among those who had an IOL implant compared to those without (Table 13). Visual outcomes were poorer in those who were < 50 and those >= 80 years at the time of the surgery, males, those residing in the rural areas and those who had poorer literacy. Comparing the outcomes across the different geo-political zones, it was observed that outcomes were the poorest in the South-South zone and the best in the South West.

Earlier studies in Nigeria have also documented poor visual outcomes after cataract surgery and that eyes where an IOL was implanted resulted in better outcomes[66]. Visual outcomes in surveys in India [67-71], Nepal[72], China[73,74] and Hong Kong[75] a decade earlier found also that visual outcomes after cataract surgery were not satisfactory in a significant proportion of operated individuals. and that IOLs gave better results. However, the visual outcomes recorded in Nigeria were less satisfactory than has generally been reported. A recent study on the outcomes of cataract surgery in Kenya, Bangladesh and Philippines found that one year after surgery 27% had a poor outcome (< 3/60 in the operated eye)[76]. The national survey in Bangladesh found that 24.8% of operated eyes had vision < 3/60[77]. In the recently concluded national survey in Pakistan, 29.5% of those operated had a presenting vision < 3/60[78]. In the Sao Paulo Eye Study in Brazil, the outcomes were better with only 16.5% having presenting VA < 6/60 after surgery[79].

Above Every participant had their refractive error status assessed using an automated refractor



Above An example of 'couching' – the lens is dislocated into back of the eye

After correction, nearly 50% with a poor outcome (i.e. < 6/60) improved to 6/60 or better (Table 14). However, more than half continued to remain blind which reflects on the quality of surgery or case identification for cataract surgery in Nigeria. Similar results have been found in other studies also. In the Latino Study in the US, presenting VA < 6/18 was observed in 48.1% which could be reduced to 32.2% after correction[80]. Data from 8 countries in Africa and Asia also observed that correction improved outcomes of cataract surgery universally[81]. In Bangladesh PVA < 3/60 was 24.8% after surgery and this could be reduced to 11.1% with correction[77]. Best correction improved outcomes at < 3/60 in Pakistan also[78].

Determinants of poor visual outcome (presenting vision < 6/60 in the operated eye) in Nigeria were analyzed (Table 15). Non IOL surgery had a 9 times higher risk of a poor visual outcome compared to IOL surgery, irrespective of whether it was the first eye or the second eye being operated. Studies in India[68-70], Pakistan[78] and Bangladesh[77] also reveal a better outcome with an IOL implant compared to surgery without an IOL. Other factors like gender, duration since surgery and place of residence were not found to be significant. Uncorrected aphakia, refractive errors, glaucoma and PCO were common causes for poor visual outcome after cataract surgery (Table 16).

Couching

Couching is a traditional non-surgical procedure for cataract which is still being practiced in large parts of Nigeria. Couching in Nigeria is generally carried out by traditional, itinerant healers. In the survey a total of 263 eyes (152 people) had been couched i.e. almost half of all procedures for cataract in Nigeria (46.1% of all eyes). Couching was more prevalent in the North, especially the North East compared to the South. Visual outcomes after couching were very poor with nearly ¾ being blind (presenting vision) (Table 17). Providing optical correction reduced the proportion remaining blind to 41%.

Cataract surgical coverage

Cataract surgical coverage (CSC) is a good indicator of the extent to which the need for cataract surgery is being met at the population level. CSC for eyes reflects the volume of cataract

Table 14: Comparison of presenting and best corrected visual acuity among cataract operated individuals

Presenting Visual Acuity	Best-corrected visual acuity			
	6/6-6/18	<6/18-6/60	<6/60	Total
6/6-6/18	84 (100%)			84 (100%)
<6/18-6/60	39 (54.9%)	32 (45.1%)		71 (100.0%)
<6/60	32 (27.1%)	26 (22.0%)	60 (50.8%)	118 (100%)
Total	**155 (56.8%)**	**58 (21.2%)**	**60 (22.0%)**	**273 (100%)**

Table 15: Factors associated visual acuity following first or second eye cataract surgery

Final Model	First operated eye				Second operated eye			
	n	Odds ratio	95%	CI	n	Odds ratio	95%	CI
Type of surgery								
IOL	86	1.00			93	1.00		
No-IOL	115	9.53	4.58	19.86	109	9.13	4.69	17.78
Time of surgery								
<3 years	73	1.00			79	1.00		
3-6 years	65	0.88	0.37	2.09	63	1.01	0.43	2.36
>6 years	63	2.20	0.97	4.99	60	1.55	0.72	3.36
Gender								
Female	95	1.00			95	1.00		
Male	106	1.22	0.58	2.58	107	1.50	0.77	2.91
Literacy								
Literate	76	1.00			76	1.00		
Illiterate	125	1.21	0.60	2.45	126	1.47	0.73	2.98
Residence								
Urban	76	1.00			77	1.00		
Rural	125	0.82	0.42	1.59	125	0.64	0.34	1.22

Participants waiting to be examined in South west GPZ

surgery while CSC for people measures the success of VISION 2020 initiatives to eliminate cataract blindness.

CSC can also be calculated at different VA cut offs. As surgical services improve in a country, a larger proportion of surgery is done before a person becomes blind. Therefore one can measure CSC at VA < 6/18, < 6/60 and < 3/60 (blindness equivalent). In countries where CSC among blind is very low, it will be important to measure CSC at <3/60.

In Nigeria CSC (for eyes) was significantly higher for males than females the difference being more marked in South-South GPZ where the CSC among women was as low as 5.6% compared to 24.5% among males. Compared to many other countries in the developing world, the CSC in Nigeria was very low. Only 22.8% of all cataract blind eyes had undergone cataract surgery which means that more than ¾ of blind eyes had not undergone surgery. Older persons (70+ yrs), those residing in rural areas and the illiterate had much lower CSC compared to younger persons (< 70 yrs), urban residents and the literate.

Comparing CSC (persons) at < 3/60, it was observed that the lowest coverage (21.6%) was in the South-South GPZ, while residents in the South West, North Central and North West GPZ had better access to modern cataract surgery. More than half of urban residents who were blind from cataract had been operated in at least one eye as were the literate respondents. CSC (persons) was 1.8 times higher for males (50.3%) than females (28.4%).

The CSC observed in Nigeria is one of the lowest reported in the recent past and is similar to other smaller studies undertaken in the country[66].

Table 16: Causes of visual impairment among operated eyes

Cause	Frequency	%
Uncorrected aphakia	74	39.15
Optic atrophy	18	9.5
Uncorrected refractive error	17	8.99
Glaucoma	9	4.76
PCO	6	3.17
Phthsis	5	2.64
Macular degeneration	4	2.12
Chorio retinitis	3	1.59
Anterior uveitis	1	0.53
Others	4	2.12
No reason found	36	19.05
Total	**189**	**100**

Table 17: Visual outcomes of couched eyes (presenting vision)

Couching	Persons	(n=152)	Eyes	(n=243)
Presenting visual acuity	**N**	**%**	**N**	**%**
6/18 or better	15	9.87	6	2.5
<6/18 - 6/60	25	16.45	24	9.9
<6/60 - 3/60	29	19.08	37	15.2
<3/60	83	54.61	176	72.4
Best corrected visual acuity	**N**	**%**	**N**	**%**
6/18 or better	65	42.76	77	31.7
<6/18 - 6/60	40	26.32	56	23.1
<6/60 - 3/60	5	3.29	10	4.1
<3/60	42	27.63	100	41.2
Blind to normal with correction		25.3		21.0

Above A child's eyes being examined during the national survey of blindness

Other countries in Africa have reported higher CSC at person level (Western Rwanda < 3/60: 47% among those aged ≥50 years[42]; Botswana, at VA < 6/60, 73%[82]; Kenya <3/60: 78%[44]). A meta-analysis of published studies from developing countries clearly indicated that CSC was much lower in females compared to males in 21 of the 23 studies reviewed[83]. The authors estimated that blindness and severe visual impairment from cataract could be reduced by around 11% in low and middle income countries if women were to receive cataract surgery at the same rate as men[83].

Children examined

Children aged 10-15 years were examined if they were residing in a household where there was at least one eligible respondent ≥40 years of age. A total of 5371 children were enumerated. Visual acuity was not recorded in ten children who were excluded from analysis. In interpreting the results from the children, caution has to be exercised in extrapolating the findings as the sample was not a truly representative sample. However the results can be a good indicator of the existing situation in the country.

The prevalence of blindness was 0.6% among children aged 10-15 years (Table 19). The prevalence of mild, moderate and severe visual impairment was much lower. This could also be due to a bias in blind children being over-represented in the sample as families may have been keener to get a medical opinion if they perceived that their children were not seeing well.

Females had a higher prevalence of blindness (0.89%) compared to male (0.33%). Though no blind children were observed among children who had better literacy, the prevalence of blindness was 1.53% among those who could not read or write. This could be due to the fact that blind children may not have access to educational facilities compared to the normally sighted in Nigeria, as in many other developing countries. The highest prevalence of blindness was in the South-South GPZ (1.04%) and the lowest in the South West (0.45%). The place of residence did not affect the prevalence of blindness among children aged 10-15 years.

Prevalence of hypertension, obesity and diabetes, poor water supplies and sanitation

Hypertension

Overall 10.9% of participants had Stage 2 hypertension (i.e. systolic blood pressure (BP) of ≥160 mmHg and diastolic BP of ≥100mmHg) this being more common in females than males and in older than younger participants. Overall 3.9% had Stage 3 hypertension (i.e. systolic BP of ≥180 mmHg and diastolic BP of ≥110mmHg) which again was more common in females than males and which increased with increasing age.

Obesity and diabetes

Over a quarter of survey participants had a body mass index of ≥25 the rate being higher in females than males (32.8% vs 21.7%). Rates of obesity declined with increasing age and were more common in urban than rural areas (15.1% vs 6.4%) and in the south of the country. Overall 8.3% of the population had a BMI of ≥30. Random blood glucose levels were used to diagnose diabetes among those in the normative database (i.e. one in every seven participants). 7.1% of these individuals had diabetes but only 15% knew they had the condition.

Water supplies and sanitation

Over half of all households (56.2%) included in the survey did not have a protected water supply (i.e. their water came from an open well or from ponds or streams). The South east GPZ had the highest rates of unprotected water supply (71.1%) and South west had the lowest rates (42.4%). Overall, over a quarter of households (26.9%) did not have a pit latrine or flush toilet the rate being highest in the North central GPZ (48.2%).

This small pond was the only source of drinking water for a village in the North East geopolitical zone

Table 18: Cataract surgical coverage in Nigeria (presenting vision< 3/60) in persons and eyes

Characteristics	Eyes			Persons		
	Female	Male	Total	Female	Male	Total
All	18.3	29.0	22.8			37.2
GPZ						
NE	15.3	22.5	18.0			33.8
SE	25.7	29.4	27.4			42.4
SS	5.6	24.5	13.2			21.6
NW	14.3	29.6	20.7			35.4
SW	27.0	26.3	26.7			46.1
NC	21.8	40.5	30.7			41.5
Age						
40 – 69 y	21.6	31.6	25.8			48
70+ yrs	15.9	27.1	20.6			31.9
Residence						
Rural	13.6	25.6	18.7			31.1
Urban	33.5	41.1	36.6			56.8
Literacy						
Literate	30.2	35.4	33.8			56.6
Illiterate	16.4	24.4	19.0			31.6

Table 19: Visual status of examined children

Characteristics	N	>= 6/12 better eye (no impairment)		< 6/12- 6/18 better eye (mild VI)		< 6/18-6/60 better eye (moderate VI)		< 6/60-3/60 better eye (severe VI)		< 3/60 better eye (blindness)	
		N	%	N	%	N	%	N	%	N	%
All Children	5361	5296	98.79	13	0.24	19	0.35	1	0.02	32	0.6
Gender											
Female	2594	2555	98.5	5	0.19	11	0.42	0	0	23	0.89
Male	2767	2741	99.06	8	0.29	8	0.29	1	0.04	9	0.33
Residence											
Rural	3991	3944	98.82	10	0.25	12	0.30	1	0.03	24	0.6
Urban	1370	1352	98.69	3	0.22	7	0.51	0	0	8	0.58
Literacy											
Can read and write easily	1095	1079	98.54	6	0.55	10	0.91	0	0	0	0
Read and write with difficulty	2633	2617	99.39	3	0.11	6	0.23	0	0	7	0.27
Cannot read or write	1633	1600	97.98	4	0.24	3	0.18	1	0.06	25	1.53
GPZ											
NE	1023	1011	98.83	4	0.39	3	0.29	0	0	5	0.49
SE	492	485	98.58	1	0.2	3	0.61	0	0	3	0.61
SS	675	659	97.63	4	0.59	4	0.59	1	0.15	7	1.04
NW	1479	1463	98.92	2	0.14	5	0.34	0	0	9	0.61
SW	890	882	99.1	2	0.22	2	0.22	0	0	4	0.45
NC	802	796	99.25	0	0	2	0.25	0	0	4	0.5

Dissemination of the findings

After data entry in Nigeria, the data were cleaned and analysed in London. Preliminary results of the main findings (at national, regional and ecological zone level) were presented at a national meeting in Abuja, in July 2008 and subsequently at regional meetings in each of the 6 geopolitical zones. These meetings were attended by all the relevant stakeholders. Following the national meeting the National Council on Health was requested to include eye care and prevention of blindness in the next WHO Nigeria Country Cooperation Strategy.

A recent report drawn up by Dr U Onyebuchi (National Coordinator, NPPB) following the last zonal meeting indicates that less than half of the 36 states in Nigeria currently have a VISION 2020 plan and only a few states have active Prevention of Blindness Committees or are actually implementing their plans. The remaining (20) States urgently need to develop their VISION 2020 plans with support from NPPB and the NGOs.

The national survey in Nigeria provides the epidemiological evidence and data needed for planning, priority setting, advocacy and for measuring the impact of service delivery in Nigeria. The data also contribute towards the global database of blindness, which is being used for global planning, advocacy, resource mobilization and to monitor VISION 2020 initiatives.

The following areas will need attention in the following months and years in Nigeria in order to reduce the number of people who are needlessly blind or visually impaired and so that the goal of eliminating avoidable blindness can be achieved:

- Programme Management
- Service Delivery
- Advocacy
- Information Education and Communication
- Infrastructure and Technology
- Capacity Development
- Management Structure.

Capacity building

As a result of the survey the team members will have become familiar with survey methodology, and the importance of quality assurance, team work and project management and how these can be achieved under difficult circumstances.
A two-day workshop on “writing for publication” was held in Kaduna in March 2008 which was attended by the core team who have subsequently been actively involved in writing up the findings of the survey for publication.

Publications

The following papers have been published in peer reviewed medical journals:

1. **The Nigerian national blindness and visual impairment survey: rationale, objectives and detailed methodology.**
   Dineen B, Gilbert CE, Rabiu M, Kyari F, Mahdi AM, Abubakar T, Ezelum CC, Gabriel E, Elhassan E, Abiose A, Faal H, Jiya JY, Ozemela CP, Lee PS, Gudlavalleti MV. BMC Ophthalmol. 2008 Sep 22;8:17.
2. **Prevalence of blindness and visual impairment in Nigeria: the National Blindness and Visual Impairment Study.**
   Kyari F, Gudlavalleti MV, Sivsubramaniam S, Gilbert CE, Abdull MM, Entekume G, Foster A; Nigeria National Blindness and Visual Impairment Study Group. Invest Ophthalmol Vis Sci. 2009 May;50(5):2033-9.
3. **Causes of Blindness and Visual Impairment in Nigeria: The Nigeria National Blindness and Visual Impairment Survey.**
   Abdull MM, Sivasubramaniam S, Murthy GV, Gilbert C, Abubakar T, Ezelum C, Rabiu M. Invest Ophthalmol Vis Sci. 2009 Apr 22. [Epub ahead of print]

The following have been submitted for publication or will be shortly:

4. **Ecological determinants of blindness in Nigeria.** Rabiu MM et al
5. **Couching in Nigeria: prevalence and visual acuity outcomes.** Gilbert C et al
6. **Outcome of cataract surgery in Nigeria: results from the national survey of blindness and low vision.** Abdullahi U Imam, et al.

Several other publications are in preparation.

The findings will be presented at national and international meetings.

Below Enumerator numbering each household with a unique survey number after identifying eligible participants

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Above Blind participant arriving at the examination site

Above A very happy participant after being given a pair of spectacles to correct her vision

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