The “segment knockout” survey method for large trachoma-endemic districts

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ABSTRACT

Prevalence surveys are mandatory before new trachoma control projects are funded and existing ones continued. When a large administrative district with >200,000 people is surveyed as one trachoma intervention unit, the survey clusters are widely spaced and it is difficult to establish the distribution of the disease at the sub-district level with certainty. As a result, some trachoma-endemic areas in Kenya have been missed out and non-endemic areas included in mass antibiotic treatment. The other challenge is the large sample size required in standard trachomatous trichiasis (TT) surveys that include participants aged ≥15 years. The main objective of this study was to develop an effective and efficient survey method to justify administration of mass antibiotic treatment for active trachoma. The other objective was to establish the optimum lower age limit of TT survey participants, to ensure that the time required to complete a TT survey was the same as the time required to complete a TF survey, while ensuring that the sample was adequately representative of the TT backlog. The costs of surveys and administration of mass antibiotic treatment were determined for comparison of the standard and new survey methods. Data sets for previous surveys were re-analysed to calculate the optimum lower age limit of TT survey participants and correction factors to extrapolate the total backlog of TT.

A "Trachoma Survey by Segment" (TSS) method was developed to justify and reduce the cost of mass antibiotic treatment. It was tested in Turkana, a large hyper-endemic district with 543,199 people and Narok, a meso-endemic district with 576,388 people. Each district was divided into five geographical areas (segments). A segment had a population of 100,000–200,000 people. Areas with similar risk of trachoma were aggregated in the same segment. The segments with <10% prevalence of TF in children 1-9 years were excluded (knocked-out) from mass treatment, 10%-30% treated for 3 years and >30% treated for 5 years.

An efficient TT40 survey method was also developed where the backlog of TT was estimated in people ≥40 years old and correction factors used to extrapolate the total backlog. A TT40 survey required a smaller survey sample than a standard TT survey. The backlog correction factor for the lower age limit of 40 years was 1.1.

In Turkana district 3,962 children aged 1-9 years were examined and the prevalence of TF in the whole district was 38.0% (95%CI: 32.2%-43.9%). If the survey was conducted using the standard survey by administrative district method the whole population would have been treated for 5 years. However, the TSS method revealed that two segments needed treatment for 3 years and three segments for 5 years. After mass treatment the areas will be re-surveyed to justify further treatment.

In Narok district 3,998 children aged 1-9 years were examined and the prevalence of TF was 11.0% (95%CI: 8.0%-14.0%). The entire district had received three rounds of mass antibiotic treatment prior to this study. If this study was conducted by administrative district method, the whole population could have been treated for another three years. The TSS method identified three non-endemic segments which were excluded (knocked-out) from further treatment.

In Turkana district 2,962 people $\geq$40 years were examined and 7.8% (95%CI: 6.8%-8.8%) had TT while in Narok 2,996 people $\geq$40 years were examined and 2.9% (95%CI: 2.2%-3.6%) had TT. All the segments in both districts needed TT surgical services.

The cost of a survey by the administrative district method was $15,726 to $28,905, while by the TSS method it was $31,917 to $40,610 ($6,383 to $8,122 per segment). In 2009, the unit cost of administration of mass treatment was $0.20 to $0.42 per person treated. In Turkana district (hyper-endemic setting), the total cost of a survey and administration of mass treatment by the TSS method was $11,705 (1.7%) more expensive that by the administrative district method. In Narok district (meso-endemic setting with clustered trachoma) the survey by TSS method and administration of mass treatment was cheaper by $168,275 (53.2%).

It was concluded that the TSS is an effective trachoma survey method to identify the areas that need mass antibiotic treatment. For short term (<3 years) mass treatment in a hyper-endemic district like Turkana, the TSS method has no advantage over the administrative district method. For long term treatment, the TSS method is recommended because some segments may not require treatment for >3 years. The TT40 is an efficient trachoma survey method to determine the backlog of people with TT.

DECLARATION

This is to certify that:

i. The thesis comprises only my original work towards the PhD,
ii. Due acknowledgement has been made in the text to all other material used,
iii. The thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

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PUBLICATIONS AND PRESENTATIONS

Publications

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. What is the appropriate age range of individuals to be included in a survey to estimate the prevalence of trachomatous trichiasis? Br J Ophthalmol. 2011;95:1058-60.

Karimurio J, Le Mesurier R, Mwanthi M, Keeffe J. Cost and consequences of trachoma survey and mass drug administration in the Narok district in Kenya. Clin Exp Ophthalmol. 2011;39:58.

Papers and posters presented in conferences

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. The cost of surveys and mass drug administration (MDA) for active trachoma in high and low endemic districts in Kenya. XXXIII World Ophthalmology Congress, February 2012, Abu Dhabi, United Arab Emirates.

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. What are the correction factors to be used when extrapolating the overall prevalence and backlog of trachomatous trichiasis (TT) in surveys with different participant age limits in Kenya? XXXIII World Ophthalmology Congress, February 2012, Abu Dhabi, United Arab Emirates.

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. What is the appropriate age of participants for a survey to estimate the prevalence of trachomatous trichiasis (TT)? XXXIII World Ophthalmology Congress, February 2012, Abu Dhabi, United Arab Emirates.

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. Costs and consequences of trachoma survey and mass drug administration in the Narok district in Kenya. 43rd Annual Scientific Congress of the Royal Australian and New Zealand College of Ophthalmologists, November 2011, Canberra, Australia.

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. The "segment-knockout" survey method for large trachoma endemic districts. 20th Annual Scientific Meeting of the Melbourne Ophthalmic Alumni, July 2011, Melboune, Australia.

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. The survey by trachoma district method for large trachoma endemic districts. 39th Annual Scientific Conference Ophthalmological Society of Eastern Africa (OSEA), August 2010, Dar es Salaam, Tanzania.

Non-peer reviewed reports submitted

The reports for Turkana and Narok surveys were submitted to the Government of Kenya, United Nation High Commission for Refugees and the non-governmental organizations that funded the surveys including: European Union, Operation Eyesight Universal, Sightsavers, African Medical and Research Foundation, and Spanish Volunteer Eye Doctors.

Articles and abstracts accepted

Karimurio J, Rono H, Le Mesurier R, Mwanthi M, Keeffe JE. The "Trachoma Surveys by Segment" (TSS) and "TT40" methods in seven districts in Kenya. 9th General Assembly of the International Agency for the Prevention of Blindness (IAPB), September 2012, Hyderabad, India.

Articles submitted, waiting for feedback

Two articles: one on prevalence of active trachoma in Turkana and the other on TT correction factors submitted to East African Medical Journal (EAMJ), awaiting feedback.

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CHAPTER ONE

1. Introduction

The purpose of this Chapter is to introduce this thesis. It describes the problems which triggered off this study, states the aims and the significance of the study. It concludes with an overview of what is contained in the subsequent chapters.

1.1 Problem statement

Trachoma is the leading infectious cause of blindness in the world caused by the bacterium Chlamydia trachomatis(1-5). Active trachoma is common in children while blindness occurs in adulthood. Scientific evidence from epidemiological surveys is mandatory before new trachoma control projects are started or old ones extended since trachoma is not evenly distributed but clusters in communities with poor hygiene(1, 2, 4, 6).

The World Health Organization (WHO) recommends the SAFE strategy for trachoma control(7), where "SAFE" stands for: Surgery for trichiasis/entropion, Antibiotics treatment for active disease, Facial cleanliness, and Environmental changes to reduce transmission. Prevalence of trachomatous follicular inflammation (TF) in children aged 1-9 years is the monitoring indicator for the "AFE" components while trachomatous trichiasis (TT) in adults $\geq$15 years is the indicator for the "S" component(8). The endemicity of trachoma is classified according to the prevalence of TF as follows(1): hypo-endemic (5% to <10%), meso-endemic (10% to <20%) and hyper-endemic ($\geq$20%). However, in 2010 WHO reviewed the treatment thresholds for mass antibiotic treatment as follows: if prevalence of TF is <10% mass treatment is not required, 10%-30% treatment needed for 3 years and >30% for 5 years. Mass treatment is followed by a repeat survey to justify continuation or stoppage. As a result in this thesis it was assumed that hyper-endemic means prevalence >30%, meso-endemic 10% to 30% and hypo-endemic. The "FE" components are implemented in all the areas under antibiotic treatment to disrupt further transmission of infection.

Trachoma prevalence surveys and interventions are conducted in administrative districts(9-11). However, this posed a major challenge in Kenya since the population size of trachoma-endemic districts vary from 80,000 to 1,000,000 people(12) and the disease is clustered among the nomadic communities in dry areas(13). In a study area with >5,000 people, the population size is not included in the mathematical formulae used to compute the sample size for population based surveys(10, 14) because a further increase in the population beyond >5,000 does not significantly increase the sample size(15). This is the case in most trachoma prevalence surveys. As a result, both the large (>200,000 people) and small administrative districts in Kenya were allocated equal sample sizes. In large districts, the survey clusters were widely scattered, making it difficult to locate some endemic areas ("hot spots") in hypo-endemic districts. In endemic districts, some non-endemic communities that did not need treatment were included in mass treatment. The untreated "hot spots" may re-infect the treated areas since the endemic communities are nomadic. Furthermore, inclusion of non-endemic areas in mass treatment is a waste of resources.

The other challenge encountered in the initial surveys was the large samples needed in TT surveys where participants aged ≥15 years are recruited(9, 16); which delayed data collection and reduced the efficiency for both the TF and TT surveys.

Seven administrative districts in Kenya were surveyed prior to this study using the standard survey by administrative district method (*Figure 1.1*). The population of the districts ranged between 143,547 people in Samburu and 604,050 people in Meru North districts.

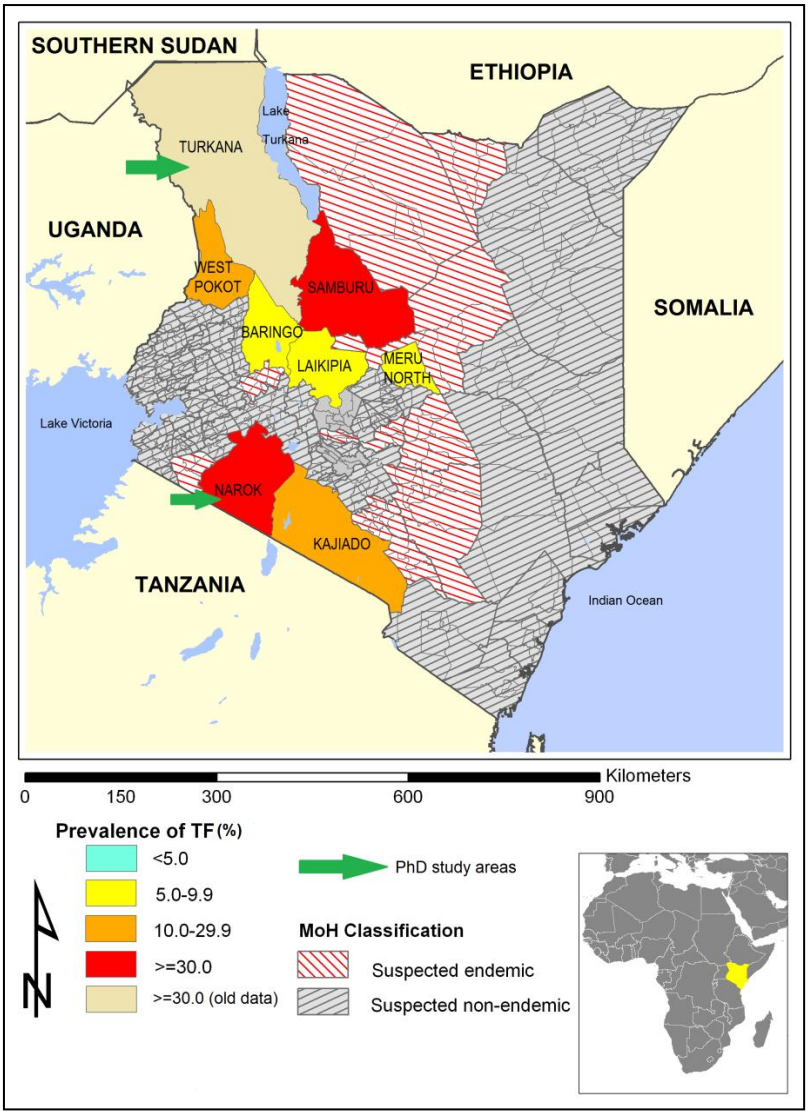


Figure 1.1: Kenya TF map prior to this study and the study areas

Permission to use maps in the trachoma atlas (www.trachomaatlas.org) was granted by the International Trachoma Initiative.

This study commenced in July 2009 to resolve the challenges faced during the preceding trachoma surveys. The main research question was how to effectively indentify the areas that require mass antibiotic treatment for active trachoma. The second question was how to improve the efficiency of data collection for both TF and TT surveys.

1.1 Objectives

The broad objective of this study was to improve the effectiveness and efficiency of trachoma prevalence surveys to justify administration of mass antibiotic treatment for active trachoma and initiation of TT surgical services in large districts.

The specific objectives were to develop an:

1. Effective active trachoma (TF) survey method to identify the areas that require mass antibiotic treatment.
2. Efficient TT survey method to estimate the backlog of people with TT, where TF and TT surveys are completed within the same time period.

The activities undertaken to fulfil the first objective were:

1. The Trachoma Survey by Segment method (TSS) was developed and tested in Kenya.
2. A large hyper-endemic district was surveyed using both the standard trachoma survey by administrative district and the TSS methods.
3. A large meso-endemic district with clustered trachoma was surveyed using the two methods.
4. The costs of a trachoma survey and administration of mass antibiotic treatment was estimated using the two methods.

The activities for the second objective were:

1. Data sets for previously-conducted TT surveys were re-analysed to determine the optimum lower age limit of TT survey participants.
2. The backlog of TT in the two districts surveyed during this study was estimated using the new lower age limit.

The outcome variable for this study was the presence of trachoma as a public health problem. The predictor variable was 10% prevalence of TF in children 1-9 years old, which is the threshold for mass antibiotic treatment(17).

1.2 Significance

It was anticipated that the findings of this study would change the way trachoma surveys are conducted in Kenya. The lessons learnt and the challenges encountered during the study will benefit other trachoma-endemic countries with similar challenges. The findings will also have direct influence on the global trachoma control policy, especially on prevalence survey methods and mass antibiotic treatment. The prevalence results of this study will be submitted to the WHO to add to the existing data base and to update the world trachoma atlas (www.trachomaatlas.org).

1.3 Thesis overview

Chapters 1 and 2 are the introductory chapters. Chapter 2 provides the context of this research project. It discusses the published literature on the epidemiology of trachoma, trachoma control strategies and survey methods. The guidelines and costs of trachoma surveys and mass antibiotic treatment are examined. Additionally, the Chapter provides the background information on trachoma control in Kenya and highlights the challenges which triggered this research project. Based on Chapter 2, Chapter 3 provides the details on how the new trachoma survey methods were developed, describes the settings where the methods were tested and how the surveys were conducted. Additionally, the methods used to estimate the costs of trachoma surveys and mass antibiotic treatment are presented. The Chapter ends with the details of the statistical methods used to analyse the data for this study and re-analysis of data sets of the previously-conducted TT surveys.

Chapter 4 presents the results of this study including the: pre-survey trachoma risk assessment, creation of survey segments, active trachoma surveys, re-analysis of data sets from previously-conducted TT surveys, cost of trachoma surveys and cost of administering mass antibiotic treatment. The Chapter concludes with a comparison of the costs of a survey plus mass antibiotic treatment by the segment and administrative district methods.

Chapter 5 is the discussion, which synthesises the information in Chapters 2, 3 and 4. Chapter 6 is the conclusion of the key findings, which ends with the recommendations based on the results of this study.

CHAPTER TWO

2 Literature review

This Chapter provides the context for this PhD research project. The epidemiology of trachoma is discussed, including an overview of the global burden of the disease, microbiology of the causative agent, clinical presentation, grading of the clinical signs, risk factors which influence the occurrence of the disease and trachoma control. This is followed by a review of the published literature on trachoma survey and rapid assessment methods. The Chapter ends with a description of the Kenya ophthalmic and trachoma control programmes, giving special emphasis to the challenges that triggered this study.

Literature search was done through international journal databases, using key words like: trachoma, trichiasis and survey methods. The data bases searched included the ISI Web of Science, PubMED and Scopus. Reports of global trachoma control meetings, global plans, treatment guidelines, maps and updates on the global trachoma situation were searched from the websites of the World Health Organization, International Coalition for Trachoma Control and International Trachoma Initiative. Information was also searched in text books on epidemiology of eye disease and trachoma. The Kenya Trachoma Control Programme and non-governmental organisations sponsoring trachoma control activities in Kenya provided project documents. Only documents written in English were reviewed.

2.1 Trachoma

Trachoma is an ancient disease which remains the leading infectious cause of blindness in the world to date. The disease is recorded in ancient writings including the Ebers Papyrus. It afflicted many European soldiers who fought in Egypt during the Napoleonic wars, which resulted in trachoma epidemics in Europe, United States and other parts of the world(1, 18). However, the disease disappeared in developed countries because of improved socio-economic development, environmental sanitation and personal hygiene. Currently trachoma

is one of the neglected diseases cramped in areas with poor personal and community hygiene(4, 19-22).

2.1.1 Global blindness due to trachoma

In 2010 the World Health Organization (WHO) published a report which indicated that there were 39 million blind people in the world(*Figure 2.1*). Trachoma was ranked the seventh leading cause of blindness with 2.2 million people visually impaired, out of whom 1.2 million are irreversibly blind(3). Previously in 2004 there were 37 million blind people in the world with trachoma being the sixth leading cause of blindness, contributing to 3.6% of the global blindness(23). However, the 2004 estimate did not include blinding refractive errors.

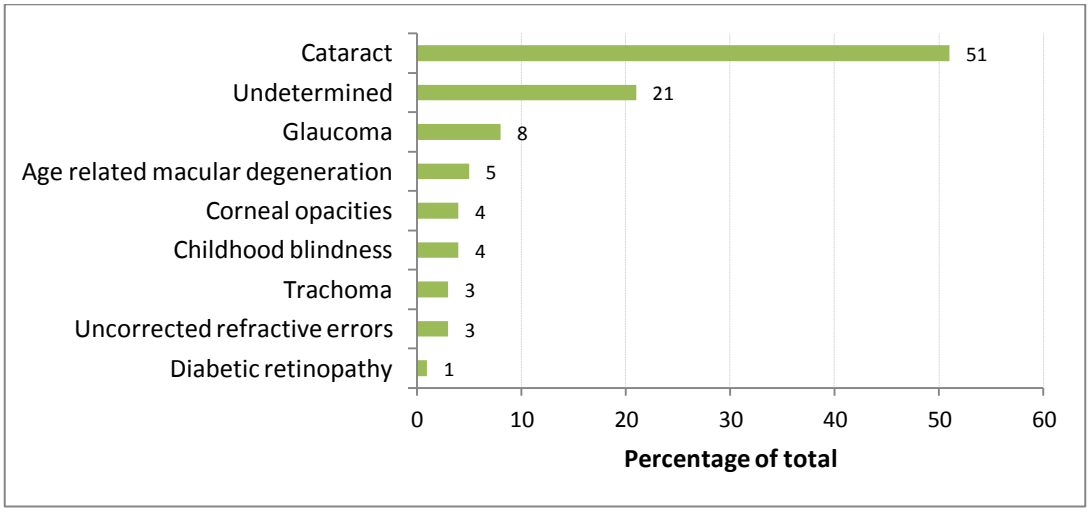


Figure 2.1: Global blindness estimates (WHO 2010)

An initial review of the trachoma situation in the world was conducted in 2003 by the second WHO Global Scientific Meeting on trachoma, to provide the benchmarks for implementation of the SAFE strategy(17). It was estimated that there were 1.5 billion people living in trachoma-endemic areas in 57 countries, 84 million with active trachoma and 7.6 million with TT. A second review in 2008 indicated that the number of people living in trachoma endemic areas had declined to 1.2 billion. In addition, the number of people with active trachoma had declined to 40.6 million people. However, the global burden of TT had increased from 7.6 million to 8.2 million people(2).

In 2012, an update of the progress on trachoma elimination indicted that the number of trachoma-endemic countries had decreased to 53. The countries certified to have eliminated blinding trachoma as a public health problem and entered the post-endemic surveillance stage were: the Gambia, Oman, Ghana, Morocco, Myanmar and Viet Nam. There were 352

millions people living in the trachoma endemic areas in the world, 21 million with active trachoma and 7.3 million with TT(4).

This global trend indicates that active trachoma is likely to be eliminated earlier than TT and currently the main challenge in trachoma control is how to deliver effective TT surgical services. The decrease in the number of people with active trachoma is attributed to the success of the ongoing interventions and improving social-economic development (secular trend)(2, 19) in the endemic countries. Conversely, the backlog of TT is increasing as a result of inadequate TT surgical services. By 2011 the number of TT operations performed in the whole world since the inception of the SAFE strategy was approximately 900,000 surgeries, against a backlog of 7.2 million people requiring TT surgery(4). This performance is too low considering that most patients require surgery in both eyes. Surgery is also to be repeated in those with recurrent TT. Therefore, there is an urgent need to scale-up the delivery of TT surgical services to meet the growing demand.

The other trend which is emerging in previously trachoma-endemic areas is the ageing of people with TT. National Surveys on Disabilities conducted in 1987 and 2006 in Sichuan province in China, revealed that in areas where active trachoma had been eliminated, TT was still present in people >40 years old(24). Similar findings are anticipated in the near future in countries which have ongoing interventions for active trachoma.

Africa is the most affected WHO Region with 72% of the population estimated to be living in the trachoma-endemic areas in the world(4). By 2010 there were 27.8 million cases of active trachoma (68.5% of all the cases in the world), 3.8 million cases of trichiasis (46.6%) and 279 million people living in the trachoma-endemic areas in Africa(2). The African trachoma belt (*Figure 2:2*) covers the Sahel and the Great Rift Valley regions(18). Twenty nine out of the 46 countries in Sub-Saharan Africa are trachoma-endemic.

Kenya is one of the endemic countries in Africa where trachoma is commonly found among the nomadic communities living in the arid areas in the Rift Valley and Eastern Kenya regions(13, 25, 26). The trachoma situation in the country is discussed in detail below.

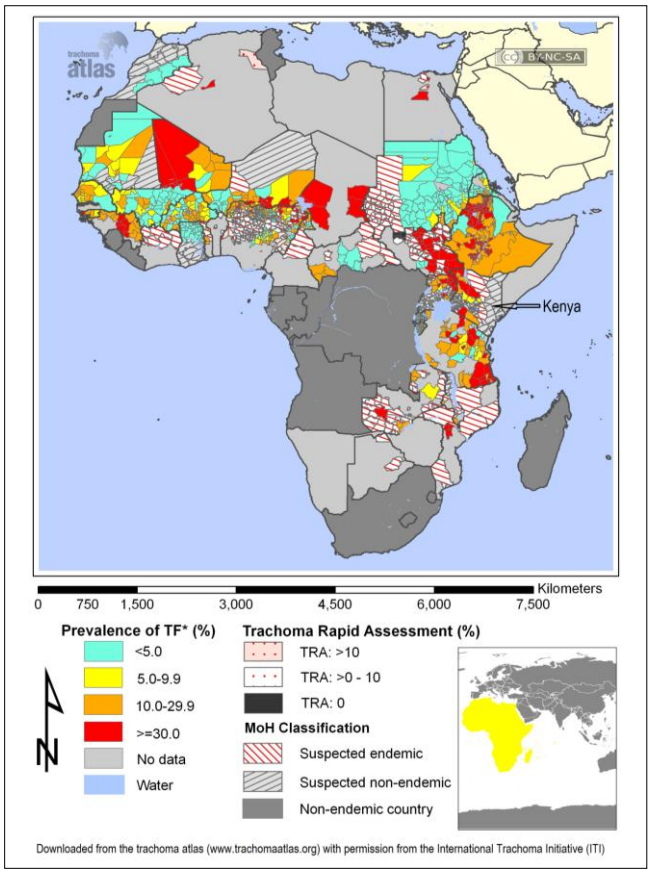


Figure 2.2: Distribution of active trachoma (TF) in Africa (www.trachomaatlas.org)

2.1.2 Limitations to estimate the burden of trachoma

The major limitation in estimation of the global burden of trachoma is lack/insufficient prevalence survey data for some suspected trachoma-endemic areas, data which are old and variation in the quality of data from different countries(2, 3, 18, 27). For example the actual situation in countries with large population like China and India is not clear. Because of their large population sizes, even a low prevalence of trachoma in the two countries can greatly affect the global figures(18).

Trachoma is clustered and highly correlated with poverty, poor personal and community hygiene, limited access to health care and water(2, 4, 28). Aggregation of the number of active trachoma cases in the world or in an entire country should thus be treated with caution because it may distort the potential risk of blinding trachoma in marginalised communities(6). Pockets of blinding trachoma still persist in countries where the disease was endemic and in countries where control activities have been in place for a number of years(6, 29). This focal distribution demands that both prevalence surveys to identify the endemic communities and interventions should also be localised.

The main challenge encountered when estimating the national or global burden of TT is that not all surveys where the prevalence of TT is reported recruit participants ages ≥15 years as recommended(2, 17). In Kenya, persons aged ≥15 years were recruited in the initial seven TT surveys conducted in 2004 and 2007(25, 30-32). Subsequently, 3 Rapid Assessment of Avoidable Blindness surveys were then conducted in Nakuru district, Kericho district and South Nyanza region in Kenya where participants aged ≥50 years were recruited(33). In Australia, the 2008 trachoma surveillance report indicated that people aged ≥30 years were examined for TT(34). In this study the participants aged ≥40 years were examined(35). In a Trachoma Rapid Assessment conducted in the Pacific Islands Mathew et al participants aged ≥40 years were examined(36).

Due to these differences in the age of participants of studies where TT prevalence is estimated, in 2003 the WHO recommended the following three correction factors to extrapolate the prevalence of TT for the whole population(17): if the prevalence of TT is available for population aged >14 years, no correction factor is required. If prevalence is available for adults >30 years and >40 years the correction factors to be used are 1.03 and 1.1 respectively(17). The prevalence of TT in a specified age category is divided by the respective correction factor to extrapolate the prevalence of TT in the whole population. The use of correction factors to extrapolate the national or global burden of TT may introduce errors because the population age structure and the natural history of TT may vary in different communities(24, 35). For example in the areas where active trachoma has been eliminated the people with TT are likely to be older than in areas where TF is prevalent.

2.1.3 Microbiology

2.1.3.1 Causative agent

Trachoma is caused by an obligate intra-cellular gram-negative bacterium called Chlamydia trachomatis which infect epithelial cells of the conjunctiva but the clinical disease results from the inflammatory response in the sub-epithelial tissue(1). The current classification of Chlamydia was proposed by Karin Everett et al in 1999 and the Chlamydia trachomatis species belongs to the genus Chlamydia, order Chlamydiales, phylum Chlamydiae of kingdom Bacteria. The serovars of Chlamydia trachomatis species which are associated with endemic trachoma are A, B, Ba and C(37). Like other bacteria, Chlamydiae reproduce by binary fission. They lack the ability to synthesize high-energy compounds like adenosine triphosphate (ATP) and thus rely on the host cell energy(38). They have a unique developmental life cycle distinguished by two specialised forms: the metabolically inactive extracellular infectious

form known as elementary bodies (EB) and the metabolically active replicating intracellular form called reticulate bodies (RB). The EBs acts as the “spores” since they are adapted to extra-cellular transmission. They enter the cell through endocytosis encased in vesicles which mature into inclusion bodies. Within 2 hours of infection the EBs transform into RBs which multiply and fill the entire host cell. The host cell finally lyses and releases the infective particles which infect more host cells(15).

2.1.3.2 Laboratory diagnosis

The laboratory tests used to detect the presence of Chlamydia trachomatis infection are expensive(39, 40). Therefore, it is not feasible to routinely use the tests in trachoma surveys, especially in developing countries(39). The tests include(1):

1. Cytological tests used to identify the intra-cytoplasmic inclusions in the infected epithelial cells using Giemsa stain or fluorescent-labelled monoclonal antibodies, for the direct fluorescent antibody [DFA] test. DFA cytology can also be used to identify free EBs.

2. Culture of chlamydiae in egg yolk and cell-culture systems.

3. Enzyme immunoassay which involves binding of antichlamydial antibodies to a specific chlamydial antigen and labelling the antibody with labelled anti-IgG to allow detection.

4. Serology testing which measures anti-chlamydial antibodies in host serum or secretions.

5. Nucleic acid detection tests which identifies chlamydial DNA or RNA via probing or amplification techniques.

Currently Nucleic Acid Amplification Tests are the commonly used tests. They include the polymerase chain reaction and ligase chain reaction tests. These tests are highly sensitive hence there is poor correlation between the prevalence of active infection as detected by the tests and the prevalence of the clinical disease(41, 42). In areas with very low prevalence of trachoma the reliability of clinical examination is poor and Nucleic Acid Amplification Tests test are recommended(43, 44). In an untreated village in Tanzania where 234 children aged 1-7 years were examined and the prevalence of TF was 42.7%, 24% of the children with no signs of trachoma were polymerase chain reaction test positive while 54% of those who had TF were polymerase chain reaction test positive(45). In a study conducted in a rural trachoma-endemic community in the Gambia by Burton et al, the prevalence of infection was 7.2% in the total population but only 25% of the subjects with infection detected by polymerase chain reaction test had clinical signs of active trachoma(46). In a hypo-endemic

area in Nepal, none of the 46 children with clinically active trachoma had infection detectable by ligase chain reaction test in a study on reliability of clinical diagnosis in identifying infectious trachoma conducted(39). Positive laboratory results without a clinical disease can be due to a sub-clinical infection, mild clinical disease (<5 follicles) and contamination of the specimen(1). Other bacterial infections, allergy and viruses such as adenovirus, coxsackievirus and Molluscum contagiosum can cause follicular inflammation of the conjunctiva which can be confused with active trachoma(47).

In Kenya laboratory test have not been used in trachoma prevalence surveys because the cost is prohibitive. In 1987 a small scale trachoma sero-epidemiological study (25 isolates) was conducted in Meru district using direct fluorescent antibody test and Chlamydia trachomatis serotypes A, B and Ba were isolated(48).

2.1.4 Pathology

It is universally accepted that the chlamydial infection occurs in the conjunctival epithelium and it is rarely found in the sub-epithelial tissue(1). However, the detailed immunopathology is not fully understood(49). Histology of conjunctival biopsies specimen obtained from patients with active trachoma revealed the presence of both humoral and cell mediated immune responses and a possible role for autoimmune mechanisms(50). The inflammatory cells in an infected conjunctiva consist of polymorphonuclear leucocytes, macrophages, T lumphocytes and dendritic cells. The underlying conjunctival stroma is organized into B lymphoid follicles surrounded by plasma cells, B lymphoid cells, dendritic cells, T cells, macrophages, and polymorphonuclear leucocytes. The infection with Chlamydia trachomatis causes up-regulation of local production of cytokines such as IL-la, IL-I3, TNF-a and PDGF which might contribute to conjunctival damage and scarring(51).

In a normal conjunctiva types I and III collagen are found in the substantia propria while type IV is found in the epithelial and capillary endothelial basement membranes. Type V collagen is absent(52). In trachoma there are increased fibroblastic changes with formation of types I and III collagen fibrils among epithelial cells, upper stroma, and in the substantia propria. Type IV collagen is found in the irregularly thickened epithelial basement membrane and type V collagen in the upper substantia propria, walls of blood vessels and in the walls of accessory lacrimal glands.

2.1.5 Clinical presentation and grading of trachoma

2.1.5.1 Clinical presentation

A primary ocular infection with Chlamydia trachomatis results in a self-limiting inflammatory response and short lived immunity(42). Repeated infections trigger an immune reaction characterised by chronic inflammation of the tarsal conjunctiva with formation of follicles and papillae and scarring(45, 50, 53). As the scar tissue increases and matures it causes the eye lid to roll inwards (entropion), the lashes to rub on the eye ball (trichiasis), loss of the mucous secreting glands and obstruction of the tear ducts(54). Consequently, the cornea becomes opaque due to the repeated abrasion, decreased tear production and infection.

Super-infection with other microorganisms may mimic and/or worsen the clinical signs and symptoms of active trachoma(39, 55). Other diseases can also cause corneal scarring as was reported in two National blindness surveys conducted in the Gambia, which reported that the causes of non-trachomatous CO in the country were: corneal infection, measles/vitamin A deficiency, harmful traditional practices and trauma (unilateral scarring)(56).

Active trachoma is predominantly found in children <5 years and it becomes less frequent with increasing age(46, 57, 58). Adults contribute approximately 10% of active trachoma cases in the total population(44). The peak prevalence of TF among the Australian Aborigines is 30 to 36 months(1). A study conducted in a hyper-endemic area in Sudan indicated that 48% of the children under the age of one year had clinical signs of active trachoma(59).

Resolution of the active infection and disappearance of clinical signs take longer in children than in adults. This is attributed to the maturation of the immune system(60). A study conducted in Ethiopia revealed that children with chronic malnutrition have higher risk of having active trachoma and developing more severe disease than well nourished ones(28).

Trachomatous trichiasis (TT) is the potentially blinding stage of trachoma and it mainly occurs in adults. Generally women have higher prevalence of TT than men because of their close contact with children(30, 57, 58, 61, 62). The longer a person stays with uncorrected TT the higher is the risk of developing corneal opacity(63).

2.1.5.2 Clinical grading

The first trachoma grading scheme (*Table 2.1*) was published by MacCallan in 1908(64). The scheme had four grades which incorrectly assumed that trachoma was a clear cut clinical

entity which ran a known course divisible into stages through which each case passes(1). The grading did not allow for the possibility of active disease co-existing with the late stages.

Table 2.1: MacCallan Classification of trachoma

Stage	**Description**
Stage I	Incipient trachoma: immature follicles in the superior tarsal conjunctiva and early corneal changes.
Stage IIa	Follicular hypertrophy: mature superior tarsal follicles with possible limbal follicles, superior panus and sub-epithelial infiltrates.
Stage IIb	Papillary hypertrophy: follicles become obscured by conjunctival inflammation
Stage III	Cicatrization: scarring and early lid deformities in addition to the presence of follicles.
Stage IV	Inactive trachoma: Scarring with lid deformities (entropion and trichiasis) and tear insufficiency. No inflammation and follicles.

Over the last six decades, several trachoma grading schemes have been developed to suit both detailed epidemiological studies and routine surveys. The simplified trachoma grading scheme was published in 1987(65) and is the most widely used scheme in trachoma control programmes (*Figure 2.3*). It is based on the natural history of the disease and has the following five grades which are independently assessed: Trachomatous inflammation – Follicular (TF), Trachomatous inflammation – Intense (TI), Trachomatous Scarring (TS), Trachomatous Trichiasis (TT) and Corneal opacity (CO).

The clinical grades provide an indication of the treatment required(16): TF = active infection requiring antibiotic treatment; TI = severe current infection with an increased risk of scarring(53) and needing antibiotic treatment; TS = evidence that one has had trachoma; TT = eyes which may develop corneal opacity/visual loss and need corrective lid surgery; CO = indication of visual loss and the need for rehabilitation.

The aim of trachoma control is to eliminate the active infection and to surgically correct TT and entropion to stop visual loss. Therefore, the clinical signs used as indicators for planning are: TF, TT and CO. The 3 indicators were adopted in 2006 and included in the guide for trachoma mangers(10) and the VISION 2020 Action Plan(5). The prevalence of TF (active trachoma) is the indicator to justify the need for trachoma control programmes, until a suitable (rapid and field-ready) laboratory test for Chlamydia trachomatis is developed(44). TT (potentially blinding trachoma) indicates the need for TT surgical services while CO is the indicator for the burden of blindness and visual impairment.

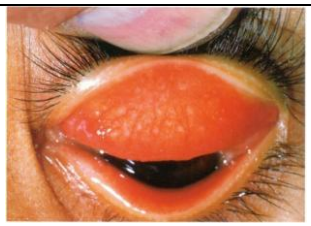
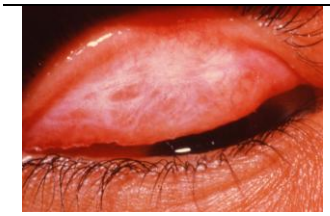
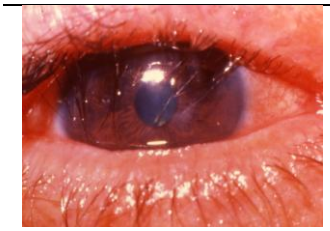
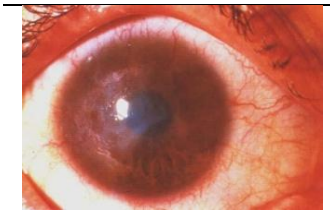
Image	Description
	Trachomatous inflammation - Follicular (TF) = The presence of five or more follicles of at least 0.5 millimetre in diameter in the upper tarsal conjunctiva. The follicles are whitish round spots that are paler than the surrounding conjunctiva.
	Trachomatous inflammation - Intense (TI) = There is pronounced inflammatory thickening of the tarsal conjunctiva that obscures 50% or more of the normal deep tarsal blood vessels. In TI the tarsal conjunctiva appears red, rough and thickened because of inflammatory oedema and papillae.
	Trachomatous Scarring (TS) = The presence of scarring in the tarsal conjunctiva. Scars (fibrosis) are easily visible as white lines, bands, or sheets. They can also obscure the blood vessels and they should not be confused with TI.
	Trachomatous Trichiasis (TT) = There is at least one eye lash rubbing on the eye ball or evidence of resent removal of in-turned eye lashes.
	Corneal Opacity (CO) = Easily visible corneal opacity over the pupil. This refers to a central corneal scarring that is so dense that at least some part of the pupil margin is blurred when viewed through the opacity.

Figure 2.3: WHO simplified trachoma grading scheme(65)

TI is not used as a planning indictor because it is more difficult to diagnose than TF. The ratio of TF to TI is expected to be of the order of 3:1 to 10:1 but some studies have reported ratios of 1:1, suggestive of over-diagnosis of TI(1). Often redness or inability to see the conjunctival vessels for any reason has been misclassified as TI, resulting in over reporting and poor Inter-observer agreement(1, 10). However, TI is a better indicator to assess the short-term efficacy of interventions than TF treatment because after treatment it resolves faster than TF(1). Therefore, TF is a slow but reliable indicator while TI is more sensitive to change but unreliable. Because of the poor inter-observer agreement for TI, its is recommended that in prevalence surveys TF and TI should be reported separately(1, 11, 66).

TS has no value in programme planning because people with TS do not require treatment.

2.1.5.3 Using photographs for trachoma grading

Good quality photographs have been used for trachoma grading. However, there is no consensus on whether they should be used for inter-observer agreement. Studies conducted in Tanzania and Australia to test the validity and reliability of using photographs to grade trachoma indicates that photographic documentation is a valid and reliable approach(67, 68). The challenge of misclassification of TI faced in clinical assessment was also encountered in photographic assessment(68). Solomon et al conducted a study to evaluate the use of photographs in grading of active trachoma in Tanzania where the right eyes of 948 persons were graded and the ungradable photographs classified as disagreements. There was fair-to-moderate agreement between the three assessments (by different examiners) of the photographs. The authors did not support the use of photographs in inter-observer agreement testing(69).

2.1.6 Risk factors

The factors associated with increase in individual risk of contracting active trachoma include: age, gender, dirty face, living with an infected person, absence of basic sanitation facilities, eye-seeking flies, over-crowding and poverty in general(70-73).

2.1.6.1 Age and Gender

Young children are the reservoir of active trachoma(1, 46, 57, 58, 72). Adults contribute approximately 10% of the active trachoma cases(44). Women and girls have a higher risk of contracting the infection than men because of their close contact with young children(18). Consequently, TT and visual loss due to trachoma are also more common in women than men(57, 61, 74). In patriarchal African communities women are responsible for most of household work and they may not get an opportunity to go for TT surgery(75). Furthermore, in some communities women have to be given permission by men to go for treatment.

2.1.6.2 Dirty face

A dirty face is considered to be the critical final pathway by which a variety of environmental factors affect the risk of trachoma(1, 70). Ocular secretions from infected persons contain Chlamydia(76) which can be passed on to other people through physical contact, fomites and mechanical vectors. Studies conducted in Mali and Tanzania indicate that children with dirty faces were 2 or 3 times more likely to have active trachoma than children with clean faces(77-79). Also the eye-seeking flies are attracted by the ocular and nasal secretions(80).

In surveys it is often difficult to define what constitutes a dirty face and this may introduce errors in estimation of the prevalence. Cleanliness of the children's faces varies with the time of the day. Those who are washed in the morning may be reported to have dirty faces if examined later in the day. Crying increases nasal discharges and a child may be graded as having a dirty face if he/she was crying during the examination. The other issue is whether children with food particles or dust on the face should be graded as having dirty faces. Children eat frequently and they are likely to have food particles on their faces at the time of the examination. Most trachoma-endemic areas are hot, dry and dusty. Application of clay on the body is also part of some traditional cultures.

Zack et al conducted a study to determine the reliable indicators of a clean face in a child and the disparities between the assessment of faces at a clinic and at home. Five hallmarks of a clean face were assessed on 50 children in Tanzania. They reported that ocular/nasal discharge, and flies on the face were reliable indicators of facial cleanliness while dust and food were not. A sign was considered reliable if the kappa value was >0.6. They further evaluated 973 children aged 1-5 years for facial cleanliness at home, and again 2 days later at a central location. Unclean faces were more prevalent when measured at home (62%) than at the clinic (51%), although both were related to trachoma(81).

2.1.6.3 Water scarcity

Water scarcity is often used as a proxy indicator for a dirty face. In Tanzania it was reported that the prevalence of active trachoma increased with increasing water collection time but it was unrelated to the amount of water collected(82, 83). Distance from household to water source was also found to increase the prevalence of trachoma in Mali(77). When people walk for long distances or take long period of time to fetch water, they may not be able to collect enough for both household use and face washing.

2.1.6.4 Flies

The role of eye-seeking flies in transmitting active trachoma is not clearly understood since trachoma has been found in areas with very low fly density(1, 84). Flies are attracted by the discharges from a dirty face and there is strong evidence implicating them, especially Musca sorbens, as the mechanical vectors for trachoma(76-78, 84). Chlamydia has been detected in flies(76) and children with flies on the faces having a higher risk of having active trachoma(72, 73, 77, 80). Two randomised controlled trials conducted in 1999 and 2004 in the Gambia(84, 85) reported that insecticide spray effectively reduced transmission active trachoma. However, it is still not clear whether the insecticide spray reduces the prevalence

of trachoma(86). The toxic effect the chemicals have on the environment should also be taken into consideration.

2.1.6.5 Environmental sanitation

The environmental factors which encourage breeding of flies and transmission of ocular discharges have been associated with increased prevalence of trachoma. They include poor refuse disposal, crowded sleeping arrangements, animals near or inside the house and living at lower altitudes(79, 87, 88). Latrine ownership has been associated with reduced occurrence of active trachoma(77, 89). A Cochrane review on environmental sanitary interventions for preventing active trachoma reported that there is an acute insufficiency of data from clinical trials to determine the effectiveness of all aspects of environmental sanitation in the control of trachoma(86).

2.1.6.6 Lifestyle

Lifestyle and culture: trachoma is frequently reported among specific communities and cultural groups; especially those who are nomadic and rear cattle(13, 26, 88, 90). In Kenya the trachoma endemic communities are found in the arid areas. They are nomadic and rear domestic animals.

2.1.6.7 Seasonal variations

Prevalence of active trachoma is known to vary with seasons, probably due to fluctuation in the magnitude of risk factors such as fly density and water availability(1, 91). A study conducted among Australian Aboriginal communities by Cruz et al revealed a significantly higher prevalence of trachoma during the wet season (14-59% in dry season compared with 46-69% in wet season) and also an increase in the population of bush fly populations(92). Lee et al monitored the prevalence of active chlamydial infection in an endemic community in Ethiopia and used a mathematical model to demonstrate that the effectiveness of mass antibiotic treatment for active trachoma could be enhanced if it is administered before the season with low prevalence of infection(91).

2.1.7 Trachoma control

Trachoma control is part of the broader VISION 2020 “The Right to Sight” global initiative(5). The aims of VISION 2020 are to eliminate the main causes of avoidable blindness by the year 2020 and to prevent the projected doubling of avoidable visual impairment between 1990 and 2020. The initiative has 3 components: cost-effective disease control, human resource development and infrastructure and technology. The epidemiology of blindness, visual

impairment and health/eye care systems vary considerably among countries and regions. These variations are to be taken into account when designing monitoring frameworks for individual countries. Countries are encouraged to select the indicators that are appropriate for their epidemiological situation and intervention strategy(5, 93).

The current trachoma control frame-work was put in place at a WHO consultation meeting held in Geneva in November 1996(94), to plan for the global elimination of blinding trachoma. The WHO Alliance for the Global Elimination of Trachoma by the year 2020 (GET 2020) was created. The GET2020 is a working group of non-governmental organizations, foundations, and other interested parties. Its aim is to foster planning, advocacy research and programme coordination towards the goal of eliminating blinding trachoma as a public health problem by the year 2020. In May 1998, the fifty-first World Health Assembly adopted a resolution on elimination of trachoma as a cause of blindness by 2020 through implementation of the SAFE strategy(7).

2.1.7.1 Trachoma intervention unit

Trachoma is more of a “community disease” than a “district level disease”. However, to harmonise trachoma project planning with other health care and development activities, the WHO recommends that a trachoma interventions unit should be the district. When this study commenced in 2009, a “trachoma district” was defined as the normal administrative unit for health-care management(17) with approximately 100,000 people(10). Later in 2010 the population size was revised. The new definition states that a “trachoma district” should at least be 100,000 but not more than 250,000 persons(8) This restriction of population size is critical for a focal disease as it ensures that needs assessment (prevalence surveys) is not conducted in large population units, which dilutes the prevalence in the marginalised endemic communities(20). It will also ensure focused interventions.

The other population units which are important in trachoma control are(8):

- Sub-district: a geographic or other grouping of at least three villages that permits finer stratification of a district into sub-units that might be expected to have greater or lesser prevalence of trachoma.
- Village: a population unit of 8,000-10,000 persons
- Community: a defined group of households, a village, or a group of neighbouring villages, for which mass trachoma control activities can be implemented. A community may be as large as a sub district or may be smaller than a village.

2.1.7.2 Surgery for trachomatous trichiasis

Surgery for TT is the "S" component of the SAFE strategy. It prevents blindness due to injury of the cornea by the in-turned eye lashes. Treatment options for TT are broadly divided into methods used to treat the offending eye lashes that give temporary relief and surgical methods which corrects the underlying anatomical eyelids abnormality that give permanent relief(62, 95). The non-surgical treatments include manual removal of the offending eye lash/s (epilation), eyelid-taping where tapes are used to hold the lid in the correct position and lash ablation procedures which include: cryotherapy, electrolysis laser and radiotherapy.

The surgical treatments that correct TT and entropion include(95):

1. Bilamellar tarsal rotation: a full thickness incision is made through the eyelid, including the scarred tarsal plate, orbicularis oculi and the skin.
2. Posterior tarsal lamellar rotation: the eyelid is everted and then an incision is made through the conjunctiva and the scarred tarsal plate, leaving the skin and orbicularis oculi intact.
3. Tarsal advance procedures: the commonest is the tarsal advancement and rotation (Trabut procedure) where the conjunctiva and the tarsal plate are incised and the terminal portion rotated.
4. Posterior lamellar lengthening procedures for severe entropion: graft from nasal septal cartridge, palatal mucosa or bucal mucosa used in order to achieve lid closure.
5. Anterior lamellar and lid margin procedures: the commonest is the Cuenod-Nataf used in Vietnam where the incision is made on the skin and the tarsal plate.

Both surgical and non-surgical methods are available for treatment(96). However, most national trachoma control programmes use one surgical procedure country-wide. Trachoma is commonly found in resource-scarce settings and most of the TT surgery is conducted by nurses and community health workers. Consequently, it is recommended that the surgical method(s) used should be effective and easy to perform with minimal surgical equipment. Based on findings of an RCT conducted in Oman(97), the WHO recommended the bilamellar tarsal rotation procedure as the method of choice(98).

During the Surgery for Trichiasis Antibiotics to prevent Recurrence (STAR) clinical trial conducted 2002-3 in southern Ethiopia to access whether post-operative azithromycin and tetracycline eye ointment could reduce recurrence of TT, Gower et al also evaluated the risk factors for early recurrence and other unfavourable short-term outcomes(99, 100). They

examined 2,615 eyelids at baseline and 6 weeks after TT surgery. Of these, 2,601 eyelids without surgical failure were followed up 6 weeks after surgery while data on eyelid contour abnormalities and granuloma formation were recorded for 1,881 eyes. Two point three percent of the eyelids developed recurrent TT and 1.3% had eyelid closure defects. Eyelid contour abnormalities and granuloma occurred in 1.2% and 10.5% of the patients respectively. The associated risk factors differed by outcome. Surgeon was predictive of eyelid closure defect and granuloma formation. Eyelids with short surgical incisions (<22 millimetres length) were 4 times more likely to develop recurrent TT. Baseline TT severity was predictive of eyelid contour abnormalities and recurrent trichiasis. Epilation was associated with granuloma formation, but was protective against eyelid closure defect.

The main challenges faced when providing TT surgery at community level are poor TT surgical coverage and a high long term recurrences rate after surgery(1, 35, 98, 101). TT surgical coverage is generally low mainly in most endemic countries, mainly due to(2, 101-106): low acceptance of TT surgery, shortage/low productivity of TT surgeons and high recurrence rate. Other barriers include: long distances to hospitals, poverty, lack of awareness and lack of somebody to escort the person with TT to hospital(107).

The factors associated with long term recurrence of TT(101, 104, 106, 108, 109) include: persistence inflammation, bacterial infection, surgeon's skills level and quality of surgery.

In programme planning, a TT prevalence of $\geq$1% in people $\geq$15 years old is the threshold to justify initiation of TT surgical services(17). Ideally all persons with TT require immediate lid surgery to avert visual loss. The ultimate intervention goal for elimination of TT is a district level prevalence of <1/1,000 total population of trichiasis cases unknown to the health system(8). Known cases of TT include recurrent cases and those that have refused surgery, which must be recorded as part of the surgical information system. There must also be evidence that the health system is able to identify and to manage incident trichiasis cases. Incidence of TT is the ideal indicator for elimination of TT because it is a measure of the new cases of TT over time. However, cohort studies to measure the incidence are expensive. Therefore, the ultimate intervention goal is used as a proxy indicator(4). In communities where the people aged $\geq$15 years constitute 50% of the total population, the ultimate intervention goal generally corresponds to <2 cases of TT per 1,000 people (<0.2%) in the population aged $\geq$15 years.

2.1.7.3 Antibiotic treatment

Antibiotic treatment for active trachoma is the "A" component of the SAFE strategy. Trachoma programmes use an antibiotic calculator provided by the ITI to estimate the amount of antibiotics required for mass treatment. Mass treatment reports from Kenya indicate that most people take azithromycin and those who require the eye ointment are approximately 2%.

The antibiotics used for treatment of active trachoma are oral azithromycin and tetracycline eye ointment for control(10). The ointment is administered twice daily for 6 weeks while azithromycin is administered as a single oral dose. Clinical trials conducted in the Gambia and Saudi Arabia demonstrated that a single dose of oral azithromycin was as effective as a six-week course of tetracycline eye ointment in clearing the active ocular infection and the clinical signs(110-112). The advantage of tetracycline ointment is that it has no systemic side effects, is cheap and can be given to people for whom azithromycin is contraindicated (children <6 months old, pregnant women and those allergic to azithromycin). The disadvantages of the ointment are(1):

- Unsupervised topical treatment for a prolonged period of time results in poor compliance.
- An ointment is difficult application in young children.
- It is also "greasy" and causes blurred vision.
- There is some irritation of the eye after installation.
- It treats the infection in the eye only since it is a topical medication.

Azithromycin is an azalide, a sub-class of macrolide antibiotics derived from erythromycin with methyl-substituted nitrogen in the lactone ring. It is taken as a single directly observed oral dose of 20 mg/Kg body weight. During mass treatment adults are given a single dose of 1 gram (4 x 250 milligram tablets). The doses for children are estimated using a standard height stick. The height is used as a proxy for the weight of the child. A study conducted in Kenyan by Rono et al established that the standard height stick provided by the International Trachoma Initiating can accurately determined the azithromycin doses for Kenyan children in the studied communities(113).

The advantages of azithromycin over tetracycline eye ointment are:

- Treatment is directly observed hence the compliance is good.
- It is a systemic drug hence it clears the infections in all parts of the body.

- It is well tolerated but has minimal side-effects experienced by a few people. These include diarrhoea, nausea, vomiting and abdominal pains.

Ideally treatment should be administered to all persons with active infection but this is not feasible in community setting as it would require all the suspected individuals to undergo laboratory testing. This is further compounded by distribution problems. Administration of mass antibiotic treatment is considered cost-effective when conducted in communities with ≥10% prevalence of TF in children 1-9 years old(1, 17). The ultimate intervention goal is to treat the whole population in the targeted area(8) and an antibiotic treatment coverage of ≥80% is considered successful(17). If the prevalence is 10% to 30% mass treatment is administered annually for three years and >30% for five years. This is followed by repeat surveys to justify further mass treatment(8). After stoppage of mass treatment, family and individual treatment is continued(4). Surveillance is also essential to detect re-emergence of the disease in the treated communities.

2.1.7.4 Re-emergence of active trachoma after mass treatment

It is not clear at which prevalence level mass treatment should be stopped, especially when the treatment coverage is not consistent and treatment is guided by clinical diagnosis(114). The WHO recommends that mass antibiotic treatment is not needed when the prevalence of TF at community level is <5%(115) but in hyper-endemic communities in Ethiopia active trachoma has re-emerged after four annual rounds of mass treatments with high treatment coverage and a reduction of the prevalence of infection to 2.6%(116).

Re-emergence of active trachoma was also reported three years after mass treatment in eight out of thirteen treated districts in Mali(117). Mass treatment was administered for three years but in several districts the coverage was <80% and inconsistent. However, the "FE" components of the SAFE strategy were not implemented in the entire programme area. Programme reports indicated that the district level antibiotic treatment coverage ranged between 20.9% and 108.6%. The inconsistencies in coverage rates were attributed to difficulties in estimation of the target population(117).

The risk of re-emergence could increase if the antibiotic dosage is not adequate. Campbell et al conducted a study in Tanzania to investigate whether 2-day dosing of azithromycin may improve the efficacy of azithromycin dosing in children with severe trachoma (defined as either TI or TF with ≥10 follicles)(118). Fifty children with severe trachoma were enrolled in the treatment group and 99 children in the control group. Those in the treatment group

were given treatment for 2 days while those in the control group received 1-day dosing. After six weeks, the decline in the prevalence of infection was significant in both groups but greater in the treatment group. The authors concluded that a Randomised Controlled Trial is warranted. The limitation with 2 day dosing for children with severe trachoma is that the children would have to be examined before treatment. This would cause delays and increase the cost of mass treatment.

The antibiotic treatment coverage and presence of trachoma risk factors, especially children with dirty faces and high fly density can reduce the effectiveness of mass antibiotic treatment. Studies conducted in Ethiopia and Tanzania(116, 119, 120) revealed that if the treatment coverage is low (<80%) or the duration of treatment is short, the infection re-emerges within six to twelve months. The return of infection is more likely in the areas where the risk factors like dirty face and poor environmental sanitation are prevalent(119). This indicates that mass antibiotic treatment should not be considered in isolation. All the components of the SAFE strategy should be implemented simultaneously.

West et al further investigated whether the infants aged <6 months who are treated with tetracycline eye ointment and may have poor compliance were the source of re-emergent infection in their families after mass treatment in trachoma-endemic communities. They identified 91 infants age less than six months living in 86 of 1,241 households. All children in all households aged <10 years were examined for trachoma and ocular infection with *C. trachomatis* at baseline, and six months after mass drug administration. The prevalence of infection at baseline in the infants was 5.9%. At six months post mass drug administration, the prevalence of infection among children older than 6 months and <10 years who resided in households with infants was 6.0% compared to 11.1% in children in households without infants (p=0.18). After adjustment for age, gender, baseline infection status and treatment, residing in a household with an infant was not associated with infection at six months (OR= 0.50, 95% CI= 0.20-1.22). There was no evidence that living in a household with an infant increased the risk of infection 6 months post administration of mass treatment in other children residing in the household(121).

The effectiveness of mass antibiotic treatment is also be affected by the frequency of treatment and the duration of treatment. A mathematical model developed by Lietman et al indicated that areas with <35% prevalence of active trachoma should be treated annually and those with prevalence >50% biannually(122). The limitation with the model was that it did assumed universal antibiotic coverage and did not consider effects of other factors such

as migrations from endemic areas. A Randomised Controlled Trial conducted by Gebre et al in 24 hyper-endemic sub-districts in northern Ethiopia to compare the effect of annual and twice-yearly mass treatment reported that after 42 months of treatment, the prevalence of ocular infection with Chlamydia was similar in the groups treated annually and twice-yearly(123). The antibiotic treatment coverage was >80% in both groups. In the group treated annually the mean prevalence of infection dropped from 41.9% at baseline to 1.9% at 42 months, while in the group treated twice-yearly it dropped from 38.3% to 3.3%.

Reports from trachoma control programmes indicate that 3 annual doses of mass antibiotic treatment may not eliminate active trachoma in hyper-endemic districts(8). Trachoma risk factors are also more prevalent in hyper-endemic districts than in hypo-endemic districts. The risk factors take a long time to eliminate, especially those that require behavioural change. West et al conducted a study in Tanzania to determine the number of years of annual mass treatment with azithromycin was needed to control trachoma in hyper-endemic districts. They reported that three years of mass antibiotic treatment was not adequate(120). In district with prevalence >50% they recommended that annual treatment may be required for >7 years. The mean treatment coverage in the studied 71 villages was 78% and the range was 56% to 98%(120).

In nomadic communities, administration of mass antibiotic treatment in small geographical areas increases risk of re-emergence of infection. This was the main challenge encountered in the pilot project that preceded the roll-out of the SAFE strategy in Kenya(30). Burton et al conducted a longitudinal study to measure the effect of mass treatment on the conjunctival burden of Chlamydia trachomatis in a Gambian community with low to medium trachoma prevalence and investigated the rate, route, and determinants of re-emergent infection. They administered mass azithromycin treatment to the community at baseline and took conjunctival swabs for Chlamydia Polymerase Chain Reaction test at baseline, 2, 6, 12, and 17 months. The study revealed that the effect of mass treatment was heterogeneous in the studied villages and the risk of return of infection was increased by contact with other untreated communities. They concluded that after mass treatment, communities need to be monitored for treatment failure and control measures should be implemented over wide geographical areas(124). However, it is not clear how wide the areas should be.

2.1.7.5 Collateral benefits of mass treatment with azithromycin

Trachoma is commonly found in poor communities with poor hygiene and environmental sanitation(2). Such communities have limited health care services and other infectious

diseases like diarrhoea, sexually transmitted infections, malaria, respiratory tract infections and urinary tract infections may be prevalent(1). Mass azithromycin treatment reduces both the prevalence of active trachoma and also most of the other commonly found infections. Azithromycin has been used as a prophylaxis as well as treatment for malaria, either alone or in combination with other therapies (125-130). A Cochrane review conducted in 2010 to investigate the effect of azithromycin in treatment of uncomplicated malaria reported that that it is a weak anti-malarial with some appealing safety characteristics(131). In rural Ethiopian villages mass administration of azithromycin reduced the prevalence of respiratory tract infections, malaria and diarrhoea(132, 133). In rural Gambian villages azithromycin treatment for active trachoma had short term effects on childhood morbidity, particularly in the high malaria transmission season, and adverse effects were not a problem(134). Azithromycin has also been shown to reduce the incidents of sexually transmitted infections(135) and pneumonia(136).

There are fears that mass treatment with azithromycin to eliminate active trachoma may promote antimicrobial resistance(94, 137, 138). A study conducted in Nepal to investigate the adverse and beneficial secondary effects of mass treatment with azithromycin reported that there were no macrolide-resistant isolates after the first round of mass treatment but in the second round, azithromycin-resistant pneumococci were isolated in 4.3% of children. It was concluded that there is need for resistance monitoring when multiple rounds of mass treatments are administered(139). In Ethiopian communities 76.8% of nasopharyngeal Streptococcus pneumoniae isolates from children aged 1-5 years were resistant to macrolides after administration of six bi-annual rounds of oral azithromycin for active trachoma. Within twelve and twenty-four months after the last azithromycin treatment, the resistance decreased to 30.6% and 20.8% respectively. After the conclusion of a three year mass treatment programme, the prevalence of azithromycin resistance decreased markedly. The authors concluded that antibiotic resistance decreases after cessation of mass treatment and mass treatment with azithromycin is therefore safe(140).

2.1.8 Facial cleanliness

Ocular and nasal discharges are the potential source of infection(1, 40). Face washing has been associated with inadequate or lack of access to water hence provision of water is important. In Mali Schemann et al found that long distance from household to water source associated with increased prevalence of trachoma (77). However, in a study conducted in Tanzania by Polack at al a similar trend but it was reported that the long distance was a

limitation to the quantity of water a household was able to fetch, which in turn reduced the amount allocated for washing(82).

A Cochrane review published in 2007 reported that the current evidence does not support a beneficial effect in reducing active trachoma by face washing in isolation, or in combination with topical tetracycline(86). The review underscored the importance to implement all the components of the SAFE strategy. However, a major limitation with Cochrane reviews is that only evidence from randomised controlled trials is considered while evidence from other study designs is ignored(141).

In most countries promotion of personal hygiene is a fundamental component of Primary Health Care and School Health Programmes. Therefore, implementation of this component is likely to continue after conclusion of the SAFE strategy.

2.1.9 Environmental improvements

This is the most effective component to disrupt the transmission of active trachoma by eliminating the environmental risk factors. However, implementation of this component is expensive and takes a long period of time to reduce the prevalence of trachoma. The spontaneously disappearance of trachoma in European countries was attributed to social-economic development, which led to reduced overcrowding, easy access to water and improved waste disposal(1, 19, 142).

The modifiable environmental risk factors include water scarcity, overcrowding, lack of pit latrines, animals close to human dwellings and poor garbage disposal(1, 71, 78, 143, 144). The main challenge encountered in studies to determine the effect of these factors is that they tend to occur together in the same family and confound each other(71). Provision of water is vital for facial cleanliness(77, 78, 80, 145) and there is evidence that reduction of the distance to the water source (<1 kilometre or <30 min walk) reduces the prevalence of trachoma(84, 145-147).

Provision of latrines, garbage disposal and separation of animals from the households are aimed at reducing the fly breeding sites. Presence of a household latrine has been associated with a reduction in the prevalence and severity of active trachoma(77, 78, 84, 89, 148, 149). However, in nomadic communities it is difficult to promote use of pit latrine since there are no permanent human dwellings. Furthermore, some communities have cultural beliefs that hinder latrine use. A study conducted in Ethiopia on low cost pit latrines recommended

community mobilisation as an effective and minimal cost approach to increase latrine ownership. Health education and awareness raising being the key tools for creating a demand in latrines that can be constructed using locally available materials(150).

Environmental sanitation is a fundamental element of Primary Health Care hence the "E" component is likely to be sustained after implementation of the SAFE strategy. The other factor which may provide additional resources to this components is the integration of trachoma control with control of other Neglected Tropical Diseases(21, 22).

2.1.10 Cost of implementing the SAFE strategy

2.1.10.1 Cost of prevalence survey to assess the need for intervention

Prevalence surveys to confirm the presence of trachoma are mandatory before new projects are initiated or old ones extended(9, 13, 16, 20, 143, 151). This requirement is due to the fact that trachoma can be eliminated by treatment and social-economic development.

An analysis to estimate the cost of trachoma surveys in eight national trachoma control programmes in Africa was conducted between 2006 and 2010 by Chen et al(152). Data for 165 districts in Ethiopia, Ghana, Mali, Niger, Nigeria, Sudan, Southern Sudan and the Gambia were analysed. The incremental cost of surveying a single administrative district ranged between US$1,511 in Ethiopia and $25,000 in Southern Sudan. The median cost per district surveyed was $4,784 (inter-quartile range $3,508-$6,650) while the median cost per cluster was $311 (inter-quartile range $119-$393).

The cost items included in the analysis were: personnel, transportation, supplies, training, field work, supervision and data entry. It revealed that the main cost drivers were personnel and transportation during field work. However, consultancy charges and technical assistance (including travel) for headquarters staff were not included. It was noted that the average cost for airfare, hotel, meals and incidentals per person-trip was $1,779, with a standard deviation of $2,027.

2.1.10.2 Cost of implementation

Implementation of the SAFE strategy is expensive and requires comprehensive public health interventions, supported by a broad partnership between governments and development partners(143). Frick et al estimated that economic loss caused by trachoma globally was about US$5.3 billion annually in 2003(153). In 2011 the International Coalition for Trachoma Control collated information on the costs of the various components of the SAFE strategy

when updating the global plan for trachoma control(154). They estimated that the cost of implementing the strategy for the period between 2011 and 2020 will cost approximately $430 million. The estimate did not include the cost of drugs since azithromycin is donated free of charge but the International Trachoma Initiative. They also included a minimal cost for construction of pit latrines and provision of water. The average cost of mass treatment was $0.25 per dose and for one TT surgical operation $40.

In 2010 Kolaczinski et al conduted an economic analysis to determine the cost of mass antibiotic treatment for active trachoma in a remote setting in Southern Sudan and reported that the economic cost of an initial round of mass treatment with donated azithromycin was US$1.5 per person treated(22). The financial cost, meaning what the project paid, was $1.4 per person treated. The cost of overheads was estimated at a flat rate of 25%, based on previous experiences in the country. Capital costs were discounted at the rate of 3%. The cost of tetracycline eye ointment was 3.8% of the total cost. It was included since it was purchased by the project. It was concluded that in remote settings, the cost of mass treatment was three times that of a previous estimate of $0.5 per person treated.

Lessons learnt in Burma over a period of 30 years (1964-93) of trachoma control revealed that: both the surgical and non-surgical trachoma interventions are cost effective means of preventing visual impairment. The cost effectiveness was reported as US$54 per case of visual impairment prevented: $193 for surgical and $47 for non-surgical interventions. The cost utility of the programme was $4 per handicap adjusted life year averted: US$10 and $3 for surgical and non-surgical interventions respectively(155).

In 2004 Baltussen et al investigated the cost-effectiveness of surgery and antibiotics control in seven world regions. They established that as individual components of the SAFE strategy, trichiasis surgery for trachoma is a cost-effective way of restoring sight in all epidemiological sub-regions considered. Mass azithromycin treatment is cost-effective only when the azithromycin is donated free of charge or available at a reduced price. They also noted that the production cost of a 250 mg capsule of azithromycin in India was $0.5, while the price of the same in Kenya was $7.5(156).

2.1.10.3 Challenges

Major achievements have so far been attained in trachoma control, including a reduction in the number of trachoma endemic countries from 57 to 53, >250 million people treated with

antibiotics and >900,000 TT surgeries(2-4, 6) performed. The major challenges highlighted in the VISION 2020 global plan, include(5):

1. Not all countries in which blinding trachoma is suspected to be endemic have undertaken a proper assessment of the epidemiological situation.

2. The SAFE strategy does not cover 100% of the populations in endemic countries.

3. International partners who are members of the GET 2020 Alliance do not implement all the components of the SAFE strategy.

4. The available resources for trachoma control are insufficient.

With only 7 years remaining to the 2020 deadline, there is an urgent need to complete the remaining surveys and scale up implementation of the SAFE strategy. One vehicle to achieve this is incorporation of operational research to development of efficient/effective survey methods for needs assessment. Such research should also provide data for development of evidence-based standards and guidelines for cost-effective interventions.

In their article on operational research in low-income countries, Zachariah et al defined operational research as the search for knowledge on interventions, strategies, or tools that can enhance the quality, effectiveness, or coverage of programme in which the research is being done. The key elements of operational research were that the research questions were generated by identifying the constraints and challenges encountered during the implementation of programme activities. The answers provided to these questions should have direct, practical relevance to solving problems and improving health-care delivery(157).

Yamey et al conducted interviews with implementation experts and reviewed published literature to determine the factors that enabled successful scale-up of global public health interventions. The factors were: choosing simple interventions that are widely agreed to be valuable; strong leadership and governance; active engagement of a range of implementers and of the target community; tailoring the scale-up approach to the local situation; and, incorporating research into implementation(158).

2.2 Trachoma survey methods

The lack of prevalence survey data for some trachoma-endemic areas remains an obstacle to trachoma control efforts(159). The other impediment is the discrepancies in the methods used in trachoma surveys, which makes it difficult to compare survey findings in different

populations(11). Both population-based prevalence survey and rapid assessment methods are advocated for trachoma control. However, a prevalence survey is mandatory to provide data for planning interventions.

2.2.1 Population-based prevalence survey

Trachoma prevalence surveys are generally categorised into surveys for programme start-up (baseline surveys) and to assess the impact of interventions (impact assessment surveys). The first step in a survey is to define the area to be surveyed.

In most countries, the administrative district is the implementation level for development and health care projects. Likewise, trachoma prevalence surveys are conducted in administrative districts(10, 11, 16, 17), irrespective of the population size of the districts. This creates a challenge in districts with clustered trachoma since the non-endemic areas do not require interventions. In 2010, the WHO rectified this anomaly by introducing an upper limit to the size of the reference population for trachoma surveys. In hypo-endemic areas, surveys should be conducted in areas with a population of 100,000 to 250,000 people and not larger aggregates. The same applies for all impact assessment surveys. However, surveys for programme start-up in areas which are likely to be highly endemic and trachoma is widespread can be conducted in large areas (>250,000 people)(8). The only difficulty trachoma programmes may face when implementing these guidelines is how to differentiate between the hypo-endemic and hyper-endemic areas prior to a survey.

So far, there is no standardised protocol for trachoma risk assessment. Furthermore, risk assessment is not a precise method to determine the prevalence of trachoma. If it were, then there would be no need for a survey(14). A good example of how challenging the risk assessment can be is the outcome of a survey conducted in Meru North district in Kenya. This large district (604,050 people) was among an initial set of six priority districts surveyed in 2004(25). Old survey reports indicated that the district was likely to be hyper-endemic(13, 48). This evidence was further supported by local eye clinics reports which indicated that there was a backlog of people with TT. However, the trachoma survey revealed that the district was hypo-endemic (8.1% prevalence of TF). The remaining TF cases were clustered in the dry areas. Most of the people with TT (93.3%) were $\geq$40 years old. The decline in prevalence of TF was attributed to a rapid growth in social-economic development (secular trend).

2.2.1.1 Calculation of the sample size

Once a decision is made that a survey is required and the study area defined, the minimum number of individuals to be selected and examined during the survey is computed to inform preparation of survey budget and planning. The parameters used to calculate the minimum sample size (Equation 1) include: expected prevalence(b), maximum sampling error or precision(c), z score of 1.96 indicating 95% confidence level(d) and the design effect (e)(10, 11).

The population size is not used as a parameter if the population of the study area is >5,000 people, which is the case in most population-based prevalence surveys. The reason for this is that a further increase in the population size beyond 5,000 people does not significantly increase the sample size(15).

Equation 1: Sample size calculation formula(10)

$$\text{Minimum sample size} = e\frac{d^2 b(1-b)}{c^2}$$

In addition to the mathematical parameters used in calculation of the sample size, the number of people to be examined also requires a balance between cost of the survey and the precision of the prevalence estimates that are to be made(14). A standard TT survey with participants aged ≥15 years and a survey to certify elimination of trachoma are examples of situations where this trade-off is applied(9, 16). In both surveys a very low prevalence of disease (<5%) is estimated and this usually requires very large samples. Instead, researchers reduce the sample size and cost of survey by accepting a low precision in estimation of the prevalence. For example in a survey to certify elimination of trachoma (TF prevalence <5%) it is recommended that the sample size should be adequate to detect 4% ±2% prevalence of TF in children 1-9 years old(8). The absolute precision of 2% is equivalent to relative precision of 50%, since 2% = 50% of 4%. If the ideal relative precision of 20% (4%±0.8%) for prevalence surveys is used, the sample size would be enormous hence a realistic sample size has to be calculated.

2.2.1.2 Design effect

The simple random sampling method is the “gold standard” for selection of individuals to be examined in a survey. However, in population-based surveys the cluster random sampling method is preferred because it is more feasible than simple random sampling(15). Simple random sampling involves random sampling of individual persons from a complete list of all persons in the population. This is expensive since it requires a population census prior to the

survey. In cluster random sampling a group of individuals living in a specified area, for example a village or a community is sampled.

Selection of clusters reduces the cost of a survey but it increases the random sampling errors due to the different characteristics of the individuals in a cluster and among the clusters(14). The design effect is the factor by which the sample size for cluster random sampling is multiplied, to compensate for this increase in random sampling errors. It is regarded as a penalty for deviating from simple random sampling. Survey with large clusters attract higher design effects than those with smaller clusters(9, 10, 14, 15).

It is not possible to accurately fore-tell the likely design effect prior to a survey(14, 15). Therefore, it is estimated using experiences from previously-conducted surveys. Diseases which are clustered like trachoma have higher design effects than those which are evenly distributed in the target population. The design effects for trachoma surveys with 100-300 and >300 participants per cluster are 4.0 and >6.0 respectively(9, 10, 14). The design effect for Rapid Assessment of Avoidable Blindness surveys were estimated from earlier studies on cataract blindness. For cluster with 40, 50 and 60 subjects each the design effects are 1.4, 1.6 and 1.7 respectively (https://www.iceh.org.uk). For clusters with >60 subjects the design effect is 2.0. In a National Survey on Blindness, Low Vision and Trachoma survey conducted in Ethiopia in 2005-06 a design effect of 2.0 was used with 144 individuals per cluster(160).

Stratification in the sampling design is often done to allow the determination of the prevalence of the disease in the different parts of the study area(8, 57, 66). It is assumed that stratification minimises random sampling errors(14). Strata are geographical areas which comprise of communities with similar risk of having the disease. Risk assessment is conducted to inform the allocation of the sample size in the strata. The strata with lower prevalence are allocated higher samples than those with high prevalence(11, 14). However, a major limitation with stratification is that it requires complex sampling and data analysis methods. The equations used demand that accurate assumptions are made about the prevalence in each stratum, and about the stratum-specific design effects. These are difficult and often impossible to foretell with any confidence(14).

In resource-scarce countries with few epidemiologists, it is recommended that operational research methods should be simplified so that the local teams can be able to replicate them(157). Furthermore, simple research methods and interventions are regarded key predictors of success in scale up of global public health Interventions(158). It is for this

reason that in this study segmentation was preferred to stratification. The study areas were divided into geographical areas (segments). Each segment was surveyed separately without stratification.

2.2.1.3 Precision

The absolute precision for prevalence estimate of a condition in a given population indicates the maximum random sampling error that can be accepted. The precision needed to estimate prevalence in a population depends on the anticipated prevalence. For example, if the anticipated prevalence of a disease in the population is 1%, then an estimate of 1% ± 2.5% may be acceptable, whereas an estimate of 1% ± 5% is not useful since the error is larger than the prevalence estimate. However, ± 5% may be acceptable for a prevalence estimate of 10% or more(14, 15).

The precision can also be expressed in relative terms. For example if the assumed prevalence is 10% and the absolute precision is 2%, the relative precision is 20%, since 2% is 20% of 10%. The Confidence Interval is 10% ± 2% irrespective of whether this precision is expressed in absolute or relative terms.

The ideal relative precision for prevalence surveys is 20%(9, 10) and >50% is considered too low for accurate statistical inference(14). When the prevalence of a disease is too low, adoption of a high precision results in very large survey sample size(14, 15). This is the case in surveys to certify elimination of trachoma and TT prevalence surveys in persons aged ≥15 years where the prevalence to be estimated is <5%(8, 16).

2.2.1.4 Confidence limits

The confidence level is the probability that the maximum random sampling error is not exceeded. Unless otherwise stated, in surveys the probability is usually 0.95, indicating that 95% Confidence Intervals will be calculated(15). This is interpreted to mean that one is 95% certain that the true prevalence in the population is contained in the Confidence Interval.

The 95% Confidence Intervals of prevalence estimates calculated in a survey where the cluster random sampling method is used are routinely adjusted for potential clustering since the determination of the design effect is not an exact method. The generalized estimating equations modelling developed by Bennett et al is the commonly used(161). This function is available in most statistical software, including the Predictive Analytics SoftWare version 18 used in this study.

2.2.2 Trachoma rapid assessment methods

2.2.2.1 Trachoma rapid assessment

The purpose of a Trachoma Rapid Assessment is to ascertain the presence or absence of trachoma in an area which is suspected to be endemic(11, 36, 162-165). Random sampling methods are not used in a rapid assessment hence the data cannot be used to estimate the prevalence of trachoma. The sample is selected only in the suspected endemic communities(11, 66). Consequently, a prevalence survey is required subsequent to a Trachoma Rapid Assessment to provide the benchmarks for the implementation of the SAFE strategy. Developing countries rely on donation of azithromycin to conduct mass antibiotic treatment. The donation cannot be approved without prevalence survey results.

A trachoma risk assessment is conducted prior to a Trachoma Rapid Assessment, to identify the areas which are likely to be trachoma-endemic(166). The sources of information include(9, 10, 166): reports from previous surveys, interview of the outreach teams, project and hospital TT surgery records. Documents which are older than 7 years should be reviewed with caution if the areas has experienced substantial social-economic development(166). Persons with local experience, such as regional, eye care staff from government and non-governmental organisations are interviewed. In absence of health information, anecdotal information may be used.

It is further recommended that classification of administrative districts as likely or not likely to be trachoma endemic should be done by an ophthalmologist with experience in trachoma or by a trachoma expert(10). However, in sub-Saharan Africa, there are few trachoma experts and ophthalmologist with experience in trachoma. Generally, there is shortage and poor distribution of high medical level personnel such as doctors. Where they are available, they are mainly urban based. Ophthalmic Clinical Officers and nurses have more experience on trachoma control because they are mainly based at sub-district and district levels(167). These workers should be trained to conduct the risk assessment and Trachoma Rapid Assessments.

2.2.2.2 Acceptance Sampling Trachoma Rapid Assessment

The Acceptance Sampling Trachoma Rapid Assessment survey method is based on Lot Quality-Assurance Sampling. It originated from the manufacturing industry, where it is used for quality control purposes and has been used by public health services to evaluate immunization coverage(168). The method does not have a fixed sample size and sampling

may stop once the number of “defects” or cases allowed has been exceeded. Maps for areas to be surveyed are prepared and the households are allocated individual numbers. The children in consecutive households are then examined until a predetermined number of TF cases are diagnosed. Field trials conducted in Vietnam and Malawi led to the conclusion that the method should be considered as a replacement for Trachoma Rapid Assessment(164, 165).

2.3 Kenya

This study was conducted in Kenya, a commonwealth nation which gained independence in 1963. English is the official language while Kiswahili is the national language. The country is located at the East Africa coast (*Figure 2.4*) astride the equator, covers an area of 582,646 square kilometres and lies between 5 degrees north and 5 degrees south latitude and between 24 and 31 degrees east longitude. It is hot and humid at the coast, temperate inland and very dry in the north and north-eastern parts of the country. The Great Rift Valley, which together with the Sahel forms the African trachoma belt, runs through Kenya from North to South.

Kenya is bordered by Ethiopia (north), Somalia (northeast), Tanzania (south), Uganda and Lake Victoria (west) and Sudan (northwest). To the east is the Indian Ocean, with a 536-kilometre coastline containing swamps of East African mangroves and the port of Mombasa.

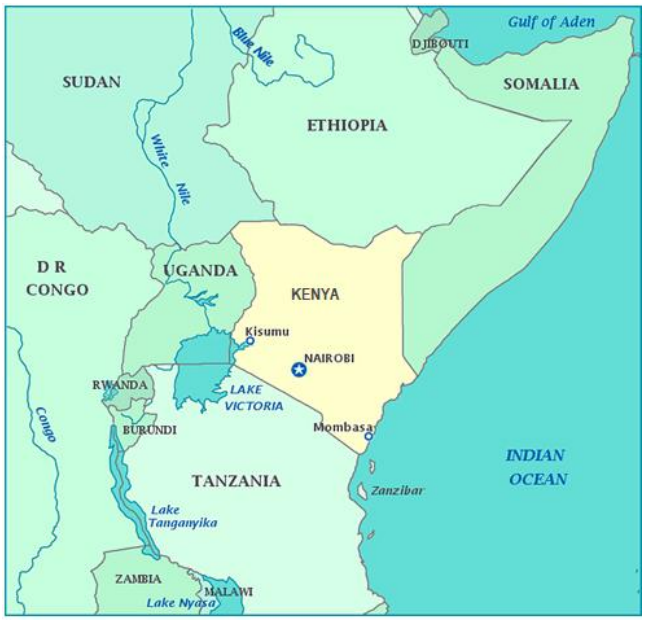


Figure 2.4: Map showing the Republic of Kenya and neighbouring countries

In 1999 and in 2009 Kenya had 28.7 million and 38.6 million people respectively (*Table 2.2*). The 1999 to 2009 inter-censal population growth rate was 3.0% per year and the total population increased by 35%.

Table 2.2: Demographic indicators for Kenya (source: Government of Kenya reports)

Indicator	**1969**	**1979**	**1989**	**1999**	**2009**
Population (millions)	10.9	16.2	23.2	28.7	38.6
Life expectancy at birth (years)	50	54	60	56.6	58.8
Total fertility rate (children per woman)	7.6	7.8	6.7	5.0	4.6
Crude birth rate (birth per 1,000 people per year)	50.0	54.0	48.0	41.3	34.8
Infant mortality rate (per 1,000 births)	119	88	66	77.3	52.0

A National Demographic and Health Survey is conducted every five years to provide data for monitoring the population and health situation in the country (*Table 2.2*). The 2008-09 survey indicated that the total fertility rate was 4.6 children per woman. This was lower than the rate of 4.9 derived in the 2003 survey. In the same period the under-five mortality and infant mortality declined from 115 to 74 deaths and 77 to 52 deaths per 1,000 live births respectively. Education of women was strongly associated with low fertility.

Kenya is divided into eight administrative provinces: Nairobi, Central, Eastern, North Eastern, Rift Valley, Coast, Nyanza and Western provinces. Each province is divided into districts, divisions, locations, sub-locations and villages. The administrative head of the nation of Kenya is the National President. A province is headed by a Provincial Commissioner (PC), a district by a District Commissioner (DC), a division by a Division Officer (DO), a location by a Chief, a sub-location by a Sub-chief and a village by a village elder.

Development projects are implemented at the district level. In early 1990's Kenya had 70 administrative districts, which are nowadays referred to as the "larger districts". The districts were there-after sub-divided on political grounds without consideration of the population size of the new districts. By the time this study commenced in 2009 the country had 158 gazetted administrative districts with population sizes ranging between 32,762 people in Laikipia North and 1,144,416 people in Nairobi East(12). The frequent changes in the size of administrative districts create difficulties in project planning since the existing projects are also required to be subdivided.

In August 2010 a new constitution with a devolved system of government was promulgated in Kenya. The provinces and the provincial administration were abolished and the 158 districts aggregated into 47 Counties. Each County will form a County Government, headed

by Governor. Future development projects, the SAFE strategy included, will be implemented at the County level and not the district level.

By the time this thesis was written the County boundaries had been defined but the County Governments had not yet been formed. For example Narok County has the 4 districts, curved out of the larger Narok and the larger Transmara districts, namely: Narok North, Narok South, Transmara West and Transmara East districts. The 2009 census indicated that the Narok County had a population 850,920 people, 429,026 males and 421,894 females. Turkana County has the six new districts which were all curved out of the larger Turkana district: Turkana North, Turkana West, Turkana South, Turkana East, Turkana Central and Loima districts. In 2009 the County had a population 855,399 people, 445,069 males and 410,330 females. However, the 2009 census for Turkana was nullified because it was inflated by influx of refugees from neighbouring countries.

2.3.1 The Division of Ophthalmic Services (DOS)

Eye care services in Kenya are supervised by the Division of Ophthalmic Services (DOS) of the Ministry of Public Health and Sanitation. The division was previously a programme (Kenya Ophthalmic Programme) of the Ministry of Health. The Ministries of Public Health and Sanitation and Medical Services are the major health care providers in the country. These two ministries operate more than half of all health facilities in the country (public facilities). The public delivery system is organised in a traditional pyramidal structure. First-level care is provided at dispensaries and medical clinics. The next level comprises health centres and sub-district hospitals. Third-level care is provided at district hospitals and provincial general hospitals. There are two national hospitals: Kenyatta National Hospital in Nairobi and the Moi Teaching and Referral Hospital in Eldoret.

The Kenya Ophthalmic Programme was created in 1956 and its key milestones were(167):

- 1956: The Kenya Ophthalmic Programme was established.
- 1959: Training of Ophthalmic Clinical Officers commenced at the Kenya Medical Training College. These are mid-level workers with diploma in clinical medicine and diploma in ophthalmology. The cadre manages eye care and trachoma control activities at the district level.
- 1960: Eye care outreach commenced.
- 1966: A National Prevention of Blindness Committee was formed.

- 1978: A postgraduate degree course in ophthalmology commenced at the University of Nairobi.
- 1980s: A series of 8 regional eye surveys which constituted the first national blindness survey was conducted: cataract was the leading cause of blindness and trachoma the second(13).
- 1990: Kenya is divided into ten ophthalmic zones (geo-medical areas for eye care delivery) headed by Zonal Eye Surgeons. Rendering of eye care services by zones was more efficient than by administrative regions (provinces).
- 1996: Primary Eye Care Programme became the thirteenth element of Primary Heath Care Programme in Kenya.
- 2001: The Kenya Ophthalmic Programme is upgraded to a full Division of Ophthalmic Services of the Ministry of Health and Sanitation following a successful launch of VISION 2020. The DOS has a Head of Division who manages several national eye care programmes including Primary Eye Care, Eye Health Information and Trachoma Control Programmes. Each programme has a programme manager. The Division also has projects for control of childhood blindness, Low Vision and ophthalmic equipment/technology.
- 2003: Training of Ophthalmic Nurses commenced at the Kenya Medical Training College. These are mid-level workers with diploma in community nursing and diploma ophthalmic nursing.
- 2007: Roll-out of the National SAFE strategy officially launched.
- 2008: Training of opticians commenced at the Kenya Medical Training College. These are mid-level workers to screen for refractive errors and prescribe spectacles.
- 2008: The Minister for Public Health and Sanitation launches the first Kenya National Plan for Elimination of Trachoma(169).
- 2009: A trachoma control co-ordination office established at the Ministry of Public Health and Sanitation and a National Trachoma Programme manager appointed.

The first and so far the only national blindness survey conducted in Kenya in the 1980s indicated that the prevalence of blindness in the population was 0.7%. Cataract was the leading cause of blindness accounting for 39% of the total number of blind people(13). Active trachoma was reported to be the commonest ocular disease in rural Kenya with 18.7% of the total population and 25% of children <10 years affected(26). The WHO

simplified trachoma grading scheme and survey guidelines(10, 65) had not been developed by then. Therefore, it is difficult to compare the findings with those of recent surveys.

2.3.2 The Kenya Trachoma Control Programme

Trachoma is endemic in 18 administrative districts in Kenya with an estimated 7 million people(169, 170). The launch of the SAFE strategy in 2007 and the subsequent creation of a National Trachoma Control Programme enabled the country to build a broad partnership to mobilize resources and co-ordinate trachoma control activities. The National Trachoma Control Programme is headed by a National Trachoma Programme Manager. The National Trachoma Task Force comprises of representatives from government and non-governmental organisations. The role of the Task Force is to formulate policy, monitor implementation and mobilise resources for trachoma control.

The implementing partners for trachoma control in Kenya include government ministries, institutions and International non-governmental organisations such as the: European Union, African Medical and Research Foundation, Sightsavers, Operation Eyesight Universal, Christoffel Blinden Mission, Fred Hollows Foundation, International Trachoma Initiative, World Health Organization, Spanish Volunteer Eye Doctors, University of Nairobi, Kenya Medical Supplies Agency, Kenya Medical Training College, Magadi Soda Company and local Community Based Organizations.

Implementation of the SAFE strategy is done at the district the level. A district project has a trachoma project manager, an Ophthalmic Clinical Officer to manage the “SA” components of the SAFE strategy and a Public Health Officer to manage the “FE” components. The district trachoma team is supervised by the District Health Management Team.

The local communities are fully involved in the trachoma control activities, such as: face washing campaigns, construction of pit latrines identifying the community members who have TT and encouraging them to go for lid surgery. In Kajiado district for example, Masai village workers are also trained to screen for active trachoma and record their findings using beads (*Figure 2.5*). A red bead indicates a household member with TF/TI, blue for one with no signs of active trachoma and white for one who was absent at the time of examination. The strings with the diagnostic beads are hanged outside the houses for the visiting health worker to enter the information in a register. The health worker provides tetracycline eye ointment for those with the red beads.

Figure 2.5: Beads that Masai village workers use to record examination findings

2.3.2.1 Trachoma mapping

Trachoma prevalence surveys to provide baseline data for implementation of the SAFE strategy commenced in 2004 when the first set of six suspected trachoma-endemic districts was surveyed (*Figure 1.1, page 3*). Five of the districts are in the Rift Valley Province (Kajiado, Narok, Baringo, Samburu and West Pokot districts) and one in Eastern Province (Meru North district)(25). An additional district (Laikipia) in the Rift Valley was surveyed in 2007(31). The surveys were conducted using the survey by administrative district method(10).

The prevalence of TT was ≥1% in all of the seven districts hence they needed TT surgical services (*Table 2.3*). The prevalence of TF was ≥10% in four out of the seven districts namely: Kajiado, Narok, West Pokot and Samburu districts. Therefore, the whole population in the four districts needed mass antibiotic treatment. In Baringo, Laikipia and Meru North districts the prevalence of TF was <10% and trachoma was mainly found in the arid areas. It was recommended that the endemic areas in the districts should be re-surveyed to provide accurate data to justify mass treatment at the sub-district level.

Table 2.3: Previously-conducted trachoma prevalence surveys

Administrative district	**Children 1-9 yrs**		**Adults ≥15 yrs**	
	Total and (TF cases)	Prevalence of TF (95% C.I)	Total and (TT cases)	Prevalence of TT (95% C.I)
1. Samburu	1,250 (434)	35.0% (29.5 - 40.3)	1,368(82)	6.0% (4.4 - 8.1)
2. Narok	1,348(411)	30.5% (25.6 - 35.8)	1,376(31)	2.3% (1.3 - 3.7)
3. Kajiado	1,182(332)	28.1% (23.1 - 33.6)	1,414(46)	3.3% (2.1 - 4.9)
4. West Pokot	1,142(304)	26.6% (21.7 - 32.3)	1,324(79)	5.7% (4.2 - 7.8)
5. Laikipia	1,017(97)	9.5% (6.% - 13.9)	1225(14)	1.1% (0.5 - 2.4)
6. Meru North	880(71)	8.1% (4.9 - 12.7)	1,131(11)	1.0% (0.4 - 2.3)
7. Baringo	1,180 (75)	6.4% (3.9 - 9.9)	1,432(83)	5.8% (4.2 - 7.8)

Turkana was the among suspected hyper-endemic districts in Kenya which had not been prior to this study. A blindness prevalence survey conducted by Loewenthal and Peer in 1989 revealed that the prevalence of blindness was 1.1%(171). The major causes of blindness were: corneal disease (xerophthalmia and trachoma) in people aged up to age 35 years and cataract in people >45 years, while trauma was the major cause of blindness in one eye. The prevalence of trachoma and its complications (defined as any sign of active or blinding trachoma in at least one eye) in the whole population was 42.8%. This survey was conducted before the WHO simplified trachoma grading was adopted; hence direct comparison with this study was not possible. The district has not yet started implementing the SAFE strategy.

A rapid assessment of blinding and vision impairing conditions was also conducted in the Kakuma refugee camp and neighbouring Turkana communities in 2005 by the International Rescue Committee. The percentage of children 1-9 years old with active trachoma (TF) was 14% and 1% of the total population had TT. This was an indication that trachoma was endemic in the Kakuma refugee camp and its host community.

2.3.2.2 Prevalence of infection

Kenya is one of the trachoma endemic countries where laboratory tests to determine the prevalence of Chlamydial trachomatis infection have not been done because the tests are expensive. However, this has not hindered the implementation of the SAFE strategy in the country since the WHO prevalence thresholds for starting/stopping mass treatment and the ultimate intervention goals are all based on clinical diagnosis (prevalence of disease). Laboratory tests are also not a requirement for donation of azithromycin.

In 1987, a small scale sero-epidemiological study was conducted in Meru district in Kenya to determine prevalence of Chlamydia-trachomatis infection(48). Two hundred and twenty one children aged between 3 weeks and 15 years were examined. Ninety one children (41%) had TF while 130(59%) had papillary hypertrophy without visible follicle and they were labelled as having mucopurulent conjunctivitis. Chlamydia trachomatis was isolated from 31(34%) children with TF and 17(13%) children with conjunctivitis ($p < 0.001$). Twenty-two Chlamydia trachomatis strains were immuno-typed: 17 were from children with trachoma (nine type A, one A/L2, five B, one Ba, and one E). Five were from children with conjunctivitis (two A, one Ba, one D, and one F).

2.3.2.3 Personal hygiene and environmental sanitation

Between November 2005 and January 2006, the government in collaboration with the United Nations Children's Fund conducted a water and sanitation survey in Turkana (*Table 3.2*). The survey teams visited 644 water sources, 488 rural water supply and sanitation service level points, 225 schools and 66 health facilities. In 2010, another survey was conducted in the then 5 divisions of Turkana Central (*Table 2.4*). Both surveys revealed that Turkana is a water scarce district with low pit latrine coverage.

Table 2.4: Turkana district water and sanitation survey findings (Ministry of Health report)

Turkana: 2006 water and sanitation survey	**Percentage**
Households with scarce (<10 litres/day) water for domestic use	59
Household with risky drinking water sources (open source/no treatment)	19
Households walking >1 kilometre (30 minutes one way trip) to water source	32
Households with water connected inside the house	2
Households buying water for >50 shillings/20 litre container*	41
Households without latrines (practice open defecation)	46
Health facilities with latrines	48
Learning institutions with latrines	37
Public places without latrines (use bush/open defecation)	53
Turkana: 2010 households with pit latrines	**Percentage**
Central division	35
Kalokol division	29
Turkwel division	19
Kerio division	4
Loima division	2

**Exchange rate: US$ = 76 shillings in 2006.*

In Narok, a Knowledge, Attitude and Practice survey was conducted in 2009. The key findings are summarized in *Table 2.5*. A total of 264 respondents from 88 homesteads were interviewed. The results indicated that trachoma risk factors were prevalent in the district.

Table 2.5: Findings of the 2009 Narok Knowledge, Attitude and Practice survey (project report)

Indicators	**Percentage/ amount***
1. Most of the times, it is women who fetch water	95.4%
2. Mean volume of water fetched per household per day	57 litres
3. Mean time taken to fetch water (round trip)	2 hours
4. First priority for water is drinking and cooking	94.7%
5. Those who said that bathing/face washing would NOT be the first priority even if they were given boreholes (i.e. if they had plenty of water)	93.5%
6. Households sharing water with domestic animals	61.1%
7. Households with children with dirty faces (observation)	64.7%
8. Households without pit latrines	28.4%
9. Pit latrines which were not being used	46.7%
10. Mothers who did not dispose their children's faeces safely	78.2%
11. Households keeping animals in the compounds and inside the houses	36.1%

** A total of 264 respondents from 88 homesteads were interviewed*

2.3.2.4 Implementation of the SAFE strategy in Kenya

In 2002, the African Medical and Research Foundation, Sightsavers and the University of Nairobi conducted a small scale trachoma prevalence survey in Shompole location of Magadi Division, Kajiado District in the Rift Valley Province to verify whether trachoma was still endemic in the area. The survey revealed a TF prevalence of 46.4% in children <10 years old and 7% prevalence of TT in people ≥15 years old. The government, African Medical and Research Foundation and Sightsavers partners sponsored a pilot trachoma control project in the surveyed area, with plans to upgrade the project to cover the entire district. A fresh review of the trachoma status in Kenya became a priority for both the government and non-governmental organisations. A broad consortium was formed to embark on surveying all the suspected trachoma-endemic districts in the country and implementing the SAFE strategy.

The pilot project was evaluated in 2006 after implementing SAFE strategy for three year. The antibiotics which were used for mass treatment were: tetracycline eye ointment distributed for one year, followed by oral azithromycin for two years. The prevalence of TF in children 1-9 years decreased from 46.4% to 16.0% and that of TT in adults ≥15 years from 4.5% to 1.7%. This provided evidence that implementation of the SAFE strategy was effective in controlling blinding trachoma and justified the roll-out of the project(30). This was followed by the launch of a National Trachoma Control Programme in 2007.

In Kenya, the Ministry of Public Health and Sanitation is rolling-out a National Community Health strategy. This will create community health units of about 1,000 households (about 5,000 people) each throughout the entire country. One community health worker will take care of 20 households (100 people) and one community health extension workers will supervise 50 community health workers (5,000 people). The National Trachoma Control Programme will utilise this opportunity to facilitate the integration of the SAFE strategy into the mainstream activities of the Ministry. The integration of trachoma control with other Neglected Tropical Diseases is ongoing.

2.3.2.5 Priorities and challenges of trachoma control in Kenya

The Kenya National Plan for the Elimination Trachoma was launched by the minister for Public Health and Sanitation at the 2009 national trachoma summit. During the summit, the achievements made, lessons learnt and challenges encountered were discussed and recommendations made, including the following key issues:

1. Baseline trachoma surveys in all suspected endemic areas in Kenya should be finalised. It was further noted that re-infection could be a big problem if the SAFE strategy is not implemented in all the endemic areas, since the communities are nomadic.

2. Mass antibiotic treatment was reported to be more expensive and resource intensive than previously assumed. Therefore, there is need to development cost-effective methods of administering the treatment.

3. Surgical coverage and uptake of TT surgical services in Kenya is too low and should be improved. Operational research is needed to investigate the barriers to uptake of services.

4. More networks and collaborations are required for the “FE” components of the SAFE strategy since they are crucial, yet under-funded.

5. Appropriate operational research is an essential component which is required to be incorporated into the Kenya National Trachoma control plan.

2.3.3 Justification of this study

This section describes the standard trachoma prevalence surveys conducted in large administrative districts in Kenya prior to this study which failed to indentify the endemic areas. As a result, some endemic areas in hypo-endemic districts were left untreated and non-endemic areas in endemic districts included in mass treatment.

2.3.3.1 Challenge of surveying large hypo-endemic districts in Kenya

The prevalence of trachoma in the 3 hypo-endemic administrative districts (Laikipia, Meru North and Baringo) which did not qualify for district-wide mass antibiotic treatment is in *Table 2.3.* All had some endemic areas ("hot-spots") which were masked by the extremely low prevalence in the non-endemic areas. In such districts, surveys with larger samples than a standard survey were needed to identify the "hot spots". Left untreated, these "hot spots" may re-infect the treated areas in neighbouring districts since there are perennial nomadic migrations across the districts.

The data for the clusters surveyed in Baringo and Laikipia districts are provided below to demonstrate the "hot spots".

Baringo district survey

Baringo was among the districts included in the national blindness survey conducted in Kenya in 1980s by Whitefield et al(13, 26) before simplified trachoma grading scheme(65) and the SAFE strategy were adopted(16). It was reported that trachoma was absent in the highland areas but endemic among the Pokot. This is a nomadic pastoral community living in the dry north-eastern parts of Baringo.

The baseline trachoma prevalence survey was conducted in Baringo district(25). At the time, the district had 264,978 people. The district did not qualify for mass antibiotic treatment because the prevalence of TF was <10%. The East Pokot division covers the dry trachoma-endemic parts in Baringo district inhabited by the nomadic Pokot communities(13, 26). The rest of the Pokot community live in the neighbouring West Pokot administrative district. West Pokot district was also surveyed in 2004 and qualified for mass treatment (*Table 2.3*). The communities in West and East Pokot have similar lifestyles and there are nomadic migrations among the two areas. Therefore, treating West Pokot and leaving out East Pokot would increase the risk of re-infection of the communities in the treated areas.

Table 2.6 shows the distribution of TF in Baringo district in 2004. Twenty sub-locations were surveyed. The survey results indicated that TF was mainly found in East Pokot division. An application for donation of azithromycin to treat the division was rejected on the basis that the five clusters surveyed in the division were few.

In 2010, Baringo district became a County and East Pokot a new administrative district with 133,189 people. In May 2011, the Fred Hollows Foundation sponsored a repeat survey in East Pokot district. The prevalence of TF in children 1-9 years old was 34.3% and mass

antibiotic treatment was commenced. This was eight years after the initial survey. The prevalence of TT in people ≥40 years old was 19.0%, the highest ever recorded in Kenya. The high prevalence of TF is an indication that East Pokot needed mass antibiotic treatment in 2004 but the need was masked by the low prevalence in the rest of Baringo district.

Table 2.6: Distribution of TF in Baringo district in 2004 (survey report)

Sub-locations		**Children 1-9 years old**		
		Total examined*	With TF	Prevalence of TF
East Pokot division				
1)	Chepkrerat	60	20	33.3%
2)	Tilingwo	43	13	30.2%
3)	Seretion	36	8	22.2%
4)	Korossi	46	9	19.6%
5)	Nginyang East	143	17	11.9%
The rest of Baringo				
6)	Kinyach	35	3	8.6%
7)	Logumgum	37	2	5.4%
8)	Ngambo	115	2	1.7%
9)	Keturwo	91	1	1.1%
10)	Kaptombes	19	0	0.0%
11)	Kapsoo	68	0	0.0%
12)	Kamogul	91	0	0.0%
13)	Tirimionin	77	0	0.0%
14)	Kaptumo	68	0	0.0%
15)	Lelmen	59	0	0.0%
16)	Kibongor	21	0	0.0%
17)	Bartolimo	81	0	0.0%
18)	Katumoi	17	0	0.0%
19)	Kesetan	35	0	0.0%
20)	Kisonet	37	0	0.0%
Baringo district		1,179	75	6.4% (95% CI: 3.9% - 9.9%)

**The sample size was proportional to the population size of the sub-locations*

Trachoma surveys in Lakipia district

Laikipia district was surveyed in 2007(25). The prevalence of TF was <10% (*Table 2.7*) hence it did not qualify for mass antibiotic treatment. The survey clusters with ≥10% prevalence of TF were used to demarcate the likely trachoma-endemic area in Laikipia (*Figure 2.6*). The area is located in the north, bordering Samburu and Baringo districts.

Instead of repeating the Laikipia trachoma survey, the sponsors of the district project opted to implement the "SFE" components of the SAFE strategy. However, all health care facilities

in the district had tetracycline eye ointment to treat the individuals with active trachoma and other eye infections.

Table 2.7: Distribution of TF in Laikipia and likely need for mass treatment (2007 survey report)

Divisions and the 20 survey clusters	No. of children examined	% with TF	Likely need for mass treatment*
1. Ngarendare	20	70.0%	
2. Mumonyot	15	46.7%	**Five years**
3. Kurikuri	20	30.0%	
Mukogondo division	**55**	**49%**	
4. Olmoran	48	12.5%	**Three years**
Olmoran division	**48**	**12.5%**	
5. Pesi	37	21.6%	
6. Maundu ni meri	60	16.6%	
7. Mutara	19	10.5%	**Not needed**
8. Muruku	48	6.3%	
9. Melwa	77	0%	
Rumuruti division	**241**	**9.5%**	
10. Rugutu	18	46.7%	
11. Naibor	63	15.9%	
12. Likii	78	3.8%	**Not needed**
13.Marura	56	0%	
Central division	**215**	**4.6%**	
14. Thigio	68	8.8%	
15. Karaba	71	7.0%	**Not needed**
Ng'arua division	**139**	**7.9%**	
16. Manguo	60	5.0%	
17. Losongwa	77	7.8%	**Not needed**
18. Maina	109	0.9%	
Nyahururu Division	**246**	**4.1%**	
19. Muhonia	42	0	
20. Lamuria	31	0	**Not needed**
Lamuria division	**73**	**0.0%**	
LAIKIPIA DISTRICT	**1,017**	**9.5%**	**Not needed**

**Some divisions which did not need mass treatment had clusters which needed treatment*

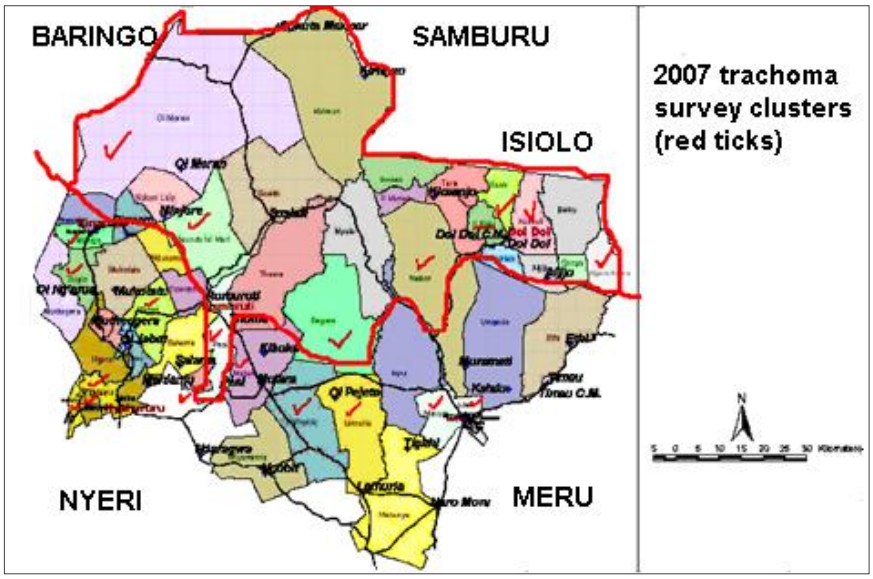


Figure 2.6: The likely trachoma-endemic areas (inside red line) in Laikipia district (2007 survey report)

An impact assessment trachoma prevalence survey was conducted in Laikipia in 2011 using the survey by administrative district method. It revealed that the prevalence of TF in children aged 1-9 years had declined from 9.5% in 2007 to 1.5% in 2011. The prevalence of TT in people aged ≥15 years 1.0%. The limitation with this study was that the sample size for TF survey was relatively small: 965 children 1-9 years old. This made it difficult to estimate the prevalence at the sub-district level. There is also the likelihood that the implementation of the "FE" components such as promotion of facial cleanliness, may have succeeded in reducing the prevalence of active trachoma.

2.3.3.2 Inclusion of non-endemic areas in mass treatment

Table 2.8 shows the data for the 20 survey clusters surveyed in Narok in 2004. Narok has two climatic zones, the northern highlands and the arid southern lowlands. The survey report showed that clusters selected in the highlands, for example Olkurto and Ilmolellian, had no TF while those in the arid lowlands were highly trachoma-endemic.

The small sample size and few survey clusters could not allow for conclusions on the prevalence of trachoma at sub-district level. Therefore, the entire population in the district was treated with antibiotic for three years.

The results of the impact assessment survey conducted during this study are presented in Chapter 4.

Table 2.8: Prevalence of active trachoma in Narok in 2004 (survey report)

Surveyed clusters (sub-location)	**Children 1-9 years with TF***
1.Olorkuto	0.0%
2. Ilmolelian	0.0%
3. Mulot	0.0%
4. Sogoo	1.1%
5. Ongata Naado	2.4%
6. Sagamian	5.5%
7. Ereteti	5.7%
8. Ololurot	5.7%
9. Olopito	17.5%
10. Lemek	24.5%
11. Aitong	34.9%
12. Oloombokishi	51.7%
13. Siyapei	51.7%
14. Ilaiser	64.3%
15. Siana	64.7%
16. Osarara	75.0%
17. Olorouwa	80.0%
18. Morija Loita	82.9%
19. Nkuta	83.0%
20. Nikipon	89.7%
Narok district	**30.5% (95%CI: 25.6%-35.8%)**

**The survey report did not indicate the number of people examined and the raw data were not available*

2.4 Conclusion

This literature review provides evidence that trachoma is an important cause of avoidable blindness in the world and the disease is clustered in communities with poor hygiene. This clustering is becoming more obvious as the number of people with active trachoma decreases. The decline is attributed to ongoing interventions and secular trends. As a result, prevalence surveys conducted in large populations tend to either "water down" the high prevalence of trachoma in the marginalised endemic communities ("*trachoma nests*") or include non-endemic communities in mass treatment.

Kenya is a country where the population size of administrative districts varies widely and trachoma is clustered. Reports of previously-conducted surveys are presented to illustrate how some endemic areas ("trachoma *nests*") in large hypo-endemic districts (>200,000 people) were missed and non-endemic areas included in mass antibiotic treatment. The untreated "trachoma *nests*" can re-infect the treated areas and lead to loss of the resources

invested in trachoma control. Also, treatment of non-endemic communities is a waste of resources and it may promote development of antimicrobial resistance to macrolides.

Treatment of healthy individuals during mass treatment cannot be completely avoided unless laboratory tests are done prior to antibiotic treatment. However, it can be minimised by conducting high resolution surveys to identify the specific communities that require mass treatment. Clinical grading may increase the possibility of treating individuals who are not infected because the clinical signs take time to resolve and there are other eye conditions with clinical signs similar to those found in trachoma. This may lead to either under-estimation or over-estimation of the prevalence of infection. The prohibitive cost of laboratory testing in surveys and complex logistics are the main reasons why they are not routinely done.

TT is the potentially blinding stage of trachoma hence everybody with it should receive immediate lid surgery to avert visual loss. The global backlog of TT is increasing despite the decrease in the number of people with active trachoma. This is mainly due to inadequate TT surgical services, poor uptake of the existing services and high TT recurrence rates. The study conducted in China indicates that in areas where active trachoma has been eliminated, TT occurs in people >40 years old. So far, no study has reported aging of people with TT in trachoma endemic areas. However, this is likely to happen in future in areas with ongoing mass treatment for active trachoma. As a result, standard lower age limit for TT surveys should be reviewed regularly in line with the changing trend and to improve the efficiency of trachoma surveys.

Both trachoma prevalence surveys and rapid assessment methods are used in trachoma control. However, prevalence surveys are mandatory before new projects are funded or old ones extended. Poor nations rely on donation of azithromycin for mass treatment, which cannot be approved without accurate prevalence survey reports.

Some key issues emerged from the review of the existing trachoma survey guidelines which needed to be addressed to improve the effectiveness and efficiency of the surveys. They include:

1. Where to conduct a trachoma survey: due to the clustering tendency of trachoma and variation of the population size of administrative districts, there is need for a clear definition of the reference population for trachoma prevalence surveys.

2. Cost of a survey and administration of mass antibiotic treatment: though not used as a parameter to determine the sample size, the cost of a survey is always taken into consideration when computing the sample size. In trachoma control, the cost of mass treatment should also be considered as well since a reduction in the resolution of a survey may increase the cost of mass treatment. A survey and mass treatment are activities of the same project cycle, which cannot be considered in isolation.
3. Lower age limit for TT survey participants: the large TT survey samples needed when persons aged $\geq$15 years are recruited in surveys reduces the efficiency of both TF and TT surveys. Therefore, there is need to determine the optimum lower age limit for TT surveys participants.

CHAPTER THREE

3 Methods

This chapter describes the preparations made and the methods used to accomplish the objectives of this research project. It contains the details of how two new trachoma survey methods were developed and tested. It also describes how the risk of trachoma was assessed to inform the creation of survey segments, determination of the survey sample sizes, selection of the study participants, as well as training and standardisation of the enumerators. Additionally, examination methods and data analysis, including re-analysis of the data sets for the previous TT surveys are described. The Chapter ends with a description on how the costs of surveys and mass antibiotic treatment were estimated. The processes are summarised in the study flow diagram (Figure 3.1).

3.1 Development of the new trachoma survey methods

The review of literature indicated that the trachoma surveys conducted in large administrative districts (>200,000 people) in Kenya using the standard survey by administrative district method could not effectively identify the areas that needed mass treatment. The population size of the trachoma-endemic districts in the country varies widely from 80,000 to 1,000,000 people and trachoma is mainly found in the dry areas(13, 26). The other problem which was encountered during the surveys was the large sample size needed when participants aged ≥15 years were recruited for TT surveys. Therefore, two new trachoma survey methods were developed during this study to provide practical solutions to these problems.

The methods are the “Trachoma Survey by Segment” (TSS) to justify administration of mass antibiotic treatment and the “TT40” to improve the efficiency of trachoma surveys where both TF and TT prevalence surveys are conducted simultaneously.

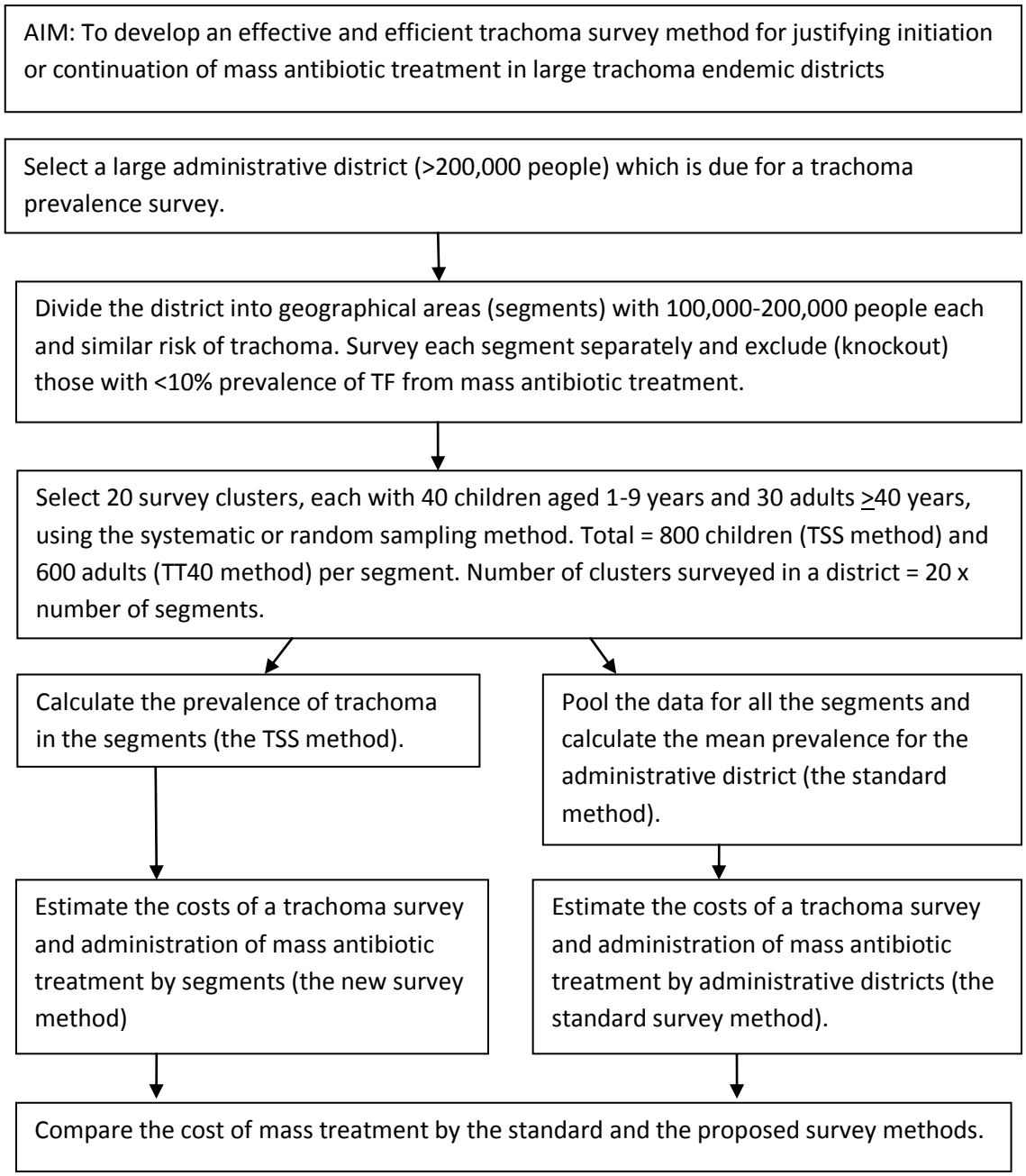


Figure 3.1: The study flow diagram

3.1.1 The Trachoma Survey by Segment method

In this study, a large district was defined as one with >200,000 people, twice the population size of a WHO recommended "*trachoma district*" of approximately 100,000 people(17). The two districts where the TSS method was tested were divided into geographical areas (segments) with 100,000 to 200,000 people each and a having similar risk of trachoma. Trachoma risk assessment was conducted to inform the creation of the segments. Neighbouring areas with similar risk scores were aggregated to form a survey segment. Each

segment was surveyed as separate "*trachoma district*". The prevalence of trachoma was determined both in the segments and the entire district. The prevalence in the entire district is the only estimate which would have been determined in a survey by the administrative district method.

The review of literature revealed alternative survey methods that can be used in large administrative districts. They include stratification in the study design to allow estimation of the prevalence at the sub-district level or to conduct a pre-survey Trachoma Rapid Assessment to identify the likely endemic areas to be surveyed. Stratification demands that fairly accurate assumptions are made about the prevalence in each stratum, and about the stratum-specific design effects, which is difficult and often virtually impossible to foretell with any confidence(14). This study was an operational research project and the new methods were to be replicated in resource scarce settings with few epidemiologists. Simplified operational research methods and interventions are key predictors of the success in the scale-up of global public health interventions(157, 158). The other advantage of segmentation over stratification was the creation of survey segments with approximately equal population sizes, which later served as standardised intervention units for trachoma control.

The main difference between a Trachoma Rapid Assessment and the TSS method is that in a TSS all the segments created in a district are surveyed, while in a rapid assessment the samples are selected in the suspected endemic areas only. As a result, a rapid assessment does not provide the prevalence estimates(11, 36, 66, 162-165) needed for donation of the antibiotics for mass treatment. Also surveying the same area twice (rapid assessment followed by a prevalence survey) may delay the treatment and increase the cost of surveys.

The Acceptance Sampling Trachoma Rapid Assessment is also a rapid assessment method used in trachoma control(164, 165, 168). This method does not have a fixed sample size and sampling may stop once the number of "defects" or cases allowed has been exceeded. It was initially proposed that similar "stopping rules" could be built-into the TSS method to further improve its efficiency. The "stopping rules" were based on the fact that trachoma usually clusters in the poorest communities(2) and it was argued that if active disease was not found among "the communities living in the worst places", meaning the areas with the highest risk scores, then there was no need to look for it in "the best places"(66). The rules were as follows:

1. Conduct a trachoma risk assessment and begin the survey in the areas with the highest risk scores (worst clusters) in a segment. Tally the number of children examined and TF cases diagnosed on daily bases.

2. After achieving 25% of the sample (1/4 of the clusters in the segment) check the tally. If the prevalence of TF in the children examined so far is <10%, stop the survey in that particular segment and if ≥10% continue.

3. After achieving 50% of the sample (1/2 of the clusters) check the tally again and if the prevalence is <10% stop the survey in that segment. If ≥10% complete the survey.

4. After achieving the full sample, check the final tally. If the prevalence is ≥10% the segment will require mass antibiotic treatment(17). If <10%, the segment should be "knocked-out" of mass treatment.

These "stopping rules" were rejected by the Kenya National Trachoma Task Force on the basis that they could increase the cost of logistics and the local communities were aware of the collateral benefits of a trachoma control project such as: provision of water for both livestock and humans and improvement of the health and eye care services. It was feared that a political backlash could be triggered by the exclusion of a community from treatment before completion of a survey. The other concern about the rules was that the prevalence of trachoma could only be estimated in the areas where the surveys were completed. The prevalence estimate for the entire administrative district was needed for comparison of the new and the standard methods.

The data for this study were analysed to verify if the rules could have influenced the outcomes and conclusions of the study. To do this, the prevalence of TF in the "worst 5 and 10 clusters" (1/4 and 1/2 of the survey clusters) in a segment was calculated. A prevalence of <10% indicated that the survey could have been stopped in that particular segment.

3.1.1.1 Pre-survey trachoma risk assessment

Key informant interviews were conducted to collate the information on the likely distribution of trachoma in different areas in the two districts. The risk was assessed by administrative division, which is the immediate sub-district level. The risk assessment data collection form in *Appendix 1* was developed and used in this study. The key informants were eye care workers, public health officers and members of the district health

management teams. The two districts had reports for previously-conducted blindness and trachoma surveys which were reviewed as part of the risk assessment. The informants assigned the risk scores for each administrative division according to their perception on the likelihood of finding trachoma in the areas.

The review of literature provided information on the trachoma risk factors to be used as parameters for risk assessment in this study. Five of the known trachoma risk factors were included in the risk assessment form and used as parameters for risk assessment. The five parameters had equal weighting and the scores for a single parameter ranged between 1 point (low risk) and 4 points (high risk). The scores for the five parameters were summed to derive the total scores which were graded as follows: 5 - 10 points = low, 11 - 15 = medium and 16 - 20 = high risk.

The first risk assessment parameter was evidence of trachoma and the risk scores were assigned as follows: the area borders a known trachoma-endemic district (1 point), TT cases reported in the area (2 points), rapid assessment report available (3 points) and trachoma prevalence survey report indicating trachoma was endemic (4 points).

The second parameter was main socioeconomic activity of the community: majority are settled urban communities (1 point), majority are settled famers (2 points), both nomadic herders and settled farmers (3 points) and majority are nomadic herders (4 points)

The third was availability of water: piped water in most of the houses (1 point), area has constant water supply from rivers/dams/boreholes (2 points), dry less than six months in a year (3 points) and dry most of the year (4 points)

The fourth parameter was the average duration of time most of the households took to fetch water (one round trip to and from the water source): piped water in every house (1 point), less than one hour (2 points), one to two hours (3 points) and more than two hours (4 points).

The fifth was poverty level where the specified community was compared with the other communities living in the same district and the scores were: whole community is rich (1 point), majority rich with few poor communities (2 points), majority poor (3 points), very poor and on famine relief supply (4 points).

3.1.1.2 Creation of the survey segments

The aggregation of neighbouring administrative units with similar total risk scores into segments was done, starting with the administrative divisions. If a segment ended with excess or fewer survey clusters, the smaller administrative units (locations and sub-locations) of neighbouring segments were re-allocated to ensure that all the segments had the required number of survey clusters. The clusters were distributed proportional to the population size of the segments since the systematic sampling method used to select the clusters is self weighting(9, 16). This means that areas with equal number of clusters also had approximately equal population.

The aggregation of areas with similar risk scores in the same segment was intended to:

1. Reduce the sampling errors by maximizing the difference in the risk of trachoma among the segments and minimizing the difference within a segment(14).
2. Allow ranking of the different areas in the administrative district by the prevalence of TF (active trachoma),
3. Simplify the decision making about the areas (segments) that needed mass antibiotic treatment and those to be excluded from treatment.

After the survey, the correlation between the total risk scores and the prevalence of TF was assessed to establish the accuracy in prediction of trachoma risk by the key informants.

3.1.1.3 Estimation of the sample size for TF surveys

A sample size is the approximate minimum number of persons that should be selected and examined in a study(14). In this study, the prevalence of trachoma was to be determined for both the segments and the administrative district, to allow for comparison between the TSS and standard trachoma surveys by administrative district methods. The objective of a survey by the TSS method is to identify the segments that need mass antibiotic treatment, while a standard trachoma prevalence survey is to determine the prevalence of the trachoma at the district level. Consequently, the 10% prevalence of TF threshold for administration of mass treatment(8, 17) was used to compute the samples for the TSS method. For the survey by administrative district method the prevalence was estimated from previous studies, as recommended(9, 10).

The sample size calculation formula recommended by the WHO guide (*Equation 1*) was used to estimate all the samples in this study(10).

Equation 1: Sample size calculation formula

$$\text{Minimum sample size} = e\frac{d^2 b(1-b)}{c^2}$$

Where: b= expected prevalence; c = desired precision of the estimate; d = 95% confidence level (z score 1.96) and e= expected design effect.

The confidence level for the prevalence estimates was 95%, which is the standard used in surveys(9, 15, 16). However, a relative precision of 30% was adopted because a higher precision would have resulted in large sample which could not be achieved with the available resources. The Ideal precision for surveys is 20% but >50% is considered too low for accurate statistical inference(14). In surveys to certify elimination of trachoma (prevalence of TF <5%), precision of 50% is used(8). Therefore, the precision used in this study was adequate for accurate statistical inference.

With this confidence level and precision, the expected confidence interval for a TSS was 10%:7%-13% and the probability that the true prevalence in the population was contained in this interval was 95%. The 13% upper limit of the confidence interval was calculated as follows: 10% plus 30% of 10% = 13% and the lower limit 10% minus 30% of 10% = 7%. All the confidence intervals were adjusted for potential clustering using the generalized estimating equations modelling(161). The computation was done using the function Predictive Analytics SoftWare version 18.0.

The probability of including a segment with <10% prevalence in treatment cannot be completely avoided, unless the whole population is examined to get the true prevalence, which is the only estimate without confidence intervals. In this study, the probability that the true prevalence was not contained in the stated confidence interval was 5%, a 2.5% probability of it being lower than the 7% lower limit and 2.5% for it being higher than the 13% upper limit(15). This implies that there was a likelihood of a segment with <10% to 7% prevalence of TF being included in mass treatment and a further 2.5% probability of including a segment with prevalence <7%. The chance of the true prevalence being higher than the upper limit of the confidence interval was not an issue because all the segments with prevalence $\geq$10% were to be included in the treatment.

It is not possible to predict the exact design effect before a survey hence one is expected to estimate it using experiences from similar epidemiological studies(14). Small survey clusters attract low a design effect and large clusters a high design effect. In this study a design effect

of 2.0 was used for the survey TSS method because I preferred to select many small clusters (40 children each) instead of few large clusters. The many small clusters improved the geographical distribution of the clusters in the study area and the effectiveness of the survey to identify the endemic areas. In trachoma prevalence surveys with 100-300 subjects per cluster a design effect 4.0 is recommended and for clusters with >300 subjects a design effect of 6.0 is used(9, 10, 16). A National Survey on Blindness, Low Vision and Trachoma conducted in Ethiopia in 2005-06 had clusters with 144 individuals each and a design effect of 2.0(160).

Using the above parameters, a minimum sample size of 768 children aged 1-9 years old per segment was calculated using *Equation 1* as follows:

$$\text{Sample size for a TF survey in one survey segment} = 2.0\,\frac{1.96^2\ 0.1(1-0.1)}{0.03^2} = 768$$

In the actual survey 800 children were sampled in each segment and 800 children x 5 segments = 4,000 children per administrative district. The participation rate in the previously-conducted TF surveys in Kenya was on average >90%(25, 30-32).

The minimum sample size required to estimate the prevalence for an administrative district (the standard method) was calculated using the standard guidelines as follows(10): prevalence of TF was estimated using the findings from the previous studies, confidence level 95%, desired relative precision of 20% of the expected prevalence and design effect of 4.0. In Turkana, the prevalence of TF was estimated to be approximately 35%, similar to the neighbouring Samburu district(25). The minimum sample size for the district was 713 children.

$$\text{Sample size for a standard TF survey for Turkana district} = 4.0\,\frac{1.96^2\ 0.35(1-0.35)}{0.07^2} = 713$$

Key informant interviews indicted that the prevalence of TF in Narok district was expected to be approximately 20%. The baseline survey had established a prevalence of 30.5% and the health workers predicted that Narok South and some parts of Narok Central were still trachoma endemic. Therefore, a sample size of 1,537 children was adequate to determine the prevalence in the whole district.

$$\text{Sample size for a standard TF survey for Narok district} = 4.0\,\frac{1.96^2\ 0.20(1-0.20)}{0.04^2} = 1{,}537$$

The sampling details for the two survey methods are summarised in Table 3.1. Generally, the samples for a survey by TSS method were larger than for the administrative district method.

Table 3.1: Minimum TF survey sample sizes by survey method

Estimate	**Survey by administrative district method**		**TSS method**
	Turkana district	Narok district	Both districts*
Prevalence estimate	35%	20%	10%
Design effect	4.0	4.0	2.0
Confidence level	95%	95%	95%
Precision+	±7%	±4%	±3%
Minimum sample	713	1,537	768
Number of segments	1	1	5
Total sample	**713**	**1,537**	**3,840**

**The parameters for the survey by segment method are fixed*

3.1.2 The TT40 survey method

Researchers often trade off small survey sample sizes for lower precision in TT prevalence estimation in order to reduce the cost of surveys to estimate the prevalence of TT in persons >15 years old(10, 16). In this study the data sets for previously-surveyed standard TT surveys were re-analysed to determine an optimum minimum age of TT survey participants and the correction factors required to extrapolate the prevalence and backlog of TT for the whole population. The results of this study (Chapter 4) indicated that the age ≥40 years fulfilled the study objective and it was considered ideal for subsequent TT surveys(35). Therefore, the TT40 survey method was developed where participants aged ≥40 years were recruited for TT surveys and correction factors used to extrapolate the prevalence and backlog of TT in the whole population.

The development of the TT40 survey method was influenced by the need to ensure that TT and TF surveys were completed within the same period of time.

3.1.2.1 Estimation of the sample size for TT survey

The re-analysis of the previous survey data sets indicated that the mean prevalence of TT in people ≥40 years was 9.4%(35) hence the parameters used to estimate the sample for the TT40 method were: 10% prevalence of TT, confidence level was 95%; precision was 30% and design effect of 1.5. It was assumed that the distribution of TT in people ≥40 years old was less clustered than in people ≥15 years old because all areas in the two districts were known to have been trachoma endemic in the past(13, 26, 171) and the eye care teams reported that they were operating on TT cases from all the areas in the two districts. In Rapid

Assessment of Avoidable Blindness surveys, a design effect of 1.4 is used for cluster size of 40 subjects. RAAB manual is available at: www.iceh.org.uk/display/WEB/Rapid+assessment+ of+ avoidable+blindness+%28RAAB%29+CD).

Using the *Equation 1*, a minimum sample size was 576 people ≥40 years old per segment was computed as follows:

$$\text{Sample size for TT survey in one survey segment} = 1.5\ \frac{1.96^2\ 0.1(1-0.1)}{0.03^2} = 576$$

In the actual survey a target of 600 participants per segment was set. The total number of participants selected in an administrative district was 600 adults aged ≥40 years x 5 segments = 3,000 participants.

3.1.3 Correction factors for the prevalence and backlog of TT

The review of literature indicated that for various reasons, not all TT surveys conducted in the trachoma-endemic countries adopted the age of ≥15 years for TT survey(2, 17). In Kenya, the standard lower age limit of 15 years was used in the initial TT surveys conducted in 2004 and 2007 (25, 30-32). Three Rapid Assessment of Avoidable Blindness surveys were also conducted in Nakuru, Kericho and South Nyanza where the age of ≥50 was used(33). In this study the age of ≥40 years was used in TT40 surveys(35). This variation in the age limits of survey participants created the need to determine the correction factors (multipliers) to be used to extrapolate the prevalence and backlog of TT in the whole population, using data collected in surveys which estimate the prevalence of TT in different lower age limits.

The data sets for the six previously-conducted TT surveys were re-analysed to calculate the correction factors. First, the mean prevalence and the total number of TT cases in the different age categories were calculated. The prevalence of TT usually increases with increasing age of survey participants but the backlog of TT determined is reduced if the age of survey participants is increased. To derive the prevalence of TT correction factor for the specified lower age limit, the prevalence of TT in a specified limit was divided by the prevalence in persons ≥15 years, which is the standard age for TT surveys. The number of all the TT cases aged ≥15 years was divided by the number of cases for a specified age category to derive the backlog of TF correction factor for the specified age category. The prevalence and backlog of TT correction factors for the standard lower age limit of 15 years was 1.0.

The precision of a correction factor for a specified age category was measured by subtracting lowest estimate, among the six districts whose data sets were re-analysed, from the highest estimate (range). A wide range indicated that there was a wide variation among the correction factors for individual districts. The range:correction factor ratio was then calculated by dividing the range for a specified minimum age with the mean correction factor for the same limit. A high ratio was interpreted to indicate a low precision.

3.2 Testing of the new survey methods

The proposal for this doctoral research project was submitted to the Government of Kenya requesting permission to conduct the study within the Kenya Trachoma Control Programme and permission was granted. The United Nations High Commission for Refugees gave permission for the Kakuma Refugee Camp in Turkana district to be included in the study. The research proposal was approved by the Royal Victorian Eye and Ear Hospital Human Research and Ethics Committee and the Kenya Medical Research Institute Ethics Review Committee.

After the approval, the Kenya National Trachoma Task Force helped to raise the US$72,527 needed for the two surveys and provided all the documents to be reviewed.

3.2.1 Selection of the study areas

Most trachoma-endemic districts in Kenya have clustered trachoma but there are a few hyper-endemic districts. Therefore, the selection criteria for the area to test the new methods included one large hyper-endemic district and one large district with clustered trachoma. The district with clustered trachoma could be either meso-endemic district with some hypo-endemic areas or hypo-endemic district with some endemic areas. The Government of Kenya provided the list of the administrative districts which were due for trachoma prevalence surveys in 2010.

The first selection was Turkana (*Figure 1:1 page 3*); an arid district located 900 kilometres north of Nairobi in the north-west corner of Kenya (*Figure 1.1, page 3*), bordering South Sudan, Uganda and Ethiopia. Turkana is the largest administrative district in Kenya covering an area 77, 000 square kilometres. It has a population of 533,837 people, whose distribution by administrative units is in Appendix 2. Temperatures in the district range between 24^0 centigrade and 38^o centigrade, with a mean of 30^o centigrade. The rainfall pattern and distribution are erratic and unreliable.

A prevalence of blindness survey conducted in Turkana district in 1989(171) revealed that the district was hyper-endemic. More resent health reports indicated that the trachoma situation had not changed. In 2005, the International Rescue Committee conducted a rapid assessment of blinding and vision impairing conditions in the Kakuma Refugee camp and surrounding Turkana communities which confirmed that trachoma was endemic. Therefore, Turkana fulfilled the criteria of a large suspected hyper-endemic administrative district. A trachoma prevalence survey by the TSS and the TT40 methods was conducted in February and March 2010 to justify initiation of mass treatment and TT surgical services.

The second selection was Narok, a semi-arid administrative district with 576,833 people (*Figure 1:1 page 3*), located 145 kilometres to the north-west of the Nairobi on the Kenya-Tanzania border and occupies an area of over 15,098 square kilometres. The distribution of Narok population by administrative units is in Appendix 2. The district consists of northern densely populated highlands and southern sparsely populated arid lowland. Prior to this study the entire Narok district had received three rounds of mass antibiotic treatment for active trachoma in line with existing WHO guidelines(17).

The baseline survey to justify initiation of mass treatment was conducted in Narok in 2004 using the survey by administrative district method and the prevalence of TF in the entire district was 30.5% (95%CI: 25.6%-35.8%). Mass treatment was commenced in 2008 and the third round was administered in early 2010. The WHO guideline that districts with >30% prevalence of TF should be treated for 5 years(8) had not been published when the decision to re-survey the district after three rounds of mass treatment was made. Narok fulfilled the criteria of a large suspected meso-endemic administrative district with clustered trachoma since it was suspected that communities in the highlands were hypo-endemic and those in the lowlands were endemic. Consequently, a survey by the TSS and the TT40 methods to justify continuation of mass antibiotic treatment and TT surgical services was conducted in November and December 2010.

3.2.2 Planning and logistics

Once the funds for a survey were available, the Ministry of Public Health and Sanitation issued release letters for the recruited staff, informed the district administration about the surveys and formally introduced the research team to the district administration. The District Commissioners (DC) informed their Divisional Officers (DOs), chiefs and sub-chiefs about the surveys. At the time of this study, the Republic of Kenya was divided into the following

administrative units: provinces, districts, divisions, locations, sub-locations and villages. During this study, the country was headed by a President, provinces by Provincial Commissioners (PCs), districts by District Commissioners (DCs), divisions by Division Officers (DOs), locations by Chiefs, sub-locations by Sub-Chiefs and villages by village elders. The district was the implementation level for all Government policies. The province was the supervisory level.

When preparing the survey time tables and route maps, predictable events which could disrupt the surveys were avoided. These include: rainy seasons, large nomadic migrations out of the districts, political campaigns and other events which required community participation. Turkana district was surveyed after a short spell of rain and there was some pasture for the livestock. This made the communities stay within the district. There was a security alert along the northern border with South Sudan and Ethiopia. The Turkana communities had moved further into Kenya about 10 kilometres away from the international border. These factors made it easier for the survey teams to reach the communities. The Narok survey was conducted three months after the completion of mass antibiotic distribution. The team that conducted the treatment confirmed that most of the local communities were within reach.

I trained one local ophthalmologist (Dr. Hilary Rono) with experience in Trachoma Control on the new trachoma methods and he was my technical assistant during the field work. This was important because there were four data collection teams thus two supervisors were required. Additionally, data entry commenced on the third day of data collection.

3.2.3 Recruitment and allocation of duties

The Trachoma Task Force appointed a survey logistics team to assist me with the logistics for the two surveys. The team members were: Mr. Ernest Barasa the head of the National Trachoma Control Programme at the Division of Ophthalmic Services (DOS), Dr. Hillary Rono the Zonal Eye Surgeon for North Rift Valley, Dr. Mukiri Mukuria the Zonal Eye Surgeon for Narok, Mr. Samson Lokele the District Ophthalmic Clinical Officers for Turkana and Mr. John Sironka the District Ophthalmic Clinical Officers for Narok. The clinical officers were the logistics managers for their respective districts. The initial two to three planning meetings were convened at the DOS and thereafter we relocated to the district. The following people assisted me to collate the data for costs of mass antibiotic treatment from project reports: Mr. Francis Dikir of African Medical and Research Foundation (trachoma project manager for Kajiado and Samburu districts), Mr. Ernest Barasa, Mr. John Sironka and Dr. Mukiri Mukuria.

The survey logistics team met with the District Health Management Teams and the district administration to plan for the surveys. The discussion guide for the introductory meetings had the following agenda: introductions, a briefing on trachoma and trachoma survey methods, survey time table, request for transport and logistical support, update on the security status in the district and any other business. The District Commissioners informed their Divisional Officers and chiefs to support the surveys. The chiefs participated in community mobilisation and dissemination of the survey time tables. They also provided armed security escort, in the areas with security alerts in Turkana district.

The United Nation High Commission for Refugees introduced the survey team to the staff of the International Rescue Committee, which assisted with the logistics in the camp. The International Rescue Committee is the organisation which provides health care in the Kakuma refugee camp and the immediate host communities in Kakuma Rural. The camp is not fenced; hence there is free movement of people and goods between the refugee and host communities. However, domestic animals are prohibited in the camp. *Figure 3.2* shows one of the survey meetings held in Turkana, attended by representatives of the District Health Management Team, Trachoma Task Force, non-governmental organisation partners and survey team.

Figure 3.2: A survey meeting in Turkana

Recruitment of the data collection team was done both at the National and district levels. The DOS, in consultation with the survey logistics team, recruited the five most experienced trachoma graders in the National Trachoma Control Programme to conduct the clinical examination in the two surveys. Four graders were Ophthalmic Clinical Officers while the fifth, a standby grader, was an ophthalmologist with experience in trachoma control and

survey methods, who assisted in supervising the data collection teams in Turkana. The trachoma graders were the data collection team leaders. In Narok the standby grader replaced one grader who could not report for the Narok survey since he was organizing for mass antibiotic treatment in Samburu district. The Zonal Eye Surgeon for the Narok County assisted in supervision of Narok survey.

The rest of the field team members were recruited by the District Health Management Teams in consultation with the logistics team. They included: four nurses to assist the trachoma graders in recording the clinical findings, two Health Information Officers to enter the data and enough Public Health Officers /Technicians to coordinate community mobilisation and assess sanitation in the surveyed households. The Public Health Officers were supported by the chiefs, community leaders and local Community Based Organisations.

Each survey had four data collection teams supervised by two Ophthalmologists and supported by a logistics team. A data collection team comprised of: a team leader/trachoma grader, an assistant grader, a Public Health Officer to assess the sanitation in the surveyed household, a driver with a four-wheel vehicle and a local guide. The data for environmental sanitation were not for this study. They were collected using separate data collection forms and submitted to the district team, to be used for planning the “F and E” components of the SAFE strategy.

Government ministries and non-governmental organisations with projects in the two districts provided adequate vehicles and motorcycles for community mobilisation, data collection and logistical support. The money for fuel and allowances was included in the survey budget. Community Based Organisations provided communication facilities in parts of Turkana district which had no telephone network. The Catholic Diocese of Turkana disseminated the survey messages through their private radio broadcasting station free of charge. The Africa Medical and Research Foundation had an established community-based project in Turkana North. They mobilized the communities in their project area. Narok district has an established trachoma control project funded by Operation Eyesight Universal, which boosted this study.

3.2.4 Advance visit to the community

Two weeks prior to the survey, the logistics team visited all the sub-locations where the survey clusters were to be selected. With the help of the chiefs and Public Health Officers, they appointed local guides and made arrangements for the accommodation of the survey

teams. They then prepared detailed survey time tables and route maps, based on the sampling frame (*Appendices 1-2*). The sampling frame had the population estimates of the district, divisions and sub-locations as listed in the 2009 census plus the cumulative populations. It also indicated the sub-locations where the clusters were to be selected and the cluster codes. The logistics team arranged for the places where the data collection teams were to meet the chiefs and guides on the days of the survey. A survey telephone directory was then compiled with telephone contacts of the chiefs, guides, security personnel, accommodation providers and survey teams.

The chiefs also prepared the list of all the villages in the sub-locations to be surveyed. Those lists were used by the trachoma graders as sampling frames for the selection of the villages to be surveyed.

The activities and the responsible persons for the two surveys are summarised in *Table 3.2*.

Table 3.2: Activities and the responsible persons for the Turkana and Narok surveys

Activity	**Where undertaken**	**Responsible person**
1. Development of survey methods and application for ethical approval 2. Preparation of the data collection tools and survey budgets 3. Determination of the sample sizes 4. Construction of the sampling frames 5. Sampling and coding of the survey clusters	Centre for Eye Research Australia	PhD student
6. Raising funds for the surveys	Kenya	Trachoma Task Force
7. Training one local ophthalmologist (assistant) on the new survey methods	Division of Ophthalmic Services	PhD student
8. Preparation for field work 9. Recruitment of trachoma graders 10. Organising training workshop	Division of Ophthalmic Services	PhD student assisted by the Head of DOS and logistics team
11. Training and validation of the trachoma graders	District	PhD student, assisted by the local ophthalmologist
12. Training data entry clerks	District	PhD student
13. Identification of survey clusters	District/community	PhD student assisted by the district team
14. Community mobilisation, preparation of survey time-tables, route maps and directories	District/community	District team supervised by the PhD student.
15. Selection of the households and conducting clinical examinations	Community	Four trachoma graders
16. Supervision of the enumerators 17. Inspection of completed data forms	Community	PhD student, assisted by local ophthalmologist
18. Supervision of data entry	District	PhD student
19. Data management	Centre for Eye Research Australia	PhD student/Statistician
20. Writing survey report	Centre for Eye Research Australia	PhD student
21. Briefing the sponsors	Division of Ophthalmic Services/District	PhD student, assisted by local ophthalmologist

3.2.5 Sampling plan

The 2009 National Census was used to construct detailed sampling frames for the Narok and Turkana surveys (*Appendix 2-3*). However, the 2009 population estimates used in the Turkana sampling frame were projected from the 1999 census by the district statistics office

after the 2009 census report for Turkana was nullified by the Government of Kenya due to a large influx of refugees from the neighbouring Southern Sudan and Somalia. However, the administrative units in the 2009 census reports for both districts were used in this study. Each sampling frame indicated the population of the district, divisions and the sub-locations as listed in the 2009 census plus the cumulative population. The survey clusters were selected at the sub-locations which are the smallest administrative units listed in the census report.

One hundred survey clusters were selected in each administrative district using the systematic sampling method. This is the preferred method for trachoma surveys(9, 10, 16) because it is self-weighting, hence survey clusters are distributed proportional to the population size of the areas the clusters covered. The total population in a district was divided by the total number of survey clusters to derive the sampling interval. The sampling interval was multiplied by a random number between 0 and 1 generated from an excel spread sheet to calculate the starting point on the sampling frame (where to pick the first survey cluster). The second cluster was identified by adding the sampling interval to the cumulative population from which the first cluster was selected. The third cluster was selected by adding the sampling interval to the cumulative population for the second cluster and so on. The clusters were allocated code numbers between 001 and 100.

The population of Turkana district was 543,199 people and 100 clusters were to be selected. The sampling interval was 543,199/100 = 5,432. The random number generated from excel was 0.88 and the starting point (where cluster number 001 was selected) was in the sub-location with individual number 5432 x 0.88 = 4,780 on the cumulative column on the sampling frame. The next cluster was selected at 4,780 + 5432 = 10,212th individual and cluster number 003 at 10,212 + 4,780 = 15,644.

In Narok district the total population was 576,388 people and 100 survey clusters were selected. The sampling interval was 576,388/100 = 5,764. The random number generated from excel was 0.024 and the starting point on the sampling frame was 5,764 x 0.024 = 138. The cluster code 001 was therefore selected in the sub-location whose cumulative population included 138th individual on the cumulative population column. Cluster number 002 was located at 136 + 5,764 =5,902 and cluster number 003 at 5,902 + 5,764 = 6,040, and so on.

In each cluster, two villages were selected using a random sampling method. This was done to further increase the geographical spread of the studied population since trachoma is not evenly distributed. All the villages in a cluster were listed on small pieces of paper. The pieces of paper were folded and mixed. One of the villagers was then requested to pick two of the papers and read the names. These were the villages to be visited.

Households to be included in the survey were randomly selected. Like in previous surveys(25, 30-32), in this study a household was defined as people who regularly eat from the same pot. The survey team started at the centre of the village and identified the direction of the first household by spinning an object. After finishing with one household, they repeated the process to identify the next household. All the children and adults in the selected households who met the survey criteria were enumerated and examined until the sample size was achieved. Visitors were excluded and efforts made to trace the children and adults who were at the household at the time of the visit but were within reach.

The random walk method has been abandoned in Rapid Assessment of Avoidable Blindness surveys and the "compact segment" sampling method has been adopted (manual available at https://www.iceh.org.uk) on the grounds that it is: more complicated than the compact segment method, less objective and hence has a higher risk of bias (preferential inclusion of blind people). Trachoma is a clustered disease hence a wide geographical distribution of the survey sample is important. In this study the geographical coverage was increased by reducing the size of the survey clusters and selecting at least two villages. Many small clusters have better geographical coverage than few large clusters. In a compact segment, the areas where the cluster is to be selected is divided into several geographical areas (segments) and only one segment randomly selected for the survey.

3.2.6 Examination methods and inter-observer agreement testing

3.2.6.1 Examination methods

The trachoma graders recruited for this study did the trachoma grading for both Turkana and Narok surveys.

Examinations were conducted after the head of a household gave permission for the household to be visited. Verbal consent was then obtained from all the examined individuals and guardians for the children. Written consent was not possible since most of the participants had no formal education. Tetracycline eye ointment was dispensed to those

with eye infections. Those who required medical treatment were referred accordingly. No participant declined to be examined.

The age and gender of the study participants were recorded. The age was recorded in completed years. If a subject (or mother of a child) did not know his/her age, relatives and friends were asked to estimate it using historical events and by comparing the age of the participant with that of an age mate whose age was known. Some of the participants had documents like the national identity cards and immunization cards which were used to verify their age. Turkana district team had the events calendar which was used in the 2009 national census and they used it in this study. The Narok team could not trace their events calendar.

Clinical examinations were done at the households' compounds using x2.5 dioptres binocular loupes and torches. The clinical signs were graded using the WHO simplified trachoma grading scheme(65).

Children aged 1-9 years old were examined for signs of Trachomatous inflammation-follicular (TF), Trachomatous Inflammation-Intense (TI) and facial cleanliness (*Figures 3.3*). TF was defined as the presence of five or more follicles in the upper tarsal conjunctiva while TI was defined as pronounced inflammatory thickening of the tarsal conjunctiva that obscures more than half of the normal deep tarsal vessels(65). TF is used as the indicator for active trachoma because it is known to be a more reliable indicator than TI(8, 10, 17). Facial cleanliness is considered to be the most important risk factor for trachoma and the critical final common pathway by which the environmental risk factors affect the risk of trachoma(1, 4). A dirty face was defined as a face with eye and/or nasal discharges(81).

Figure 3.3: A trachoma grader goes down on her knees to examine a child for TF

Adults aged ≥40 years were examined for trachomatous trichiasis (TT), TT surgical scars and corneal opacities (CO) (*Figures 3.4*). TT was defined as at least one eyelash rubbing on the eyeball or evidence of removal (epilation) of one or more inturned eye lashes(16). History was taken to verify whether a scar noted on an eye lid was a TT surgical scar. CO was defined as a central corneal scar which obscured part of or the entire margin of the pupil. Visual acuity was not measured since it is not an indicator for the SAFE strategy. However, people with CO were assumed to have significant visual loss.

Figure 3.4: An elderly woman examined for TT

3.2.6.2 Training and inter-observer agreement testing

A two day training workshop was conducted: the first day in class and second day in the field. The enumerators and data entry clerks were updated on the epidemiology of trachoma, trachoma survey methods and the survey logistics. The clinical signs of trachoma were demonstrated in class using the WHO trachoma grading slides and on the persons examined during the pilot study.

The data collection tools were field tested during the pilot study and there were no amendments to the data collection form for TT survey. In the data collection form for TF survey the question on whether a child was attending school in the children's form was amended to include all children, irrespective of whether they had attained the school going age or not because in the famine stricken areas in Turkana, children of all ages were taken to school to feed from the school feeding programme. The schools were deserted when food was not available.

The enumerators were given the following reference materials and data collection forms: survey telephone directory, survey route maps, WHO trachoma grading card, data collection forms for TF and TT surveys (*Appendix 4-5*), daily tally sheet for recording the number of subjects examined and TF/TT cases diagnosed (*Appendix 6*), guidelines for the enumerators

(*Appendix 7*), checklist for the items to carry to the field (*Appendix 8*), inter-observer agreement form (*Appendix* 9) and Consent forms (*Appendix 10*).

Formal validation of the diagnostic reliability for TF is required(10). On the first day of the training workshop for this study, the guidelines for inter-observer agreement testing were presented. In Turkana survey the agreement was tested in class using WHO trachoma grading slides (photos) since the graders selected for this study were experienced had been validated in previous surveys. This is the method which was used in the previous surveys conducted in Kenya. Photographs are used to grade trachoma in surveys but there is no consensus on their use in inter-observer agreement(67-69). In Narok district the testing was conducted using children 1-9 years during the pilot study. Only the four graders were tested since they are the ones who examined the children. Each grader recorded her/his findings in their own inter-observer agreement data collection form. Examinations were done at the households using x2.5 magnification loupes.

Eropata village, Olenkulua sub-location, Osupuko Division in Narok district was indentified by the district team as a suitable area for the excercise. The village was known to be trachoma-endemic but had not been selected for the survey. A total of 50 children aged 1-9 years in consecutive households were selected for the inter-observer agreement testing. Each child was examined by all the four graders. One grader everted the upper eye lid of the child and examined, without disclosing her/his findings. Before releasing the eye lid to record her/his findings, she/he allowed the other graders to examine it, without disclosing her/his findings. The next grader everted the lid of the next child and the same process was repeated. After finishing with one household, the team moved to the next and continued with the examinations until 50 children were examined. They then handed over the data collection forms. Disposable gloves were used and the graders wiped their hands with spirit swabs to avoid cross-infection.

The data were entered in the Predictive Analytics computer SoftWare and the kappa values computed. Interpretation of the kappa values was as per the Landis and Koch classification as follows(172): <0.0 no agreement, 0.0-0.20 slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, 0.61-0.80 substantial agreement and 0.81-1.0 almost perfect agreement.

In trachoma surveys formal validation of diagnostic reliability for TT is usually not undertaken because TT is easy to diagnose(10).

3.2.7 Estimation of the cost of trachoma survey

The projects' financial reports were reviewed and the money spent on surveys was calculated. Therefore, the costs presented in this study were incremental costs and not the total cost of surveys. Both trachoma surveys and administration of mass treatment are done as part of ongoing trachoma control programmes and the term incremental cost refers to the additional funds a programme requires to undertake an additional activity. This includes the allowances to cover travel, food and accommodation for the project staff. The cost of staff salaries and capital items are not included when calculating the incremental cost.

In the 2004 survey, six administrative districts were pooled and surveyed using the same survey budget. The cost for surveying one district was derived by dividing the total amount of money spent by six districts. The cost of surveying one survey cluster was calculated by dividing the cost of surveying one district by 20, since 20 clusters were surveyed in each administrative district. For the TSS method, the cost of surveying one district was divided by 5 to get the cost of surveying one segment since each district was divided into 5 segments. The cost of surveying one survey cluster was derived by dividing the cost of surveying a segment by 20 because 20 clusters were selected in each survey segment.

3.2.8 Estimation of the cost of administering mass antibiotic treatment

The 2009 mass treatment reports for the districts which were conducting mass antibiotic treatment (Narok, Kajiado and Samburu) in Kenya were used to collate the data on treatment coverage and the incremental cost of administration of mass antibiotic treatment.

District and divisional committees were formed to plan, coordinate, and monitor the community mobilisation and administration of mass treatment. The members of the committees comprised of representatives of the District Health Management Teams and trachoma control stakeholders (Government ministries, non-governmental organizations and local communities). The districts, divisions and sub-locations were the coordination, supervisory and operational levels respectively. The planning teams updated the population census data, prepared the list of facilities to be used as treatment sites and identified the organizations/individuals to be approached to support the mass treatment. The population estimates were used to quantify the amount of antibiotics required. The number of treatment sites was used to determine the number of health workers to be trained, the

number of drugs storage sites and to prepare the community distribution route maps. The stakeholders provided vehicles, personnel and treatment sites.

The detailed check list of the items which were included in the cost analysis is in *Appendix 11*. In 2009, the WHO recommendation that 5 rounds of mass antibiotic treatment should be administered in a district with >30% before a repeat survey(8) had not been published. Therefore, the costs in this thesis were based on 3 rounds of mass treatment before a repeat survey for all the districts, as previously recommended(17).

It is recommended that the number of people to be treated with antibiotics in a trachoma-endemic district be based on the endemicity of active trachoma and the ultimate intervention goal for antibiotic treatment (UIG-A) is the number of people to be treated(2). In districts where mass treatment is justified (prevalence $\geq$10%), the UIG-A is the total population in the targeted district. In hypo-endemic districts (prevalence <10%) the UIG-A is the number of active trachoma cases multiplied by a factor of 3 to include the average number of family members. Mass antibiotic treatment is considered successful if $\geq$80% of the total population is treated(10).

In Kenya the district trachoma control projects paid for transport of the donated antibiotics from government stores to the treatment sites and for administration of the antibiotics in the target communities (project cost).

The projects did not pay for the following (non-project costs):

(a) Donated azithromycin: Provided by ITI.
(b) Import duty and clearing charges: Paid by the Government of Kenya.
(c) Bulk storage: Provided by Kenya Medical Supplies Agency.
(d) Tetracycline eye ointment: this is an essential drug which is provided and distributed by the Government of Kenya free of charge. Any individual who cannot take azithromycin (children younger than six months and pregnant mothers) was given two tubes of ointment.

The number of people treated was divided by the total population to calculate the antibiotic treatment coverage. The number of people treated was divided by the number of drug distributors multiplied by the number of days the mass treatment was administered to calculate the productivity of the drug distributors (people treated per distributor per day).

The money spent during mass antibiotic treatment was divided by the number of people treated to derive the cost per person treated.

3.2.9 Data management and analysis

Data were collected for: assessment of the risk of trachoma, inter-observer agreement testing, estimation of the prevalence of trachoma, cost of administration of mass antibiotic treatment and cost of trachoma survey.

3.2.9.1 Data management

Completed data forms were delivered to the survey secretariat. The completed forms were inspected to ensure that they were properly filled. The secretariat was located at the district headquarters (Lodwar town for Turkana survey and Narok town for Narok survey).

Data entry was done by two trained clerks and supervised by the principal investigator. The data clerks attended the training workshop and joined the data collection teams for the first two days to gain experience on how the data collection forms were being filled. They were then trained on how to enter data using Predictive Analytics computer SoftWare. On the first day, they practised using the data collected during the pilot study. The following day they entered survey data using one computer and assisting each other. From the third day they were competent enough to enter data using individual computers.

The survey team leaders sent their daily tallies (number of people examined and the cases diagnosed) using mobile phone text messages. The tally sheets from some parts of Turkana district that had no telephone network coverage were picked up by the logistics team. They were delivered together with the completed data forms. The daily tallies were entered in excel spread sheets, analysed and cross-checked with the survey data set.

Every evening, the four data collection team leaders tallied the number of adults and children they had examined during the day and the number of cases (TF and TT) they had diagnosed. The tallies were transmitted to the survey secretariat via mobile phone text message. The information was entered in excel spread sheets and analyzed. The number of TF and TT cases reported using the daily tallies was compared with that from the data entered by the data clerks and were the same.

Data analysis was done at the Centre for Eye Research Australia using Predictive Analytics SoftWare version 18.0. It was supervised by a biostatistician at the Centre for Eye Research Australia and a consultant from the University of Melbourne Statistical Consulting Unit.

The prevalence estimates were calculated for each of the surveyed segments. The data for all the segments in an administrative district were pooled to create a master data set for the administrative district. The prevalence calculated using the pooled data set was the mean prevalence for the administrative district. This was the only prevalence estimate which could have been determined if the survey was conducted using the standard survey by administrative district method. The 95% Confidence Intervals for all the prevalence estimates were adjusted to account for potential clustering using the generalized estimating equations (GEE) modelling developed by Bennett et al(161). This function was available in PASW software. The desired precision for this study was 30%. A 95% Confidence Interval was therefore considered to be wide if the confidence limits were wider than the estimated prevalence $\pm$30% of the prevalence estimate, for example 10%$\pm$3%.

Endemicity of trachoma was classified according to the prevalence of TF as follows(1): non-endemic (<5%), hypo-endemic (5% to <10%), meso-endemic (10% to 20%) and hyper-endemic (>20%). However, the thresholds for mass antibiotic treatment are(8): if prevalence of TF is <10% targeted treatment needed (no mass treatment), 10%-30% mass treatment needed for 3 years and >30% mass treatment needed for 5 years. Mass treatment is followed by a repeat survey to justify continuation or stoppage. The “FE” components are implemented in all the areas under antibiotic treatment to disrupt further transmission of infection.

The backlog of people with TT was estimated by multiplying the target population by prevalence of TT.

Cross-tabulations were done and the Pearson Chi-squared test used to test the association between categorical variables. A p value of <0.05 was considered statistically significant. An Odds Ratio (OR) was calculated to assess the risk of a particular outcome if a certain factor was present. For example to assess the likelihood of a child with a dirty face having active trachoma as compared to a child with a clean face.

A scatter-plot was constructed to provide the visual display of the relation between two continuous variables. If the points on a scatter-plot were distributed from the lower left to the upper right, it was interpreted to imply that as one variable goes up the other variable tended to go up as well (positive relationship); and vice versa for a negative correlation.

The Pearson Correlation Coefficient (r) was used to test the strength of the association between the plotted variables. A correlation coefficient has values ranging between -1.00 to

+1.00 and the larger the coefficient, the stronger the correlation. A positive sign indicates that the specified correlation is positive and vice versa for a negative sign. Correlation Coefficient of 1.0 indicates a perfect correlation, 0.75-0.99 strong, 0.5-0.74 moderate, 0.25-0.49 weak and <0.25 no linear correlation.

3.2.10 Ethical statement

Ethical approval was granted by the Royal Victorian Eye and Ear Hospital Human Research and Ethics Committee in Melbourne and the Kenya Medical Research Institute Ethics Review Committee in Nairobi.

To the knowledge of the principal investigator, there were no potential conflicts of interest. The study posed no risks to the subjects. On the other hand, implementation of SAFE strategy had many direct and collateral benefits including: strengthening of health care partnerships and networking, improvement of health/eye care infrastructure, training of health and community workers, restoring of sight to those with avoidable blindness, supporting the local water projects, promotion of personal hygiene and antibiotic treatment among others. The benefits were a direct contribution to the achievement of the Millennium Development Goals in Kenya.

Community own resource persons were used to mobilize the local communities and to take community consent. They were supervised by the District Health Management Teams. Consent was also taken from the head of household before entering the household. Due to low literacy levels in the two districts, verbal consent was taken from the participants and mothers/ guardians for the children, before a clinical examination was carried out or a photograph taken. The consent forms (*Appendix 10*) were used to ensure that the messages communicated to the subjects were standardized. The survey data collection tools and the consent forms were translated into the local language to overcome communication barriers among the enumerators, local guides (interpreters) and the participants. The participants were made aware that their participation in the survey was voluntary and choosing not to participate would not disadvantage them in any way. They were informed of the benefits that a SAFE strategy project would bring to their community. Privacy was assured for the information which the participants disclosed during the survey and their health status. The names of the subjects were not included when entering the data; serial numbers were used instead.

No invasive medical procedures were undertaken. Cleanliness and hygienic disposal of used

examination gloves, alcohol soaked tissue paper/gauze was observed to avoid cross-infection. The people who needed treatment were given medication and referred accordingly.

People with TT were operated in free eye camps which were conducted soon after the surveys. The camps for Turkana district were sponsored by the Spanish Volunteer Eye Doctors and for Narok district by the Operation Eyesight Universal. The two non-governmental organisations paid the hospital charges and post-operative medications for all the patients with cataract and TT who were diagnosed during this study.

CHAPTER FOUR

4 Results

This chapter presents the results of the two trachoma prevalence surveys conducted in Kenya to test the TSS and TT40 trachoma survey methods in a hyper-endemic setting (Turkana district) and a meso-endemic setting with clustered trachoma (Narok district). Additionally, the results of the re-analysis of previously-conducted TT survey data sets are presented. The re-analysis demonstrated how the lower age limit of TT surveys participants and the correction factors to extrapolate the prevalence and backlog of TT in the whole population were calculated. Also the Chapter contains the costs of trachoma prevalence surveys and administration of mass antibiotic treatment by both the administrative district and the TSS methods.

4.1 Risk scores and survey segments

A pre-survey trachoma risk assessment was conducted to inform the division of the study areas into survey segments.

4.1.1 Risk scores and segments for Turkana district

Generally, the total risk scores for the entire Turkana district were high risk (*Table 4.1*). Evidence from health reports, an old prevalence of blindness survey conducted in Turkana(171) and a rapid assessment of visually impairing diseases conducted in the Kakuma refugee camp indicated that the entire district had trachoma. As a result, the risk scores for evidence of trachoma were high in all the assessed areas.

Turkana is an arid district and the social-economic activity for most of the communities is raring of livestock. The poverty level is high and most communities survive on famine relief. However, the Kakuma refugee camp and the areas near the Lake Turkana have higher social-

economic status and lower poverty levels than the other areas in the district. The Lake is on the eastern border of Turkana district (*Figure 4.1*).

Table 4.1: Pre-survey trachoma risk scores for Turkana district

Survey segments	**Divisions**	**Risk indicators and scores***					
		Evidence of trachoma	Socio-economic activity	Water availability	Time taken to fetch water	Poverty level	Total risk Score
Northern Turkana	Lokichogio	4	3	4	3	3	17
	Kibish	4	4	4	4	3	19
	Kaaling	4	4	4	4	4	20
	Lapur	4	4	4	4	4	20
	Lokitaung	4	4	4	4	3	19
	Kakuma Rural^	3	4	2	2	4	15
	Segment	**4**	**4**	**4**	**4**	**3**	**19**
Western Turkana	Oropoi	4	4	3	4	4	19
	Loima	4	4	3	4	4	19
	Turkwel^	4	3	4	3	3	17
	Kakuma Rural^	3	4	2	2	4	15
	Segment	**4**	**4**	**3**	**3**	**4**	**18**
Refugee camp	Kakuma camp	3	1	1	1	3	9
	Segment	**3**	**1**	**1**	**1**	**3**	**9**
Central Turkana	Central	4	1	2	2	3	12
	Kalochol	4	1	3	3	3	14
	Kerio	4	3	4	3	4	18
	Turkwel^	4	3	4	3	3	17
	Segment	**4**	**2**	**3**	**3**	**3**	**15**
Southern Turkana	Lokichar	4	4	4	4	4	20
	Katilu	4	3	4	3	3	17
	Kainuk	4	3	4	3	3	17
	Lokori	4	3	4	3	4	18
	Lomelo	4	4	4	4	4	20
	Turkwel^	4	3	4	3	3	17
	Segment	**4**	**3**	**4**	**3**	**4**	**18**
Turkana district		**4**	**3**	**4**	**3**	**4**	**19**

**The greater the total scores the greater the risk: minimum = 5 and maximum = 20 points.*
^Survey clusters for two divisions were allocated to different segments

The Refugee camp is located in the middle of Turkana district (*Figure 5.1*). It has piped water and health services provided by the United Nation High Commission for Refugees. Furthermore, the camp is in an urban setting (Kakuma town) and domestic animals are not allowed inside the camp. The United Nation High Commission for Refugees provides water

and medical services to the host community around the refugee camp (Kakuma Rural) hence Kakuma Rural was assigned low risk score, same as the refugee camp.

The areas near Lake Turkana have easy access to water, fishing and agricultural activities. Therefore, the divisions in Central Tukana which are next to the Lake (Central and Kalochol) were assigned lower risk scores than those further from the lake (Kerio and Turkwel).

The first two survey segments were created in the areas with lower risk scores (*Table 4.1 and Figure 4.1*); one segment in the Refugee camp and the second in Central Turkana, extending from the refugee camp to the shore of Lake Turkana in the east. The Western Turkana, Northern Turkana and Southern Turkana segments were then created in the remaining high risk areas.

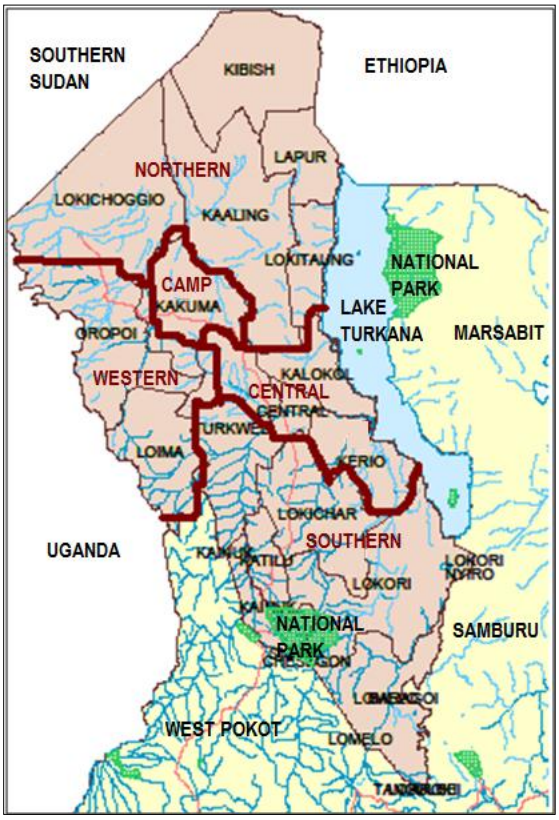


Figure 4.1: Administrative map of Turkana district showing the five survey segments

Creation of a segment started with aggregation of the immediate sub-district administrative units (divisions). The smaller administrative units (locations and sub-locations) of neighbouring segments were then re-distributed to ensure that all the segments had the required number of survey clusters. During aggregation of the divisions and re-distribution of the smaller administrative areas it was ensured that areas with similar risk scores were

included in the same segment. For example, the Turkwel division is centrally located and extends from Southern Turkana to Central Turkana. The 13 clusters in the division were distributed to the corresponding segments as follows: Central Turkana 2, Western Turkana 6 and Southern Turkana 5.

The 533,837 people in the Turkana administrative district were distributed by segments as follows: Western Turkana 127,403 people, Northern Turkana 116,324 people, Central Turkana 110,786 people, Southern Turkana 116,324 people and the refugee camp 63,000 people. The distribution of the survey clusters was as follows: Western Turkana 23, Northern Turkana 21, Southern Turkana 21, Central Turkana 20 and the refugee camp 15.

Kakuma refugee camp was the only segment with less than the anticipated 100,000 people per segment. The camp is a special settlement hence the population in the camp could not be toped-up with the host community. The 5 survey clusters selected in the host community (Kakuma Rural) were re-distributed to the neighbouring segments.

4.1.2 Risk scores and segments for Narok district

The total risk scores for the Narok administrative district were generally high (*Table 4.2*) but the northern parts of the district had lower scores than the southern areas. Evidence from health reports indicated that there were TT cases reported in all the areas in the district. The 2004 trachoma prevalence survey report indicated that the entire district was trachoma-endemic but the disease was more prevalent in the southern arid lowlands than in the northern highlands. With this evidence, the key informants assigned high risk scores for all the assessed areas. The scores were assigned for evidence of trachoma (TF and/or TT) in an area and not how high the prevalence was.

Narok district comprises of two distinct climatic zones: the northern highlands with rain most of the year and southern arid lowlands. The only area with adequate rainfall in the highlands is the Mau Forest Reserve. In the rest of the highlands areas the forest has been cleared to pave way for agricultural activities, resulting in reduction of the amount of rainfall. Majority of the people take >1 hour fetch water from streams and rivers because of hilly terrain. As a result, the risk scores assigned to some divisions in the northern like Olkorto and Mulot were high. In southern arid lowlands, the communities are poor and live a nomadic lifestyle. Furthermore, there are perennial south-north nomadic migrations which increase the risk of trachoma in the northern areas.

The entire Narok district had received 3 rounds of mass antibiotic treatment prior to this study. The third round took three and a half months, starting from Narok South and ending in Narok North. Therefore, the areas in the south were treated three months earlier than those in the north. However, the key informants could not predict the effect mass treatment had on the risk of trachoma.

Table 4.2: Pre-survey trachoma risk assessment scores for Narok district

Survey segment	**Division^**	**Parameters and risk scores**					
		Evidence of trachoma	Socio-economic activity	Water availability	Time taken to fetch water	Poverty level	Total score*
North Western	Olkurto	4	3	3	3	1	14
	Mulot	4	3	3	3	3	16
	Segment	**4**	**3**	**3**	**3**	**1**	**14**
North Eastern	Olkurto	4	3	3	3	1	14
	Upper Mau	4	2	3	2	2	13
	Segment	**4**	**3**	**3**	**3**	**2**	**14**
Central	Central	4	3	4	3	3	17
	Ololulung'a	4	3	4	3	3	17
	Upper Mau	4	2	3	2	2	13
	Segment	**4**	**3**	**4**	**3**	**3**	**17**
South Eastern	Loita	4	4	4	4	3	19
	Osupuko	4	4	4	4	3	19
	Central	4	3	4	3	3	17
	Lower Mau	4	3	4	3	3	17
	Segment	**4**	**3**	**4**	**4**	**3**	**18**
South Western	Mara	4	4	4	4	3	19
	Ololulung'a	4	3	4	3	3	17
	Mulot	4	3	3	3	3	16
	Segment	**4**	**3**	**4**	**4**	**3**	**18**
Narok district		**4**	**3**	**4**	**3**	**3**	**17**

** The greater the total scores the greater the risk: minimum = 5 and maximum = 20 points.*
^Survey clusters for five divisions were allocated to different segments

Mau division is expansive and extends almost the whole length of Narok district from the Mau Forest Reserve (Upper Mau) in the north to the southern lowlands (Lower Mau). Therefore, the two areas were assessed separately and the risk scores for Upper Mau were lower than for Lower Mau. The other administrative divisions with different risk of trachoma in their northern and southern areas included Mulot, Ololulung'a and Central. However, they are not as expansive as Mau.

The divisions which are exclusively in the southern arid lowlands are: Loita, Mara and Osupuko.

Narok district was divided into five survey segments with approximately equal population sizes (*Figure 4.2*).). The 20 survey clusters in Mau division were distributed to the corresponding segments as follows (*Table 4.2*): North Eastern segment 9 clusters, Central segment 2 and South Eastern segment 9 clusters. Orkuto, Mulot, Central and Ololulung'a administrative divisions also had their survey clusters distributed to more than one segment.

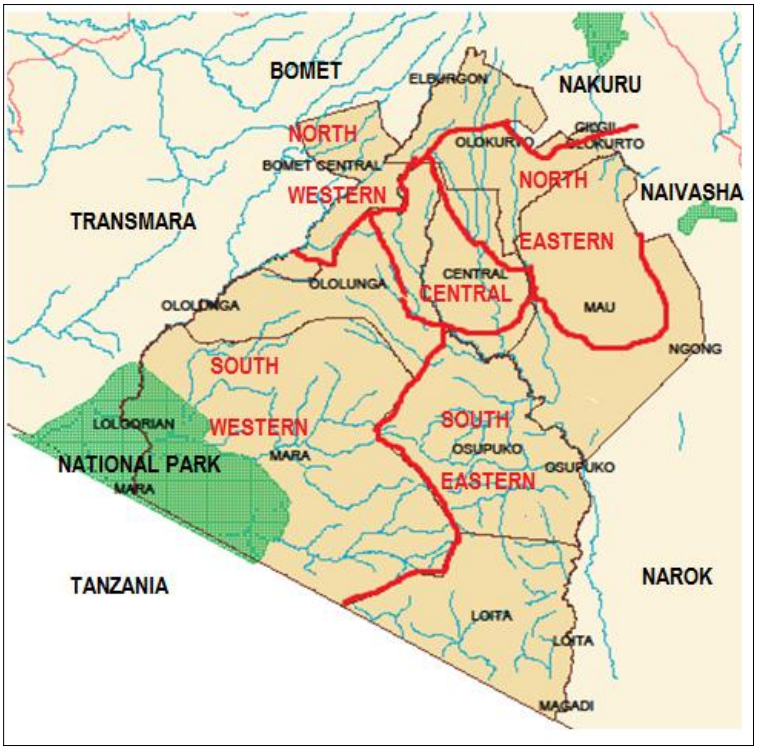


Figure 4.2: Administrative map of Narok district showing the five survey segments

Unlike in Turkana, all the segments in Narok had equal number of clusters and approximately equal population sizes. The sampling frame *(Appendix 3)* was used to estimate the population of the segments as follows: 5,764 people (sampling interval) x 20 clusters = 115,280 people per segment.

4.2 Inter-observer agreement

A total of 50 children aged 1-9 years were examined by all the four graders in consecutive households and 21 of the children (42.0%) had TF. The data are in *Appendix 12* and the Kappa values ranged between 0.92 and 1.0 (*Table 4.3*).

Table 4.3: Inter-observer agreement testing for TF

Trachoma graders*	Kappa value	Level of agreement^
Grader 4 versus grader 1	0.92	Almost perfect
Grader 4 versus grader 2	0.92	Almost perfect
Grader 4 versus grader 3	0.96	Almost perfect
Grader 3 versus grader 1	0.96	Almost perfect
Grader 3 versus grader 2	0.96	Almost perfect
Grader 2 versus grader 1	1.00	Perfect

**Grader number 4 was the most experienced and thus the reference grader*
^Landis and Koch classification

4.3 Surveys to justify mass antibiotic treatment

4.3.1 TSS method in a hyper-endemic setting

4.3.1.1 Study population

In Turkana district, 100 clusters were surveyed and 3,962 children aged 1-9 years were examined (*Table 4.4*). The number of the participants and TF cases reported using the daily tallies transmitted via mobile telephone messages and the survey data sets were the same. The study participation rate for the entire district was 99.1%. The participation rates by segments were: Western Turkana 99.5%, Northern Turkana 98.7%, Southern Turkana 97.9%, Central Turkana 99.4% and Kakuma refugee camp 100%. The number of children examined in the 100 survey clusters (sampling units) is in *Appendix 13*. The target of 40 children per cluster was achieved in most (90 out of 100) of the clusters. In four clusters 39 children were examined and 38 children in three. The assumed non-response rate of 4.2% (2 children per cluster) was exceeded in three clusters where 35, 32 and 25 children were examined. In cluster number 56 in Southern Turkana where only 25 children were examined, half of the community could not be reached due to insecurity. Forty-one and 42 children were examined in two other clusters.

The high study participation rate was achieved as a result of the rigorous community mobilisation, involvement of Government systems and Community Based Organisations, committed survey teams, well planned survey route maps and adequate transport/logistical support which allowed the survey to continue uninterrupted. The communities were receptive and no participants refused to be examined.

Table 4.4: Distribution of the survey clusters and children 1-9 years old by segments

Segment	Number of clusters*	Sample size	Number examined		
			Boys	Girls	Total
Western Turkana	23	920	420(20.8%)	494(25.4%)	915 (23.1%)
Northern Turkana	21	840	427(21.2%)	402(20.7%)	829(20.9%)
Southern Turkana^	21	840	396(19.7%)	426(21.9%)	822(20.7%)
Central Turkana	20	800	446(16.2%)	349(14.1%)	795(20.1%)
Refugee camp	15	600	326(22.1%)	275(17.9%)	601(15.2%)
Turkana district	**100**	**4,000**	**2,015(100%)**	**1,946(100%)**	**3,962(100%)**

**Allocation of the survey clusters was proportional to population size.*

The male to female ratio was approximately 1:1. The sex of 1 child aged 2 years old was not indicated. The distribution of the children by age and sex is in *Table 4.5*.

Table 4.5: Distribution of the children examined in Turkana district by age and sex

Age (years)	Children 1-9 years old		
	Boys	Girls	Total
1	254(60.2%)	168(39.8%)	422(100%)
2	342(51.0%)	328(49.0%)	670(100%)
3	379(49.2%)	391(50.2%)	770(100%)
4	334(50.7%)	325(49.3%)	659(100%)
5	233(50.9%)	225(49.1%)	458(100%)
6	170(49.6%)	180(51.4%)	350(100%)
7	122(50.8%)	118(49.2%)	240(100%)
8	94(48.2%)	101(51.8%)	195(100%)
9	87(44.2%)	110(55.8%)	197(100%)
Total*	**2,015**(50.9%)	**1,946**(49.1%)	**3,961**(100%)

**The age of 1 child was not recorded*

In Turkana, children aged <5 years accounted for 63.6% of the sample, which was higher than expected, given that the 2009 population census indicated that this age group was 50% of children aged 0-9 years. The reason for this could be the lack of accurate population estimates after the 2009 Turkana census was nullified due to influx of refugees. It is likely that this was not a true over-representation but an error resulting from the extrapolation of population estimates from an old (1999) census report. Furthermore, this survey was conducted at a time of prolonged drought and famine which had been declared a national disaster. This could have resulted in children looking younger for their age, especially those whose age was not known and had to be estimated by the enumerators.

Most mothers/guardians did not know the exact ages of their children and few had medical documents indicating when their children were born. The classes the children were attending in school could not be reliably used to estimate their ages because some classes had older children than expected. Therefore, most of the ages had to be estimated.

The mean and the median ages for the 3,961 children were 4.1 and 4.0 years respectively. Both boys and girls had a median age of 4.0 years. The mean age for boys was 4.0 years and for girls 4.2 years, p= 0.07. The box plot (*Figure 4.3*) displays the age (the median age, the quartiles and the range) by segments. Children from Northern Turkana and Central Turkana had a median age of 3 years while those from the other segments had a median of 4 years (χ^2= 177.5, df= 32, p<0.01).

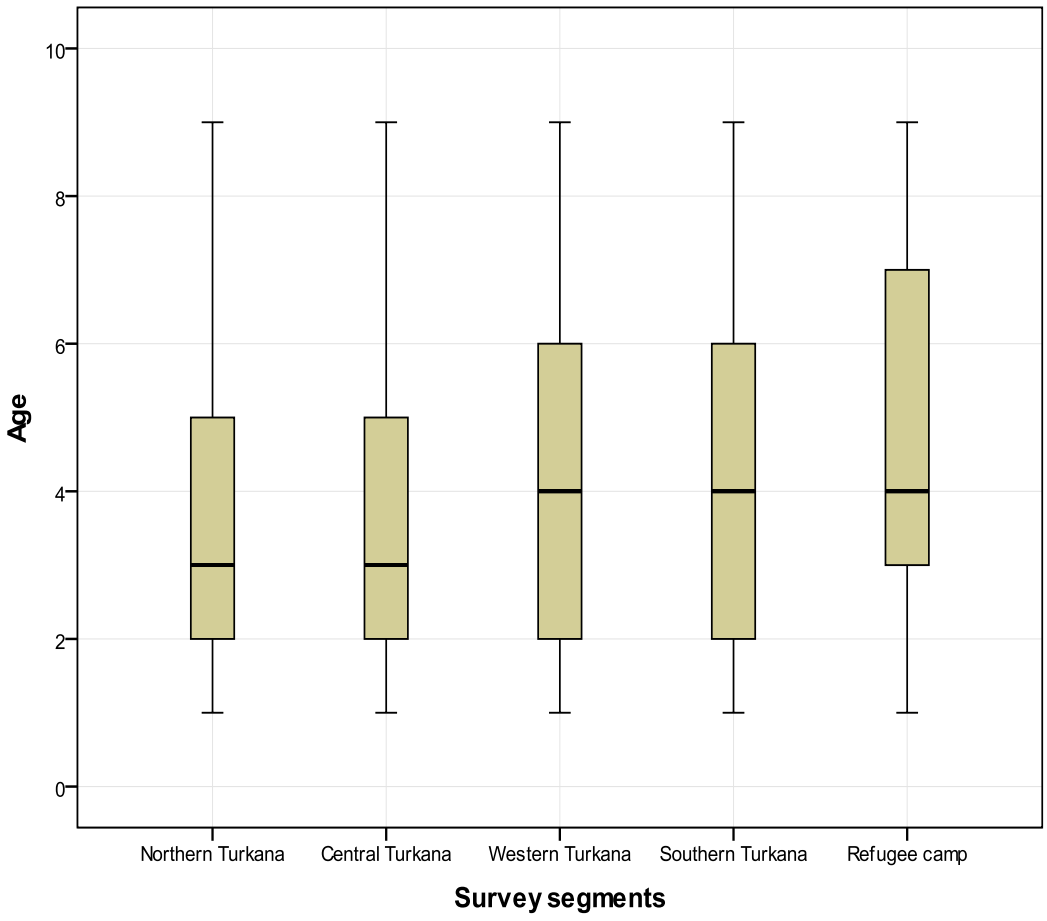


Figure 4.3: Age of the children examined in Turkana segments

4.3.1.2 School attendance

Children aged ≥5 years (school going age) were 1,440 (36.3%). The distribution by segments was: Northern Turkana 245(29.6%), Western Turkana 353(38.6%), Kakuma refugee camp 299 (49.8%), Central Turkana 250 (31.4%) and Southern Turkana 294(35.7%).

About a third (488, 33.9%) of the children 5-9 years old were not attending school (*Table 4.6*): Northern Turkana 111(27.3%, Western Turkana 179(50.7%), Refugee camp 90(30%), Central Turkana 29 (11.6%) and Southern Turkana 124 (42%). The proportion of girls (40.2%) who were not going to school was higher than that of the boys (27.2%), χ^2= 27.9, df= 2, p<0.01.

A school based intervention like face washing may therefore miss a third (33.9%) of the children of school going age in addition to the pre-school children.

Table 4.6: School attendance by children 5-9 years old in Turkana district

School attendance	**Gender**		
	Boys	Girls	Total
None*	193(27.2%)	295(40.2%)	488(33.9%)
Nursery	220(31.2%)	205(27.9%)	425(29.5%)
Primary	293(41.5%)	234(31.9%)	527(36.6%)
Total	**706**(100%)	**734**(100%)	**1,440**(100%)

**The sex of one child was not indicated*

The ages of the children who were not attending school are in *Table 4.7*. It shows that children of all ages between 5 and 9 years were equally affected.

Table 4.7: Distribution of the children who were not attending school by age

Age in years	**Children 5-9 years old**		
	Total	Not attending	% not attending school
5	458	144	31.4
6	351	120	34.2
7	240	89	37.1
8	195	70	35.9
9	197	66	33.5
Total	**1,441**	**489**	**33.9**

4.3.1.3 Prevalence of TF

One thousand five hundred and seven children had TF and the prevalence of TF in the entire district was 38.0% (95%CI: 32.2%-43.9%). This is the estimate which would have been estimated if the district was surveyed using the survey by administrative method and mass treatment would have been administered in the whole population in the district for 5 years since the prevalence was >30%.

Table 4.8 shows the distribution of TF by segments in all the segments in Turkana. The refugee camp and the Central segment had a prevalence of between 10% and 30% thus they

needed mass antibiotic treatment for three years before a repeat survey to justify further treatment. The other three segments (Western, Northern and Southern Turkana) had a prevalence of >30%. This indicates that they needed mass antibiotic treatment for five years, followed by a repeat survey. The distribution of TF in the 100 survey clusters is in *Appendix 13*. The prevalence of TF was <5% in ten, ≥5% to <10% in six, 10% to 30% in thirty-two and >30% in fifty-two clusters.

Seven hundred and forty two of the children with TF were boys (36.8%; 95%CI: 30.9%-42.7%) and 765(39.3%; 95%CI: 33.0%-45.6%) were girls. The difference in prevalence of TF between boys and girls, χ^2= 3.2, df= 2, p= 0.20.

Table 4.8: Distribution of TF and need for mass antibiotic treatment in Turkana by segments

Segments	**Children aged 1-9 years old**				**Need for mass**
	Total	With TF	% with TF	95% CI	**treatment**
Western Turkana	914	618	67.6	55.7-79.4	5 years
Northern Turkana	829	385	46.4	36.9-56.0	5 years
Southern Turkana	823	257	31.2	24.2-38.3	5 years
Central Turkana	795	163	20.5	11.1-29.9	3 years
Refugee camp	601	84	14.0	3.6-24.3	3 years
Turkana district	**3,962**	**1,507**	**38.0**	**32.2-43.9**	**5 years**

Fifteen survey clusters were selected in the camp (numbers 68-82 in *Appendix 13*). The prevalence of TF was <5% in six, 5% to <10% in four, 10% to 30% in three and >30% in two clusters. The prevalence of TF in the entire camp was 14% (95%CI: 3.6%-24.3%). The refugees from different countries are allocated designated areas (zones and phases) in the camp according to their nationalities. The United Nations High Commission for Refugees assisted us to identify the communities which were trachoma endemic (*Table 4.9*). All the 3 zones (2, 4, and 6) with prevalence ≥10% were inhabited by refugees from South Sudan, a war torn country which borders Turkana district to the North.

Table 4.9: Distribution of TF among the refugee communities in Kakuma refugee camp

Areas in Kakuma refugee camp	**Children 1-9 years old**		
	Total*	With TF	% with TF
Zone 4	40	25	62.5
Zone 6	82	30	36.6
Zone 2	40	10	25.0
Kakuma 4 Zone 2	120	9	7.5
Kakuma 4 Zone 1	39	2	5.1
Kakuma 2 Phase1	40	2	5.0
Zone 5	120	4	3.3
Kakuma 2 Phase2	40	1	2.5
Zone 1	40	1	2.5
Kakuma 3	40	0	0.0
Kakuma refugee camp	**601**	**84**	**14.0**

**The sample size was proportional to the population size*

In the initial proposal of this study it was suggested that some "stopping rules" could be included to make the TSS method more efficient. During the surveys, the trachoma graders tallied the number of children examined and the TF cases diagnosed. Turkana district was hyper-endemic and the prevalence of TF was >10% in the "worst places", meaning the ten clusters with the highest prevalence of TF, in all the segments. Therefore, in Turkana none of the surveys could have been stopped before data collection was completed.

A desired precision of 30% was assumed when computing the sample sizes. It was thus expected that the confidence limit of a prevalence estimate should not be wider than $\pm$ 30% of the assumed prevalence. The upper limit of the confidence interval was not an issue since all the segments with prevalence >10% needed mass treatment. The lower limit was important because it indicated the lowest prevalence estimate which could trigger administration of mass antibiotic treatment (*Table 4.10*). This 30% limit was exceeded in the refugee camp and the Central segments. The calculation for the refugee camp was done as follows: 14.0 (prevalence) minus 3.6 (lower limit) divided by 14.0 = 74.3% and for Central segment (20.5-11.1)/20.5 = 45.9%. The lowest precision required for accurate statistical inference is 50%(14) and the limit was exceeded in the refugee camp because trachoma was highly clustered in one refugee community.

Table 4.10: The precision of the prevalence estimates for this study

Segments	Prevalence (95% CI)	Lower limit	Difference (prevalence minus lower limit)	
			Absolute	Percentage*
Western Turkana	67.6(55.7-79.4)	55.7	11.9	17.6
Northern Turkana	46.4(36.9-56.0)	36.9	9.5	20.5
Southern Turkana	31.2(24.2-38.3)	24.2	7	22.4
Central Turkana	20.5(11.1-29.9)	11.1	9.4	45.9
Refugee camp	14.0(3.6-24.3)	3.6	10.4	74.3
Turkana district	**38(32.2-43.9)**	**32.2**	**5.8**	**15.3**

**The desired precision was 30%*

The prevalence of TF by age in Turkana district is shown in *Figure 4.4*. The prevalence ranged between 45.8% (95%CI: 38.9%-52.6%) in children 1 year old and 27.4% (95%CI: 17.3%-37.5%) in those 9 years old. The peak prevalence was at 2 years.

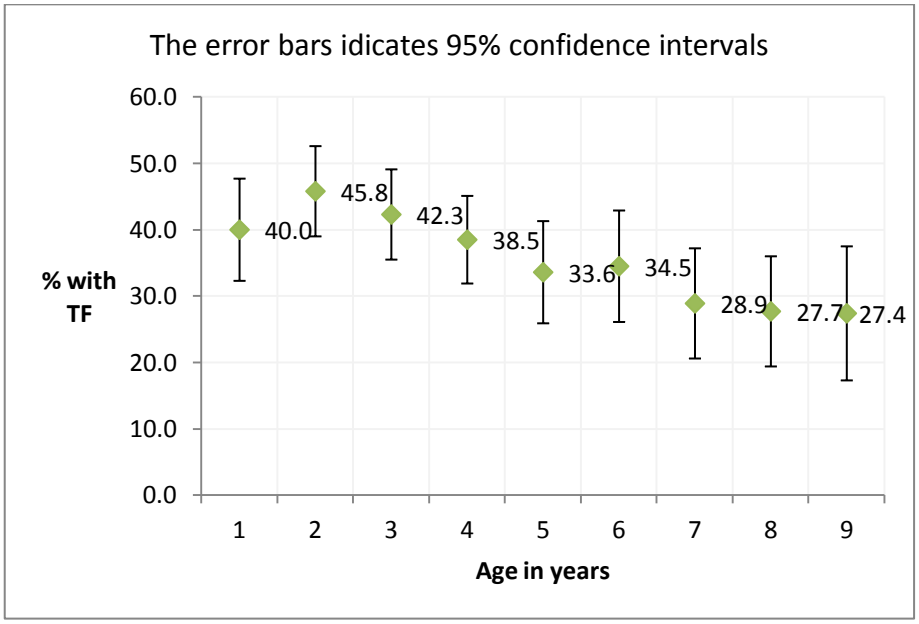


Figure 4.4: Prevalence of TF by age in Turkana district

4.3.1.4 Prevalence of TI

In Turkana district 341 children 1-9 years old had TI, out of whom 30(8.8%) had TI only and 311(91.2%) had both TF and TI. The TF:TI ratio for Turkana was approximately 4:1 (1,507 cases of TF and 341 of TI).

The prevalence of TI in the entire Turkana district was 8.6% (95%CI: 6.3%-10.9%). It ranged between 1.2% (95%CI: 0.0%-2.5%) in the Kakuma refugee camp and 18.7% (95%CI: 11.9%-25.5%) in Western Turkana segment (*Table 4.11*).

The prevalence of TI in the 100 survey clusters was <5% in forty-nine, ≥5% to <10% in sixteen, ≥10% to 30% in twenty-nine and >30% in six clusters (*Appendix 13*).

Table 4.11: Distribution of TI in Turkana by segments

Segments	**Children 1-9 years old**			
	Total	With TI	% with TI	95%CI
Western Turkana	913	171	18.7	11.9-25.5
Northern Turkana	829	83	10.0	6.2-13.8
Southern Turkana	822	43	5.2	3.3-7.3
Central Turkana	794	37	4.7	1.5-7.9
Refugee camp	601	7	1.2	0.0-2.5
Turkana district	**3959**	**341**	**8.6**	**7.7-9.5**

One hundred and ninety-one of those with TI were girls and 140 were boys. The prevalence in girls (9.8%; 95%CI: 7.0%-12.7%) was higher than in boys (7.5%; 95%CI: 5.4%-9.5%), χ^2= 7.2, df= 2, p = 0.03.

The prevalence of TI decreased with increasing age from 12.1% (95%CI: 0.8%-1.6%) in children 1 year old to 3.6% (95%CI: 1.6%-6.0%) in those 9 years old (*Figure 4.5*). There was a second but small peak at 6 years which was more pronounced than that of TF (*Figure 4.4, page 95*) and dirty faces (*Figure 4.7, page 98*). The reason for this second peak could not be explained using the data collected in this survey. May be the mothers had other younger babies and had less time to provide individual care to the older children.

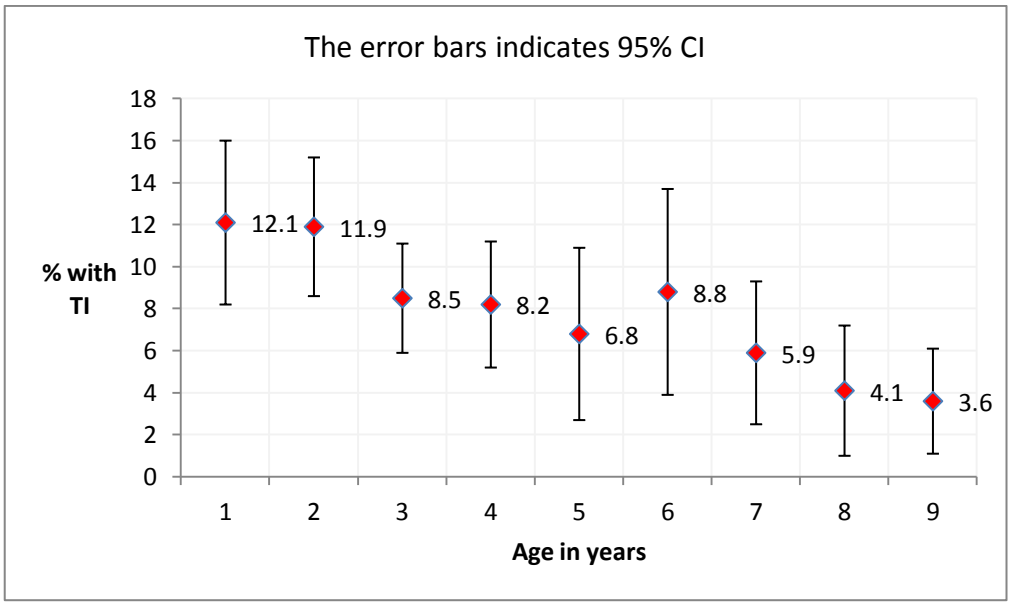


Figure 4.5: Prevalence of TI by age in Turkana district

The correlation between the prevalence of TF and TI in the 100 survey clusters for Turkana district is displayed in *Figure 4.6* and the data are in *Appendix 13*. Most of the points on the scatter plot are close to the "best fit line" that shows the mean trend of the data on the plot. The correlation was positive and statistically significant (Pearson correlation coefficient (r)= 0.70, p= <0.01). This indicates that the clusters with high prevalence of TF also had high prevalence of TI.

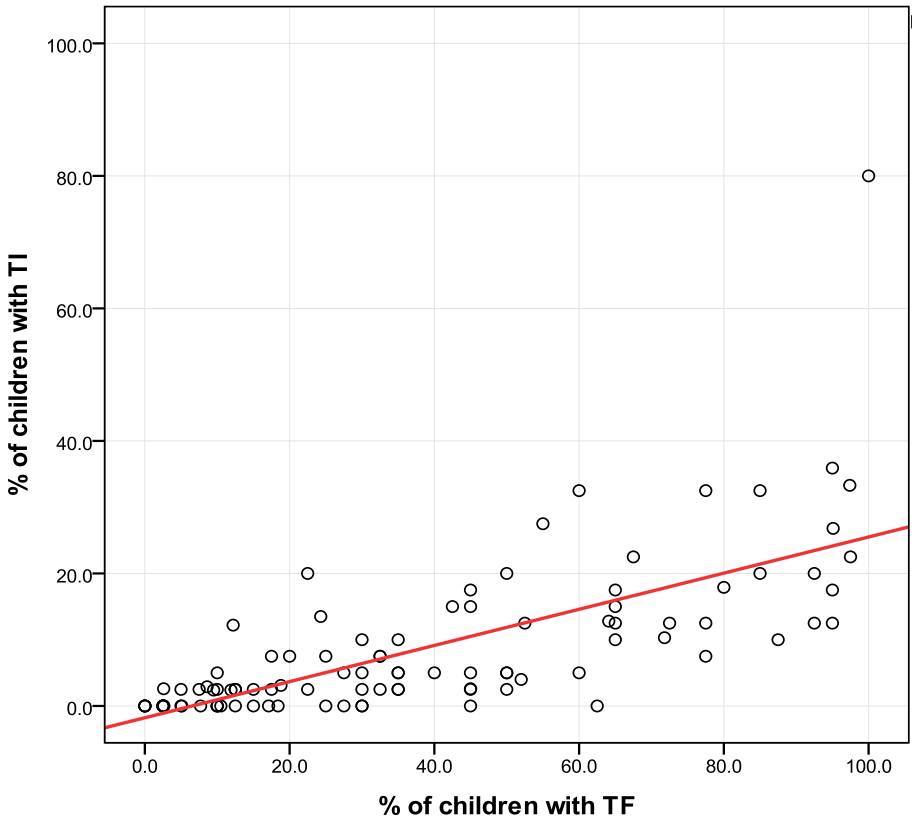


Figure 4.6: Correlation between TF and TI in the 100 clusters for Turkana district

Key: The circles represent the 100 survey clusters with a "best fit line" to shows the mean trend of the data on the scatter plot

4.3.1.5 Prevalence of a dirty face

Two thousand one hundred and fifty-nine children had dirty faces. The status of the faces of 8 children was not recorded. The prevalence was 54.6% (95% CI: 48.9%-60.2%) and ranged between 16.0% (95% CI: 6.3%-25.7%) in the refugee camp and 76.9% (95% CI: 67.9%-85.9%) in Western Turkana (*Table 4.12*).

The percentage of children with dirty faces in the 100 survey clusters (*Appendix 13*) were ≤20% in 17 clusters and >20% in 87 clusters.

One thousand one hundred and sixteen (55.5%, 95%CI: 49.5%-61.6%) of those with dirty faces were boys and 1,043 (53.7%, 95% CI: 47.8%-59.6%) were girls, χ^2= 2.6, df= 2, p= 0.28.

Table 4.12: Distribution of dirty faces in Turkana by segments

Segments	**Children 1-9 years old**			
	Total	With dirty faces	% with dirty faces	95%CI
Western Turkana	915	704	76.9	67.9-85.9
Southern Turkana	823	476	57.8	48.7-67.0
Northern Turkana	829	478	57.7	49.4-65.9
Central Turkana	787	405	51.5	39.9-63.1
Refugee camp	601	96	16.0	6.3-25.7
Turkana district	**3,955**	**2,159**	**54.6**	**48.9-60.2**

The prevalence of a dirty face decreased with increasing age between the ages of 2 years and 9 years, with a slight increase at six years (*Figure 4.7*).

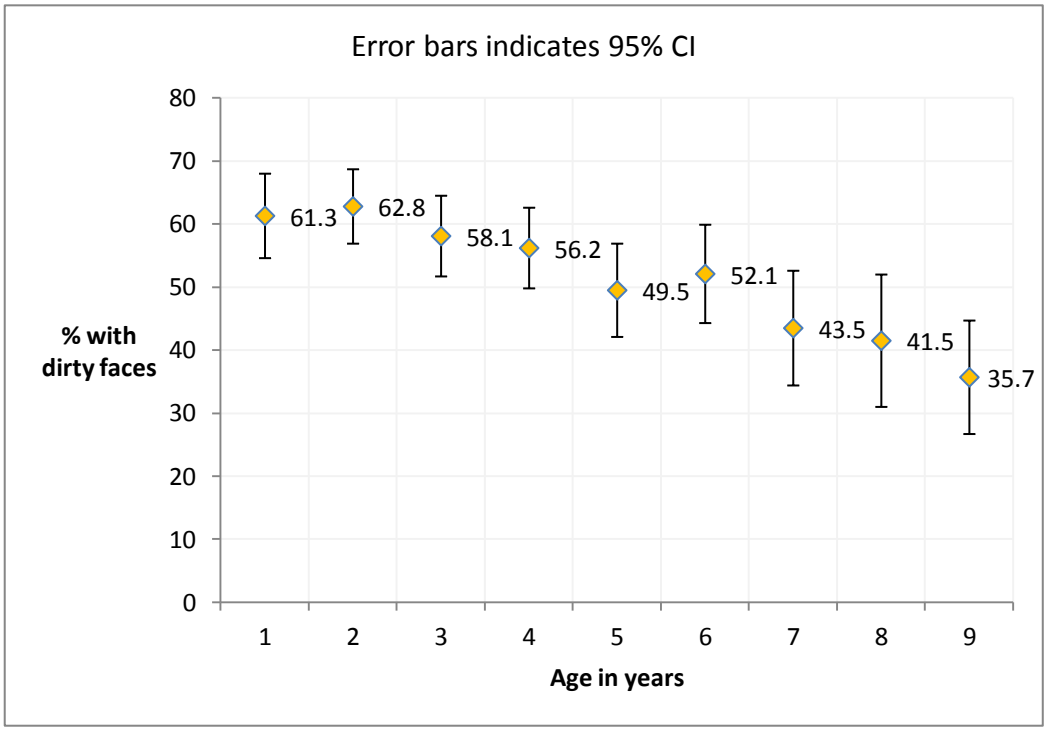


Figure 4.7: The prevalence of a dirty face by age in Turkana

In Turkana district, a child with a dirty face was more likely to have TF (OR 6.1, 95%CI: 5.3-7.1) and TI (OR 4.9, 95%CI: 3.7-6.7) than a child with a clean face.

4.3.1.6 Correlation between the prevalence of a dirty face and the prevalence of TF

The correlation between the prevalence of a dirty face and TF in the 100 survey clusters for Turkana district (*Appendix 13*) is displayed in *Figure 4.8*. Most of the points on the scatter plot are close to the "best fit line" that shows the mean trend of the data on the plot. The correlation was moderate, positive (r= 0.65, p= <0.01). This indicates that the clusters with high prevalence of a dirty face also had high prevalence of TF.

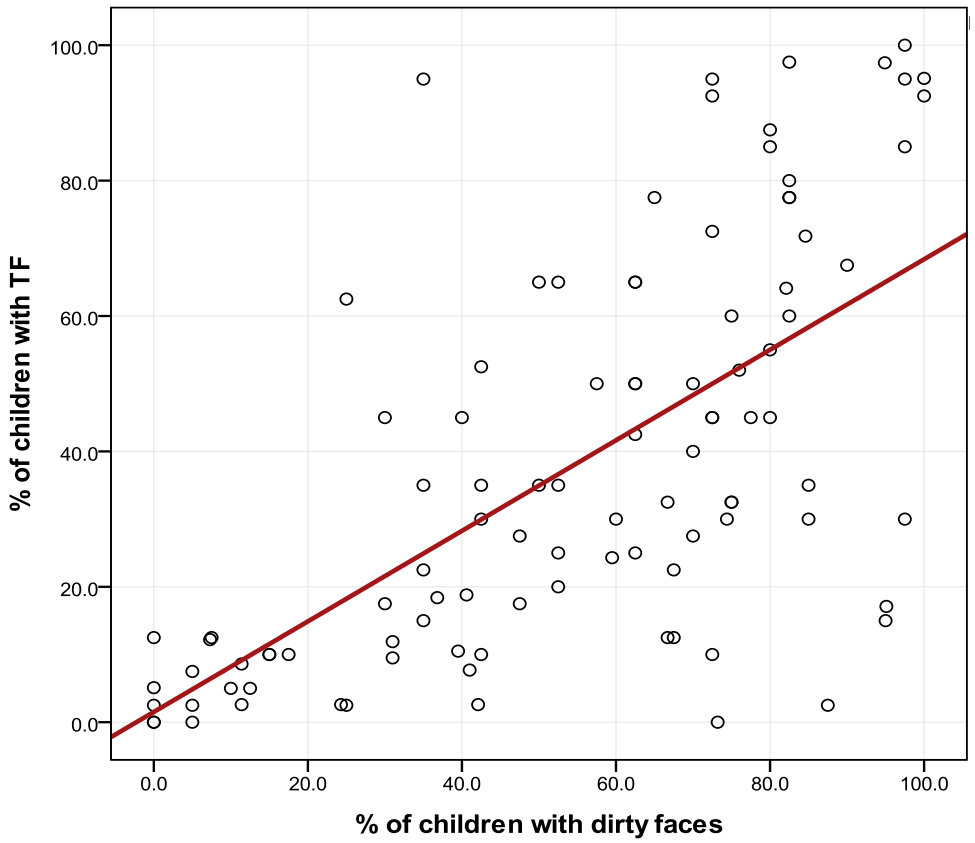


Figure 4.8: Correlation between the prevalence of dirty faces and TF in Turkana

Key: The circles represent the 100 survey clusters with a "best fit line" to shows the mean trend of the data on the scatter plot.

4.3.2 TSS method in a meso-endemic setting

4.3.2.1 Study population

One hundred clusters were surveyed in Narok administrative district and 4,000 children aged 1-9 years examined (*Table 4.13*). Two children were excluded from analysis because the age of one child had not been recorded and the other was >9 years old. The study participation rate was virtually 100%. The number of participants and TF cases reported using the daily tallies transmitted via mobile telephone messages and the survey data sets were the same.

The district had an experienced mass antibiotic distribution team which was used to mobilise the community for this study. The other factors which improved the participation rate were: involvement of the government systems, non-governmental organisations, committed survey teams, adequate transport, well planned survey route maps, and strong logistical support which ensured that the survey continued uninterrupted. The communities were very receptive and all the selected individuals accepted to be examined.

Table 4.13: Distribution of the survey clusters and children 1-9 years old in Narok district

Segment	**Number of clusters**	**Sample size**	**Number examined**		
			Boys	Girls	Total
North Western	20	800	401(19.8%)	398(20.2%)	799(20.0%)
North Eastern	20	800	394(19.4%)	406(20.6%)	800(20.0%)
Central	20	800	421(20.7%)	379(19.3%)	800(20.0%)
South Eastern	20	800	401(19.7%)	399(20.3%)	800(20.0%)
South Western	20	800	413(20.4%)	386(19.6%)	799(20.0%)
Narok district	**100**	**4,000**	**2,030(100%)**	**1,968(100%)**	**3,998(100%)**

Two thousand and thirty of the examined children were boys and 1,968 were girls. Their distribution by age and sex is in *Table 4.14*. The mean and median age for all the children was 4.8 and 5.0 years respectively. The mean and median age for boys was 4.7 and 4.0 years while for girls was 4.9 and 5.0 years respectively (χ^2= 12.7, df= 8, p= 0.12).

Table 4.14: Distribution of the examined children by age and sex

Age (years)	**Children 1-9 years old**		
	Boys	Girls	Total
1	209(51.9%)	194(48.1%)	403(100%)
2	260(52.3%)	237(47.7%)	497(100%)
3	278(54.1%)	236(45.9%)	514(100%)
4	275(52.3%)	251(47.7%)	526(100%)
5	245(49.2%)	253(50.8%)	498(100%)
6	203(48.1%)	219(51.9%)	422(100%)
7	203(49.5%)	207(50.5%)	410(100%)
8	153(55.0%)	125(45.0%)	278(100%)
9	204(45.3%)	246(54.7%)	450(100%)
Total	2,030(50.8%)	1,968(49.2%)	3,998(100%)

The South Eastern and South Western survey segments had younger children with a median age of 4 years children (*Figure 4.9*) than the other segments (median age 5 years) (χ^2= 64.3, df= 32, p= 0.01). The 2009 census indicated that children aged 1-4 years constituted 47% of the total number of the children aged 1-9 years in both Narok North and Narok South. In this

study, the number of children 1-4 years old examined in Narok district was 1,940 (48.5% of the total examined). The numbers by segment were: North Eastern 361(45.2%), North Western 377(47.1%), Central 363(45.4%), South Eastern 421(52.6%) and South Western segment 418 (52.3%).

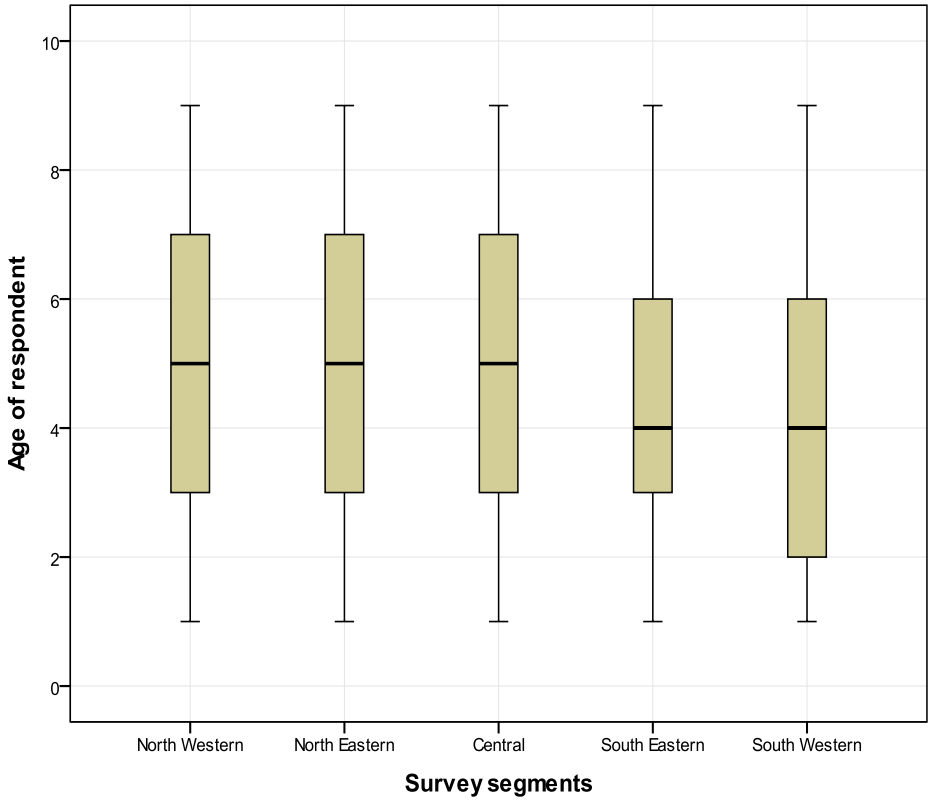


Figure 4.9: Age of the children examined in Narok segments

4.3.2.2 School attendance

One fifth (20.2%) of the children who had attained the school going age (≥5 years) were not attending school (*Table 4.15*). The difference between school attendance by boys (20.3%) and girls (20.0%), χ^2= 0.27, df= 2, p= 0.88. Therefore, in Narok district a school based intervention like face washing is likely to miss a fifth (20.2%) of the children aged 5-9 years, in addition to the children who have not attained the school going age.

Table 4.15: School attendance by the children 5-9 years old

School attendance	**Gender**		
	Boys	Girls	Total
None	206(20.4%)	210(20.0%)	416(20.2%)
Nursery	296(29.4%)	301(28.7%)	597(29.0%)
Primary	506(50.2%)	539(51.3%)	1045(50.8%)
Total	**1,008(100%)**	**1,050(100%)**	**2,058(100%)**

The southern segments had a higher percentage of children who were not attending school than the segments in the northern segments: North Western had 37(8.4%), North Eastern 49(11.6%), Central 60(13.7%), South Eastern 126(33.2%) and South Western 144(37.8%). The distribution of the children who were not attending school by age (*Table 4.16*) indicated that it was mainly the younger age groups who were not attending school.

Table 4.16: Distribution of the children who were not attending school by age

Age in years	**Children 5-9 years old**		
	Total	Not attending	% not attending school
5	498	188	37.8
6	422	91	21.6
7	410	50	12.2
8	278	39	14.0
9	450	48	10.7
Total	**2058**	**416**	**20.2**

4.3.2.3 Prevalence of TF

Four hundred and forty children had TF (*Table 4.17*) and the prevalence was 11.0% (95%CI: 8.0%-14.0%). This indicates that if the survey was conducted using the survey by administrative district method the whole population would have been treated for another 3 years. However, the prevalence in the two Northern segments and the Central segments was <5% and they did not require further mass treatment. The prevalence of TF in the two southern segments was between 10% and 30% and they needed mass antibiotic treatment for another three years.

The distribution of TF in the 100 clusters is in *Appendix 14* and the children with TF were <5% in fifty-six, ≥5% to <10% in nine, 10% to 30% in twenty and >30% in fifteen clusters. The distribution of TF in the segments with did not require mass treatment (prevalence <10%) were explored to identify if they had clusters with prevalence of between ≥5% and <10% for targeted treatment. In segment 1 only 1 case of TF was diagnosed hence no cluster had a prevalence of ≥5%. Segment 2 had 3 clusters with >10% but none with >5% to <10%. Segment 3 had 3 clusters with >10% and 4 with >5% to <10%.

Two hundred and twenty-one of the children with TF were boys and 219 were girls. Girls had a higher prevalence of TF (11.1%; 95%CI: 8.0%-14.3%) than boys (10.9%; 95%CI: 7.9%-13.9%), χ^2= 0.1, df= 1, p= 0.81.

In 2004 a baseline prevalence survey was conducted in Narok district using the standard survey by administrative district method and the prevalence of TF in the entire district was 30.5% (95%CI:25.6%-35.8%)(25). This indicates that there was a 65% decline in prevalence between the 2004 survey and this study (2010).

Table 4.17: Distribution of TF in Narok and need for mass antibiotic treatment by segments

Segment	**Children 1-9 years old**				**Need for mass**
	Total	With TF	% with TF	95% CI	**treatment**
South Western	799	213	26.7	18.7-34.6	3 years
South Eastern	800	173	21.6	15.4-27.8	3 years
Central	800	34	4.3	2.2-6.3	Not needed
North Eastern	800	17	2.1	0.0-4.5	Not needed
North Western	799	3	0.4	0.0-0.9	Not needed
Narok district	**3,998**	**440**	**11.0**	**8.0-14.0**	**3 years**

The confidence intervals of the prevalence estimates for the two northern segments and the central segments were wider than the expected precision of ±30% (*Table 4.18*) because the prevalence was lower than the 10% used to compute the samples for the TSS method. It was also unlikely that the three segments could be included in mass treatment since the upper limits for the confidence intervals were also <10%.

For the two southern segments, the lower limits of the 95% confidence intervals (*Table 4.18*) were >10%, which indicate that the true prevalence in the population was >10% (with 95% certainty). Therefore, it was unlikely that they received mass treatment without justification.

Table 4.18: The precision of the prevalence estimates for this study

Segments	**Prevalence (95% CI)**	**Lower limit**	**Difference (prevalence minus lower limit)**	
			Absolute	Percentage*
South Western	26.7(18.7-34.6)	18.7	8	30.0
South Eastern	21.6(15.4-27.8)	15.4	6.2	28.7
Central	4.3(2.2-6.3)	2.2	2.1	48.8
North Eastern	2.1(0.0-4.5)	-	-	-
North Western	0.4(0.0-0.9)	-	-	-
Narok district	**11.0**(**8.0-14.0**)	8.0	3.0	27.3

*The desired precision was 30%

The prevalence of TF in Narok district increased slightly between the ages of 1 and 2 years. It then declined from 19.7% (95%CI: 14.2%-25.2%) in children aged 2 years to 4.7% (95%CI: 2.3%-7.0%) in those aged 9 years (*Figure 4.10*). The district was implementing the SAFE strategy, which included mass antibiotic treatment, provision of water and a school health programme to promote personal hygiene. Most of the older children were attending school.

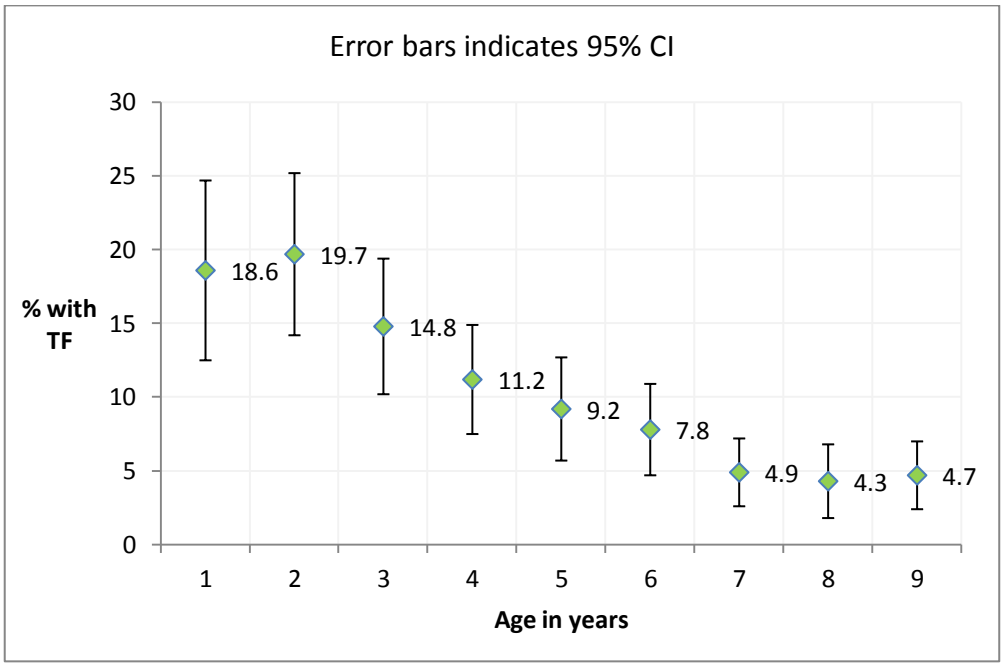


Figure 4.10: The prevalence of TF by age in Narok

If the proposed "stopping rules" were applied in Narok, surveys would have been stopped before completion of data collection in the three segments with a prevalence of <5% because the prevalence of TF was <10% in the "worst" 10 clusters.

4.3.2.4 Prevalence of TI

Thirty-eight children had TI, out of whom 5 had TI only while 33 had both TI and TF. The TF:TI ratio was 12:1 (440 with TF and 38 of TI). The prevalence of TI in the district was 1.0% (95%CI: 0.4%-1.5%). All the children with TI were from the southern segments except two (*Table 4.19*). No TI cases were reported in the North Western segment. The Central and the North Eastern segments had one case each.

Table 4.19: Prevalence of TI by segments

Segment	Children 1-9 years old			
	Total	With TI	% with TI	95% CI
South Eastern	800	23	2.9	0.8-4.9
South Western	799	13	1.6	0.1-3.1
Central	800	1	0.1	0.0-0.4
North Eastern	800	1	0.1	0.0-0.4
North Western	799	0	0.0	-
Narok district	**3,998**	**38**	**1.0**	**0.4-1.5**

The distribution of TI in the 100 survey clusters (*Appendix 14*) was: <5% in 91 clusters, ≥5% to <10% in 6 clusters and 10% to 30% in 3 clusters.

Thirteen of the children with TI were boys while 25 were girls. Girls had a higher prevalence of TI (1.3%, 95%CI: 0.5%-2.1%) than boys (0.6%, 95%CI: 0.2%-1.1%) (χ^2= 4.2, df= 1, p= 0.04).

The prevalence of TI peaked at age 1 year, then declined to zero by age >7years (*Table 4.20*). Only 3 of the 38 children with TI were >5 years old. This indicated that children <5 years had a higher prevalence of TI than the older children. The survey was conducted 4 months after completion of mass antibiotic treatment in the entire district and some of the children who were 1 year old at the time of the survey may not have received azithromycin. Children <6 months old are given tetracycline eye ointment instead of oral azithromycin. The age determination may also not be exact because the district has a high illiteracy level.

Table 4.20: Prevalence of TI by age in Narok district

Age in years	Children 1-9 years			
	Examined	With TI	% with TI	95%CI
1	403	9	2.2	0.1-4.3
2	497	9	1.8	0.0-3.9
3	514	6	1.2	0.3-2.1
4	526	7	1.3	0.1-2.5
5	498	4	0.8	0.0-1.8
6	422	2	0.5	0.0-1.1
7	410	1	0.2	0.0-0.7
8	278	0	0.0	-
9	450	0	0.0	-
Total	**3,998**	**38**	**1.0**	**0.4-1.5**

The correlation between TF and TI in the 100 survey clusters is displayed in *Figure 4.11* and the data are in *Appendix 14*. The 84 survey clusters with no TI cases are represented by the points along the horizontal axis on the scatter plot. The rest of the points are widely

dispersed from the "best fit line" that shows the trend of the data on the plot. Therefore, the correlation was moderate, r= 0.53, p= 0.01. The clusters with high prevalence of TF had higher prevalence of TI than the clusters the clusters with low prevalence of TF.

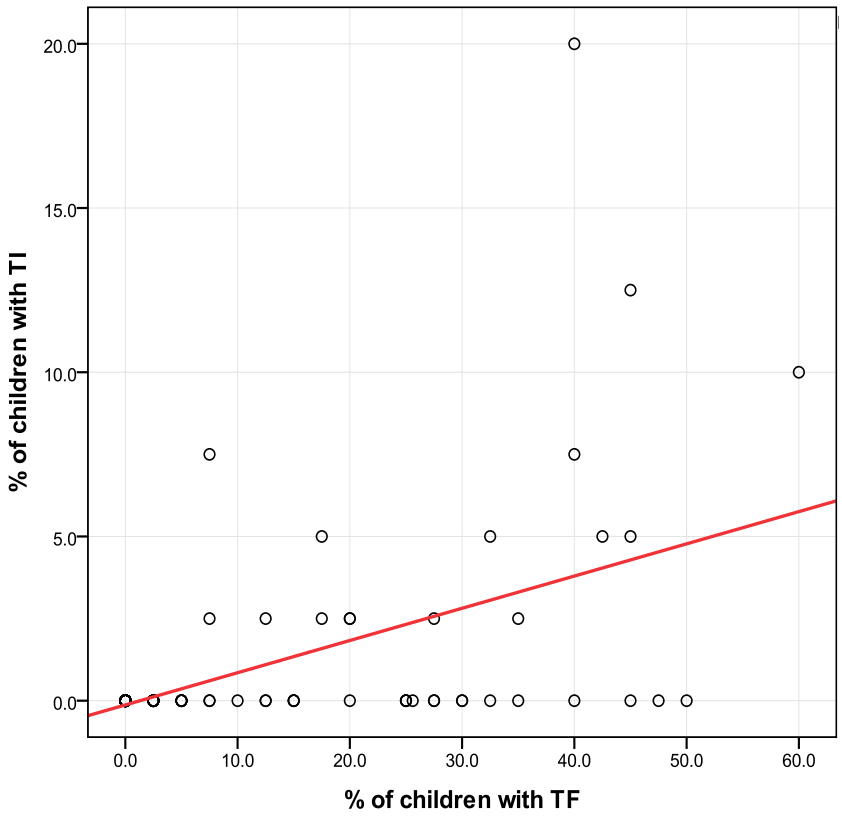


Figure 4.11: Correlation between TF and TI in the 100 clusters for Narok

Key: The circles represent the 100 survey clusters with a "best fit line" to shows the mean trend of the data on the scatter plot

4.3.2.5 Prevalence of a dirty face

One thousand seven hundred and eight children had dirty faces and the prevalence of a dirty face in Narok district was 42.8% (95%CI: 37.4%-48.1%). In twenty-one survey clusters the prevalence of a dirty face was <20% while in 89 clusters it was ≥20% (*Appendix 14*).

Narok district and all the surveyed segments had not achieved the ultimate intervention goal for facial cleanliness. The segments located in the arid southern lowlands had higher prevalence of a dirty face than the rest of the segments (*Table 4.21*).

In 2004 the prevalence of a dirty face in Narok district was 53.5% (95% CI: 50.8%-56.2%)(25). The decline in prevalence of a dirty face was 11% which was lower than the 65% decline in prevalence of TF.

Nine hundred and four boys and 804 girls had dirty faces. The prevalence of a dirty face in boys was higher (44.6%, 95%CI: 38.9%-50.2%) than in girls (40.9%, 95%CI: 35.4%-46.4%), χ^2= 5.4, df= 1, p= 0.02. This was the opposite of the findings for TF and TI where girls had a higher prevalence than boys.

Table 4.21: Distribution of dirty faces in Narok by segments

Segment	**Children 1-9 years old**			
	Total	With dirty faces	% with dirty faces	95% CI
South Eastern	800	477	59.6	50.0-69.3
South Western	799	439	54.9	43.4-66.5
North Eastern	800	289	36.1	24.6-47.6
Central	796	254	31.9	21.1-42.7
North Western	799	249	31.2	21.1-41.2
Narok district	**3,994**	**1,708**	**42.8**	**37.4-48.1**

The prevalence of a dirty face increased slightly between the ages of 1 and 2 years and then declined from a peak of 61.2% (95%CI: 54.1%-68.3%) at 2 years to 20.2% (15.0%%-25.4%) at 9 years (*Figure 4.12*). This trend was similar to the trends for TF and TI by age.

The prevalence of a dirty face was >20% in all the age groups.

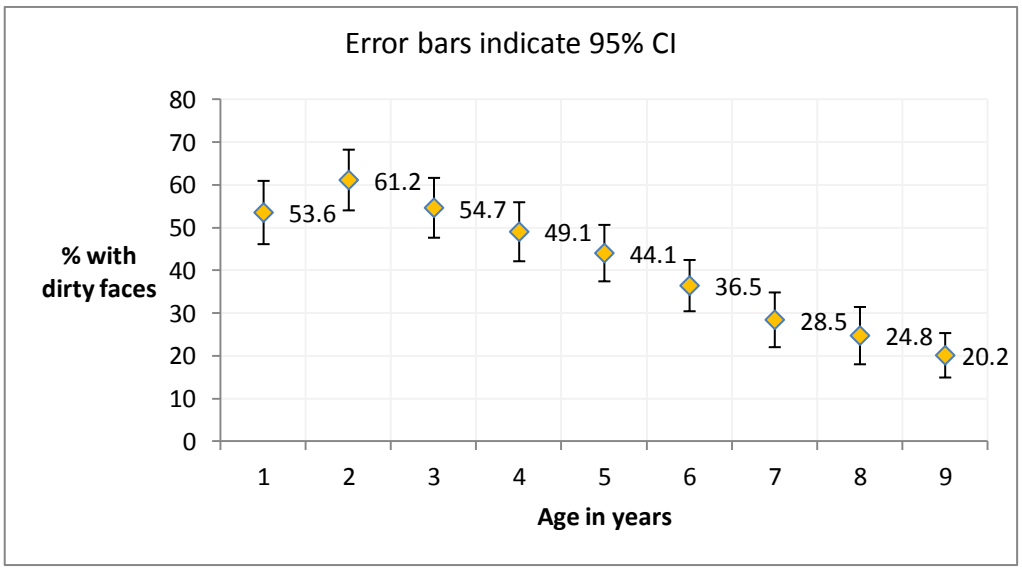


Figure 4.12: Prevalence of a dirty face by age in Narok

In Narok district, a child with a dirty face was more likely to have TF (OR 5.8, 95%CI: 4.6-7.3) and TI (OR 6.0, 95%CI: 2.6-13.7) than a child with a clean face.

4.3.2.6 Correlation between dirty faces and the prevalence of TF

The correlation between the prevalence of a dirty face and the prevalence of TF in the 100 survey clusters for Narok is displayed in *Figure 4.13* and the data are in *Appendix 14*. There were 46 clusters with no TF represented by the points along the horizontal axis on the scatter plot. The rest of the data points are widely dispersed from the "best fit line" that shows the trend of the data on the plot. Therefore, the correlation was moderately positive r= 0.54, p= 0.01. This implies that the clusters with high prevalence of a dirty face also had high prevalence of TF.

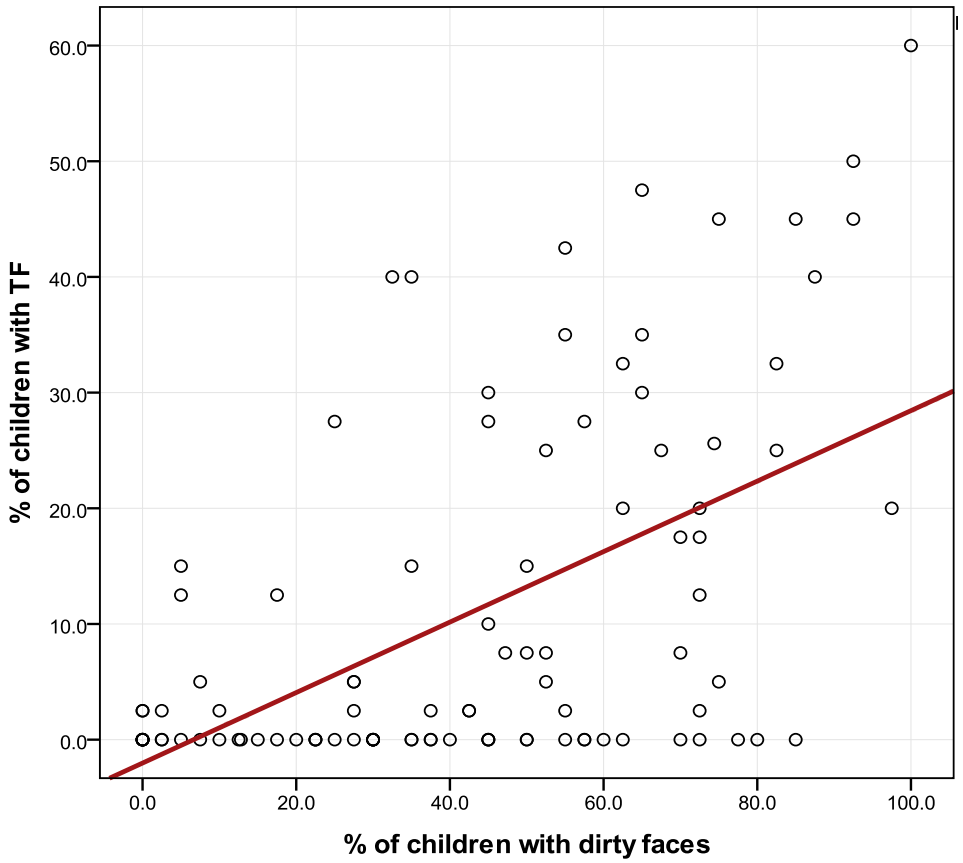


Figure 4.13: Correlation between the prevalence of a dirty face and TF in Narok

Key: The circles represent the 100 survey clusters with a "best fit line" to shows the trend of the data on the scatter plot

4.3.2.7 TF in Turkana and Narok segments

The data for the previously-surveyed districts(25, 31) and the results of this study were used to develop the Kenya TF map (*Figure 4.14*), which is available at www.trachomaatlas.com. The ten segments surveyed during this study are labelled 1 to 5. The previous surveys were conducted using the standard survey by administrative district method.

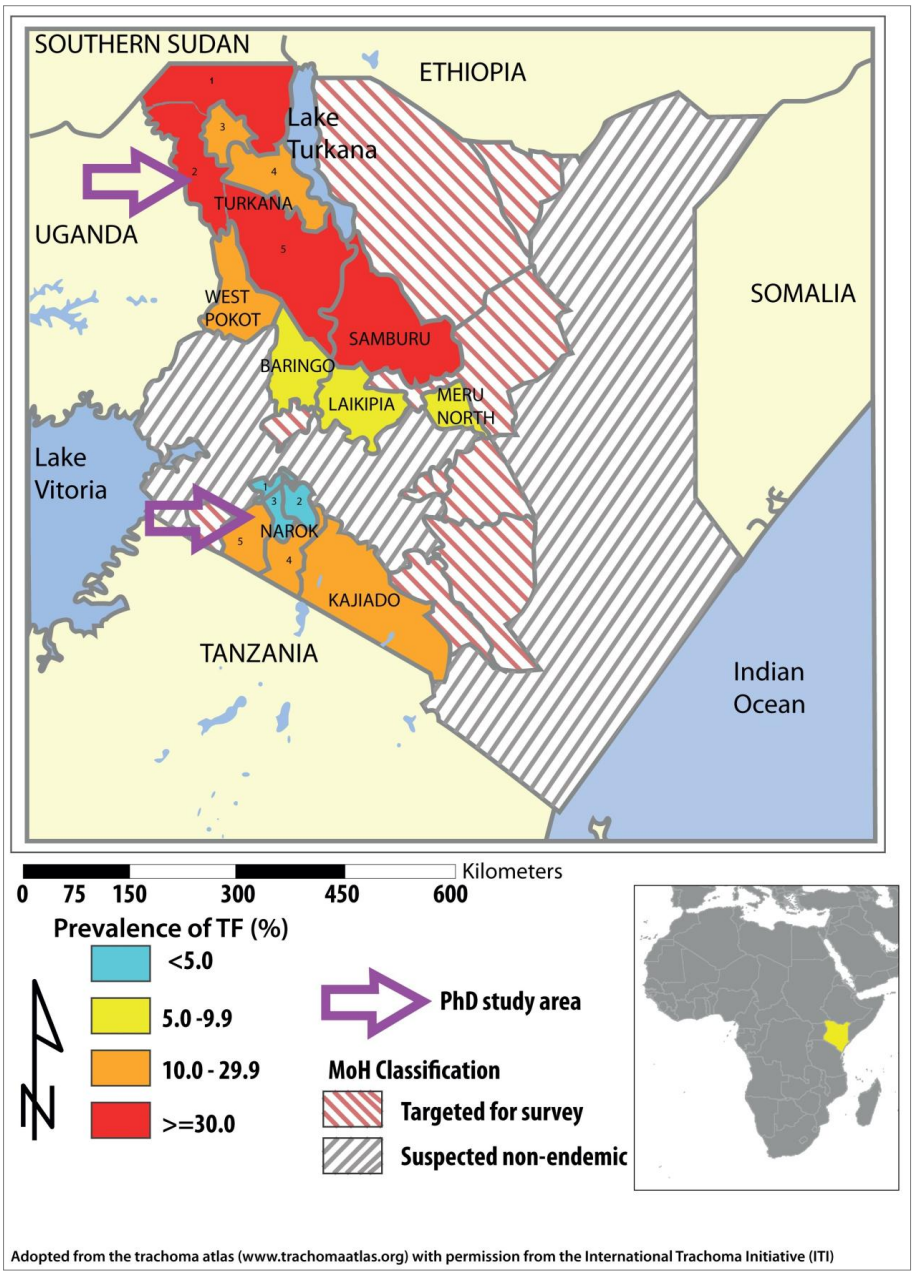


Figure 4.14: Kenya TF map (www.trachomaatlas.org) showing the 10 segments surveyed in Turkana and Narok districts

4.3.3 Correlation between pre-survey risk scores and prevalence of TF

4.3.3.1 Risk scores and prevalence of TF in Turkana district

The total risk scores for the administrative divisions and the survey segments were correlated with the prevalence of TF, so as to determine the accuracy of the predictions made by the key informants. Turkana district had 17 administrative divisions but for the purpose of this survey, Kakuma division was divided into Kakuma refugee camp (located in

Kakuma town) and Kakuma Rural (host community). The prevalence and risk scores for the 18 divisions are in *Table 4.22*.

Table 4.22: Prevalence of TF and pre-survey risk scores in Turkana administrative divisions

Divisions	**Children 1-9 years old**			**Trachoma Endemicity#**	**Total risk scores**	**Risk^**
	Total	With TF	% with TF			
Oropoi	160	126	78.8	Hyper	19	High
Kakuma Rural*	280	217	77.5	Hyper	15	Medium
Loima	236	167	70.8	Hyper	19	High
Lokichogio	280	172	61.4	Hyper	17	High
Kibish	80	46	57.5	Hyper	19	High
Kerio	115	65	56.5	Hyper	18	High
Lapur	79	39	49.4	Hyper	20	High
Turkwel	504	214	42.5	Hyper	17	High
Kaaling	232	87	37.5	Hyper	20	High
Katilu	120	45	37.5	Hyper	17	High
Kainuk	118	39	33.1	Hyper	17	High
Lomelo	40	12	30.0	Meso	20	High
Likitaung	158	41	25.9	Meso	19	High
Lokori	160	40	25.0	Meso	18	High
Lokichar	200	36	18.0	Meso	20	High
Kakuma Refugee camp*	601	84	14.0	Meso	9	Low
Kalokol	280	38	13.6	Meso	14	Medium
Central	320	39	12.2	Meso	12	Medium
Turkana district	**3,963**	**1,507**	**38.0**	**Hyper**	**19**	**High**

** The host and the refugee communities in Kakuma division were assessed separately*
#>30% = hyper-endemic, 10% to 30% = meso-endemic and <10% = hypo-endemic(8).
^ Total scores of 5-10 = low risk, 11-15 = medium risk and 16- 20 = high risk.

Kakuma Rural was assigned low risk score because it had free piped water and health care from the United Nation High Commission for Refugees. However, the survey results revealed that the division had a very high prevalence of TF (77.5%), similar to the neighbouring Oropoi (78.8%) and Loima (70.8%) divisions which did not have access to the free services. The data collection teams reported that some women in Kakuma Rural were travelling long distances to fetch water from shallow wells which they made by scooping sand from dry river beds. When asked why they were not using the free piped water, they said the "water from shallow wells is pure" but "piped water made their children contract pneumonia". The informants who assigned the risk scores were not aware of this attitude hence they award of low risk scores.

Lokichar division in Southern Turkana was assigned high risk score but the survey revealed that the division was meso-endemic. However, the neighbouring divisions were hyper-endemic.

The correlation between the total risk scores and the prevalence of TF for the administrative divisions is displayed in the scatter plot (*Figure 4.15*). The points on the plot are widely spread from the "best fit line" which represents the mean trend for the plot. The correlation was thus weakly positive, r= 0.37, p= 0.13. The correlation by segments was stronger (r= 0.78) but it was not statistically significant (p= 0.12). This implies that in a hyper-endemic setting like Turkana the risk assessment form does not work to differentiate the various levels of endemicity.

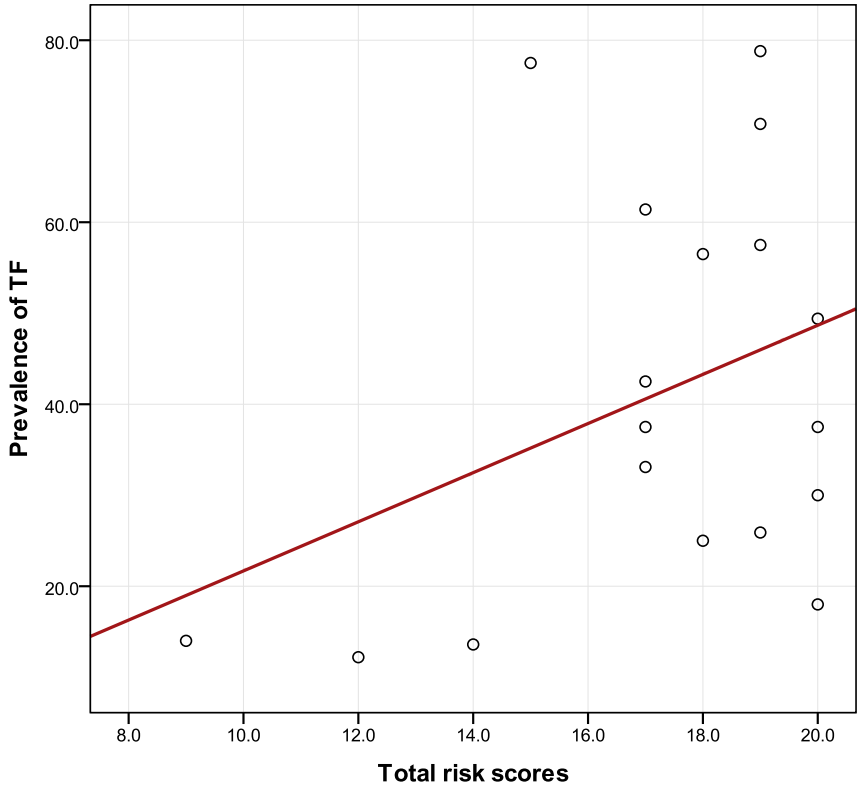


Figure 4.15: Correlation between prevalence of TF and trachoma risk scores in Turkana
Key: The points on the plot represent the 18 administrative divisions in Turkana district

4.3.3.2 Risk scores and prevalence of TF in Narok district

Narok district had 8 administrative divisions. The prevalence of TF and the total risk scores are shown in *Table 4.23*. Generally, the divisions with high risk scores had higher prevalence of TF than those with low risk scores. Mulot, Ololulung'a and Central divisions were assigned high scores because they had northern areas with low and southern areas with high risk of

trachoma. Furthermore, the risk assessment was confounded by the perennial north-south nomadic migrations. The results indicated that the three divisions were hypo-endemic.

Table 4.23: Prevalence of TF and pre-survey risk scores for Narok district

Division	**Number of children 1-9 years**			**Trachoma endemicity***	**Total risk scores**	**Risk**
	Examined	With TF	% with TF			
Mara	479	177	37.0	Hyper-endemic	19	High
Loita	160	50	31.3	Hyper-endemic	19	High
Osupuko	240	69	28.8	Meso-endemic	19	High
Ololulung'a	640	53	8.3	Hypo-endemic	17	High
Mau	800	66	8.3	Hypo-endemic	15	Medium
Central	560	22	3.9	Hypo-endemic	17	High
Mulot	639	3	0.5	Hypo-endemic	16	Medium
Olkurto	480	0	0.0	Hypo-endemic	14	Medium
Narok district	**3998**	**440**	**11.0**	**Meso-endemic**	**17**	**High**

**>30% = hyper-endemic, 10% to 30% = meso-endemic and <10% = hypo-endemic(8).*

The prevalence of TF is likely to be lower if a survey is conducted soon after mass treatment than when the survey is delayed. *Table 4.24* shows the comparison of the risk scores in relation to the months when the last round of mass treatment was distributed and the prevalence of TF as determined in both the 2004 survey and this study. The months the surveys were conducted are indicated, though not by divisions since each survey had more than 1 data collection teams and convenient survey route maps were used. They were not conducted by divisions and none took more than one month to complete data collection.

Table 4.24: Mass antibiotic treatment in 2010, trend of TF prevalence and risk scores

Division	Time of mass treatment	TF prevalence (endemicity)*		Risk score
		Baseline survey report (June 2004)^	This study (December 2010)^	
Loita	April	86.3%(+++)	31.3%(+++)	19
Osupuko	April	81.5%(+++)	28.8%(++)	19
Mara	April	58.2%(+++)	37.0%(+++)	19
Mau	July	35.2%(+++)	8.3%(+)	15
Central	July	17.5%(++)	3.6%(+)	17
Ololulunga	May	15.5%(++)	8.3%(+)	17
Mulot	May	2.2%(+)	0.5%(+)	16
Olokurto	July	0.0%	0.0%	14
Narok District	**April-July**	**30.5%(hyper)**	**11%(meso)**	**17**

**(+++) = hyper-endemic, (++) = meso-endemic and (+) = hypo-endemic*

^The 2004 survey had twenty clusters while the 2010 survey had 100 clusters

Loita, Osupuko and Mara divisions in the south were assigned high risk scores. Also, they were reported to be hyper-endemic in both surveys. However, Mau division was hyper-endemic in 2004 and hypo-endemic in 2010. The risk scores were more related to the 2004 prevalence estimate than the 2010 estimate, probably due to the fact that the division was among the last areas to be treated. Also, this could be due to the way the risk scores were assigned since the key informants had the 2004 survey findings. The other divisions with similar findings were Central and Ololulung'a. Both were meso-endemic in 2004, hypo-endemic in 2010 and had high risk scores.

The correlation between the total risk scores and the prevalence of TF for the eight divisions in Narok districts (*Figure 4.16*) was strongly positive, r= 0.87, p= <0.01. The "best fit line" indicates the mean trend for the points on the plot. This means that the key informants were able to differentiate the areas with high prevalence and low prevalence of TF in the entire district. However, the plot shows two distinct sets of data points representing the divisions <10% and those with >10%. If each set was analysed separately, the correlation would be poor and not significant. This implies in a setting with clustered trachoma, the key informants were able to differentiate between large areas with a big difference in the prevalence of TF like the northern and the southern Narok areas but they could not differentiate smaller areas with small differences.

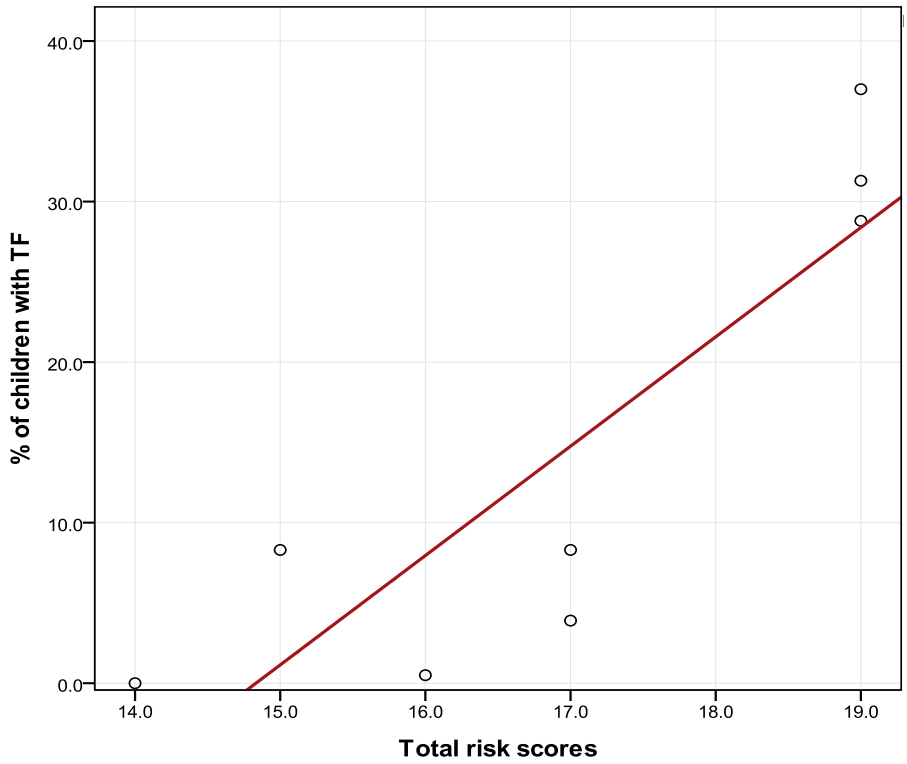


Figure 4.16: Correlation between the prevalence of TF and total risk scores in Narok

Key: The points on the plot represent the 8 administrative divisions in Narok district

The correlation by survey segments (*Figure 4.17*) was strongly positive r= 0.97, p= <0.01). The points on the plot are closer to the "best fit line" than in *Figure 4.16*. This made the correlation for the survey segments stronger than that for the administrative divisions. The segments were created by aggregating administrative units with similar risk scores and that amplified the difference between the segments with low risk scores and those with high risk scores.

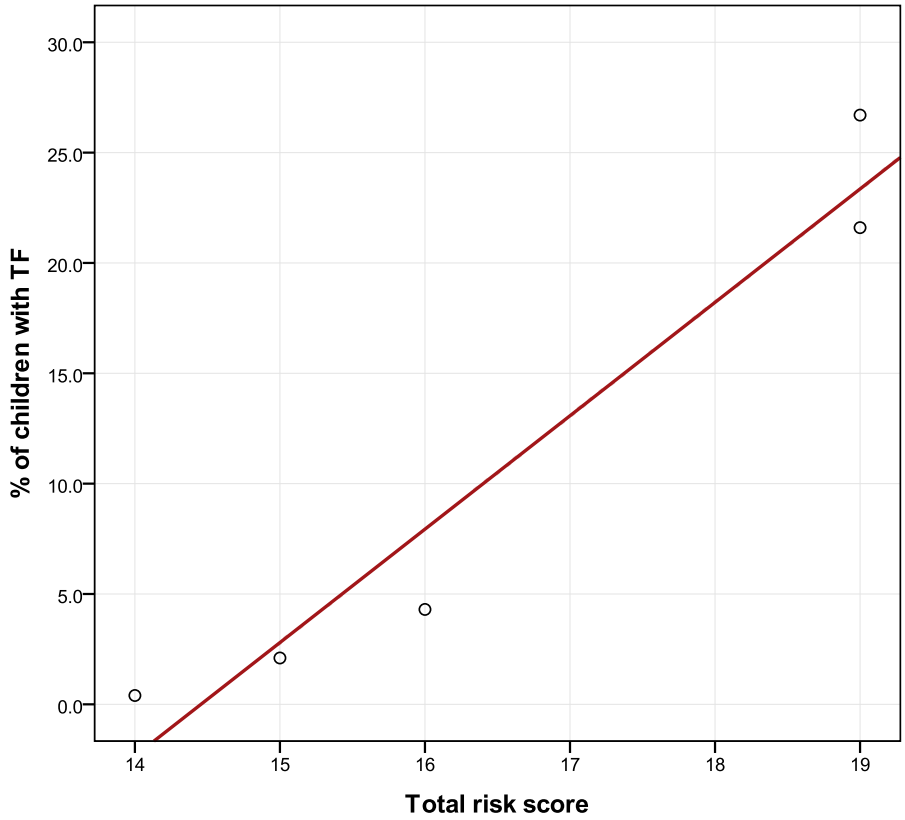


Figure 4.17: Correlation between the prevalence of TF and total risk scores by segments

Key: The points on the plot represent the 5 survey segments for Narok district

4.4 Trachomatous trichiasis surveys

4.4.1 Re-analysis of previous TT survey data

4.4.1.1 Prevalence of TT

The data sets for six previously-surveyed districts in Kenya(25, 31) were re-analysed to calculate the optimum suitable age for subsequent TT surveys. The study participation rates for the six surveys were >95%. A total of 7,944 persons aged ≥15 years were examined, of who 316 had TT (*Table 4.25*). The mean prevalence of TT was 4.0 (95%CI: 3.6%-4.4%) but it ranged between 1.0% in Meru North district and 6.0% in Samburu district.

Table 4.25: Prevalence of TT in the six previously-surveyed districts in Kenya(25, 31)

Districts	**Adults ≥15 years old**			
	Examined	With TT	% with TT	95% CI
Samburu	1,368	82	6.0	4.7 - 7.3
Baringo	1,432	83	5.8	4.6 - 7.0
West Pokot	1,374	79	5.7	4.5 - 7.0
Kajiado	1,414	46	3.3	2.4 - 4.3
Meru North	1,131	11	1.0	0.4 - 1.6
Laikipia	1,225	15	1.2	0.6-1.8
Total	**7,944**	**316**	**4.0**	**3.6-4.4**

Table 4.26 shows the mean prevalence of TT in the six districts by age. It ranged between 15.2% in persons aged ≥60 years and 4.0% in those aged ≥15 years. The multipliers (correction factors) to be used to extrapolate the prevalence of TT for the standard age (≥15 years) using the prevalence estimates for the other age categories are shown in the last column. The correction factors were calculated by dividing the prevalence for a specified age limit by that for ≥15 years. For example the prevalence of TT in persons ≥50 years was 13.3% and the correction factor was 13.3 divided by 4.0 = 3.3. For the age of ≥40 years the correction factor was 9.4 divided by 4.0 = 2.4. The prevalence estimates for the TT surveys conducted in this study were therefore divided by 2.4 when extrapolating the likely prevalence for the population ≥15 years.

Table 4.26: Prevalence of TT and correction factors for different age categories

Age	**Number of subjects**			
(years)	Total examined	With TT	Prevalence of TT (%)	Correction factor*
≥60	1,111	169	15.2	3.8
>50	1,775	231	13.0	3.3
≥40	2,925	275	9.4	2.4
≥30	4,450	296	6.7	1.7
≥20	6,795	314	4.6	1.2
≥15	7,944	316	4.0	1.0

**Correction factor = prevalence for a given* age category *divided by that for age ≥15 years*

The calculation of the correction factors for prevalence of TT for individual districts is shown in *Table 4.27* and they varied among the six districts. For example for the age of ≥50 years, they range between 2.4 in Samburu and 3.8 in West Pokot, Kajiado, Laikipia and Meru North districts. For the age of 40 years they ranged between 2.0 Samburu and 2.9 in Laikipia district. The age category of ≥15 years was the only one without any variation because it is the standard.

Table 4.27: Prevalence of TT and correction factors for individual districts

Age (years)	Variable	Previously surveyed districts					
		Samburu	Baringo	West Pokot	Kajiado	Laikipia	Meru North
≥60*	Subjects	266	233	164	107	187	154
	TT cases(%)	46(17.3)	38(16.3)	45(27.4)	20(18.7)	12(6.4)	8(5.2)
	Factor*	**2.9**	**2.8**	**4.8**	**5.7**	**5.3**	**5.2**
≥50	Subjects	426	382	289	159	281	238
	TT cases(%)	63(14.8)	60(15.7)	62(21.5)	24(15.3)	13(4.6)	9(3.8)
	Factor*	**2.4**	**2.7**	**3.8**	**3.8**	**3.8**	**3.8**
≥40	Subjects	621	577	473	488	400	366
	TT cases(%)	73(11.8)	74(12.8)	72(15.2)	32(6.6)	14(3.5)	10(2.7)
	Factor*	**2.0**	**2.2**	**2.7**	**2.0**	**2.9**	**2.7**
≥30	Subjects	867	830	796	739	653	565
	TT cases(%)	80(9.2)	80(9.6)	74(9.3)	37(5.0)	15(2.3)	10(1.8)
	Factor*	**1.5**	**1.7**	**1.6**	**1.5**	**1.9**	**1.8**
≥20	Subjects	1,208	1,231	1,115	1,239	1,064	938
	TT cases(%)	82(6.8)	82(6.6)	79(7.1)	45(3.6)	15(1.4)	11(1.1)
	Factor*	**1.1**	**1.1**	**1.2**	**1.1**	**1.2**	**1.1**
≥15#	Subjects	1,368	1,432	1,374	1,414	1,225	1,131
	TT cases(%)	82(6.0)	83 (5.8)	79 (5.7)	46(3.3)	15(1.2)	11(1.0)
	Factor*	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

**Factor = correction factor*

The range for a specified age category was calculated by subtracting the lowest correction factor among the six districts from the highest while the ratio was calculated by dividing the range by the corresponding mean correction factor (*Table 4.28*).

Table 4.28: Assessment of the precision of the correction factors for prevalence of TT

Age	**Correction factors**				
(years)	Mean	Lower limit	Upper limit	Range	Ratio
≥60	3.8	2.8	5.7	2.9	0.8
≥50	3.3	2.4	3.8	1.4	0.4
≥40	2.4	2.0	2.9	0.9	0.4
≥30	1.6	1.5	1.9	0.4	0.3
≥20	1.2	1.1	1.2	0.1	0.1
≥15	1.0	1.0	1.0	0.0	0.0

The age ≥50 years had a range of 1.4 and a ratio of 0.4 while the age ≥40 years had a range of 0.9 and a ratio 0.4. The range and the ratio for age ≥15 years was zero the correction factors were 1.0 for all the districts (no variation). The range and ratio decreased as the age of the survey participants decreased. This meant that the correction factors for older

categories were more variable for the younger age ones. A high ratio was interpreted to indicate a low precision. Therefore, the extrapolated prevalence of TT in the whole population is less accurate when the data used is from surveys with old participants than when the data is from surveys which include younger participants.

4.4.1.2 Backlog of TT

The term backlog of TT refers to the number of people with TT in a specified population. However, in this study the analysis was done using the TT cases diagnosed during the six previously surveys. It was assumed that the study populations were representative of the reference populations because non-biased selection methods were used. The distribution of the TT cases by age limits is shown in *Table 4.29*. The percentage of the cases (backlog) for the age of ≥15 years is 100% for all the districts because it includes all the cases.

The percentage of the TT cases in a given age category indicates the amount of TT backlog which would be determined if that age category is used in a TT survey.

Table 4.29: Cumulative number of subjects with TT

Age	**Number of TT cases and (percentages) diagnosed in the six districts**						
(years)	Samburu	West Pokot	Baringo	Kajiado	Meru North	Laikipia	Total
≥80	5(6.1)	7(8.9)	6(7.2)	7(15.2)	4(36.4)	3(20.0)	32(10.1)
≥70	20(24.4)	24(30.4)	21(25.3)	14(30.4)	7(63.6)	6(40.0)	92(29.1)
≥60	46(56.1)	45(57.0)	38(45.8)	20(43.5)	8(72.7)	12(80.0)	169(53.5)
≥50	63(76.8)	62(78.5)	60(72.3)	24(52.2)	9(81.8)	13(86.7)	231(73.1)
≥40	73(89.0)	72(91.1)	74(89.2)	32(69.6)	10(90.9)	14(93.3)	275(87.0)
≥30	80(97.6)	74(93.7)	80(96.4)	37(84.4)	10(90.9)	15(100)	296(93.7)
≥20	82(100)	79(100)	82(98.8)	45(97.8)	11(100)	15(100)	314(99.4)
≥15	82(100)	79(100)	83(100)	46(100)	11(100)	15(100)	316(100)
Total	**82(100)**	**79(100)**	**83(100)**	**46(100)**	**11(100)**	**15(100)**	**316(100)**

**Age ≥15 years is the standard age range for a TT survey*

Figure 4.18 shows the percentages of TT cases (backlog) likely to be missed in TT surveys with different age categories. Each percentage in the last column of *Table 4.29* was subtracted from 100% to derive the corresponding percentage in *Figure 4.18*. Persons aged ≥40 years had 87.0% of the total backlog; hence the percentage of the total backlog likely to be missed in a TT survey with participants aged ≥40 years is 100% minus 87.0% = 13.0%. The amount of backlog which could be missed in a survey participants aged ≥50 years is 26.9% (100%-73.1%).

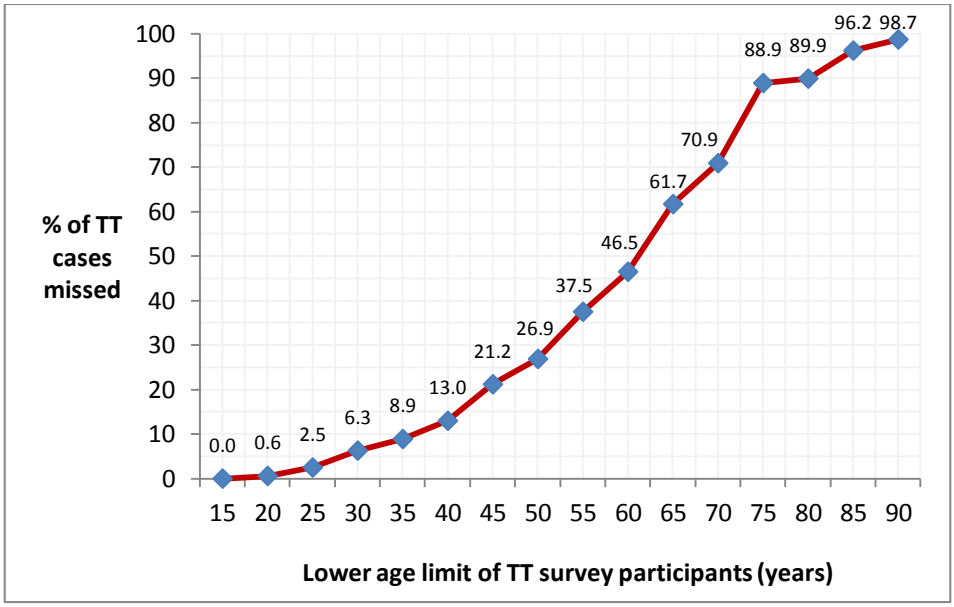


Figure 4.18: Percentage of TT cases likely be missed (n=316 TT cases)

The calculation of the backlog of TT correction factors for individual districts is shown in *Table 4.30*. The number of TT cases for the age ≥15 years was divided by the number of cases for a specified age category to derive the backlog correction factor. For example, the total number of TT cases for the age ≥15 years were 316 while for the age ≥40 years were 275. The correction factor for the age limit of ≥40 years was therefore 316/275 = 1.1.

Table 4.30: Correction factors for estimating the backlog of TT

Age	**Number of TT cases and the (correction factor)***						
(years)	Samburu	West Pokot	Baringo	Kajiado	Laikipia	Meru North	Total
≥80	5(16.4)	7(11.3)	6(13.8)	7(6.6)	3(5.0)	4(2.8)	32(9.9)
≥70	20(4.1)	24(3.3)	21(4.0)	14(3.3)	6(2.5)	7(1.6)	92(3.4)
≥60	46(1.8)	45(1.8)	38(2.2)	20(2.3)	12(1.3)	8(1.4)	169(1.9)
≥50	63(1.3)	62(1.3)	60(1.4)	24(1.9)	13(1.2)	9(1.2)	231(1.4)
≥40	73(1.1)	72(1.1)	74(1.1)	32(1.4)	14(1.1)	10(1.1)	275(1.1)
≥30	80(1.0)	74(1.1)	80(1.0)	37(1.2)	15(1.0)	10(1.1)	296(1.1)
≥20	82(1.0)	79(1.0)	82(1.0)	45(1.0)	15(1.0)	11(1.0)	314(1.0)
≥15	82(1.0)	79(1.0)	83(1.0)	46(1.0)	15(1.0)	11(1.0)	316(1.0)
Total	**82 (1.0)**	**79(1.0)**	**83(1.0)**	**46(1.0)**	**15(1.0)**	**11(1.0)**	**316(1.0)**

**Correction factor = TT cases for age ≥15 years divided by those for a specified* age category

The correction factors were not equal for all the six districts. For example for the age ≥50 years, the correction factors ranged between 1.2 in Laikipia and Meru North districts and 1.9 in Kajiado district, with a mean of 1.4. For age ≥40 years, the correction factors were 1.1 for all the districts except Kajiado which had 1.4 and the mean was 1.1.

To measure how the correction factors for the six districts varied, a range was calculated by deducting the lowest correction factor for a specified age category from the highest, among the six districts (*Table 4.31*). A ratio was then extrapolated by dividing the range by the corresponding mean. For example the age of ≥50 years had a range of 1.9 (Kajiado) minus 1.2 (Laikipia) = 0.7. The ratio was derived by dividing the 0.7 by 1.4 (the mean for the six districts) = 0.5. For the age ≥40 years, the range was 1.4 (Kajiado) minus 1.1 (the rest of the districts) = 0.3. The ratio was 0.3 divided by 1.1 = 0.3. The range and the ratio for age ≥15 years was zero since there was no variation in the correction factors for the six districts.

A wide range and a high ratio were interpreted to mean a correction factor with a low precision. *Table 4.31* shows that the older age categories had wider range and higher ratios than the younger categories. This means that the extrapolation of the backlog of TT is less precise if the data used is from TT surveys with old participants than when the data is from surveys with young participants.

Table 4.31: Assessment of the precision of the correction factors for backlog of TT

Age	**Correction factors**				
(years)	Mean	Lower limit	Upper limit	Range	Ratio
≥60	1.9	1.3	2.3	1.0	0.5
≥50	1.4	1.2	1.9	0.7	0.5
≥40	1.1	1.1	1.4	0.3	0.3
≥30	1.1	1.0	1.1	0.1	0.1
≥20	1.0	1.0	1.0	0.0	0.0
≥15	1.0	1.0	1.0	0.0	0.0

Figure 4.19 displays both the prevalence and backlog of TT correction factors. The correction factors for the prevalence of TT were higher than those for the backlog of TT in all the age categories. Between the age of ≥15 years (correction factor 1.0) and ≥40 years (correction factor 1.1), there was minimal increase in the value of the backlog of TT correction factor. However, the value of the prevalence of TT correction factor had more than doubled, from 1.0 to 2.4.

The selection of an optimum lower age limit for TT survey was to ensure that the time required to complete a TT survey was the same as the time required to complete a TF survey, while ensuring that the sample was adequately representative of the TT backlog. This was achieved by selecting an age category with a TT prevalence which is approximately equal to the 10% prevalence level used to calculate the samples with the TSS method. Both

the age of ≥40 years and ≥50 years fulfilled this criterion. However, the age of ≥50 years could miss a larger backlog of TT than the age of ≥40 years.

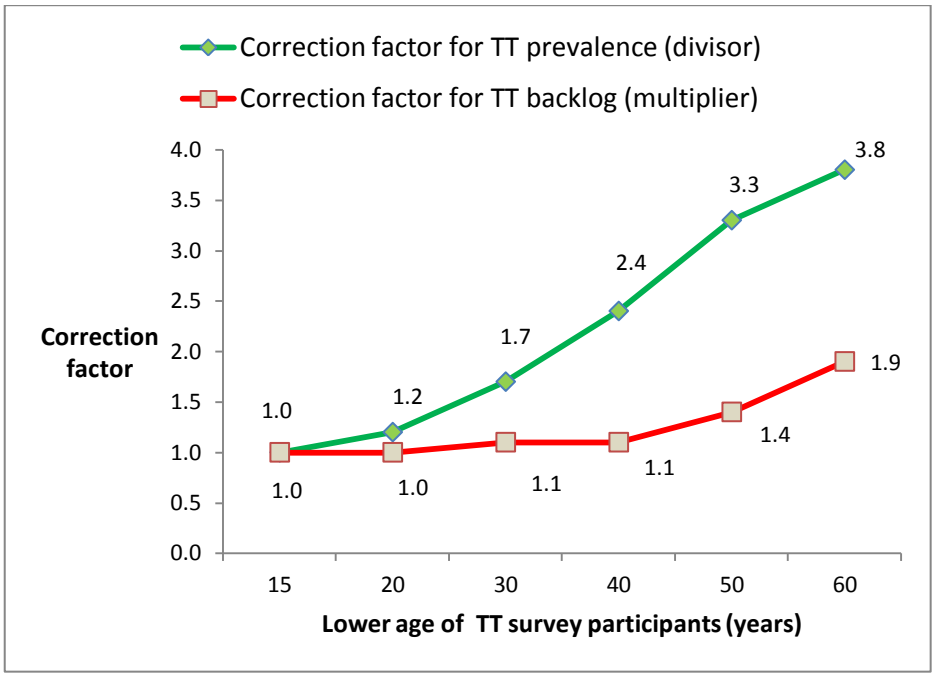


Figure 4.19: Correction factors for prevalence and backlog of TT

The final consideration was the range for the correction factors. The mean, minimum and the maximum correction factors for the six districts whose data were re-analysed are summarised in *Figures 4.20 and 4.21.* The difference between the lower and the upper limits (range) for the older age categories were wider than for the younger categories.

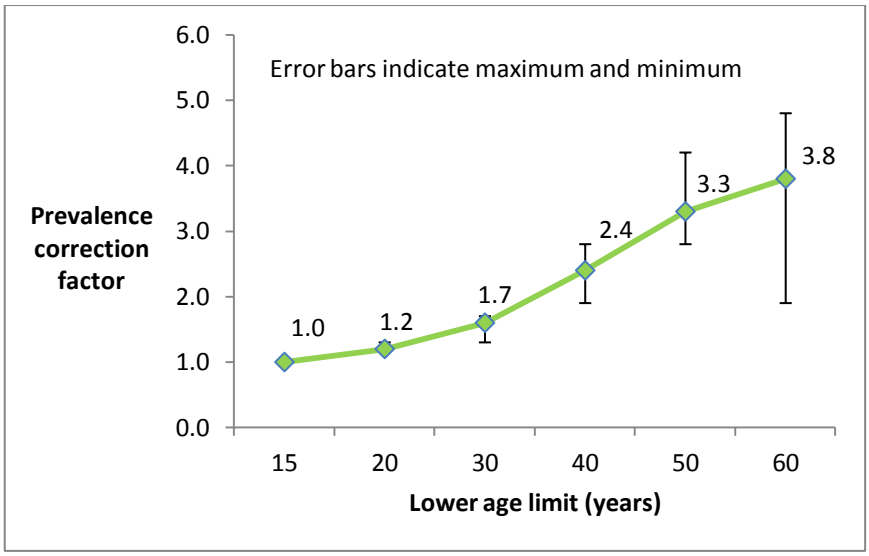


Figure 4.20: The mean and the range of the prevalence of TT correction factors for the six districts

For backlog correction factors (Figure 4.21) the range was very small for ages <40 years.

Therefore, the age of 40 years was selected as the optimum lower age limit for TT survey participants to maximise the identification of TT cases.

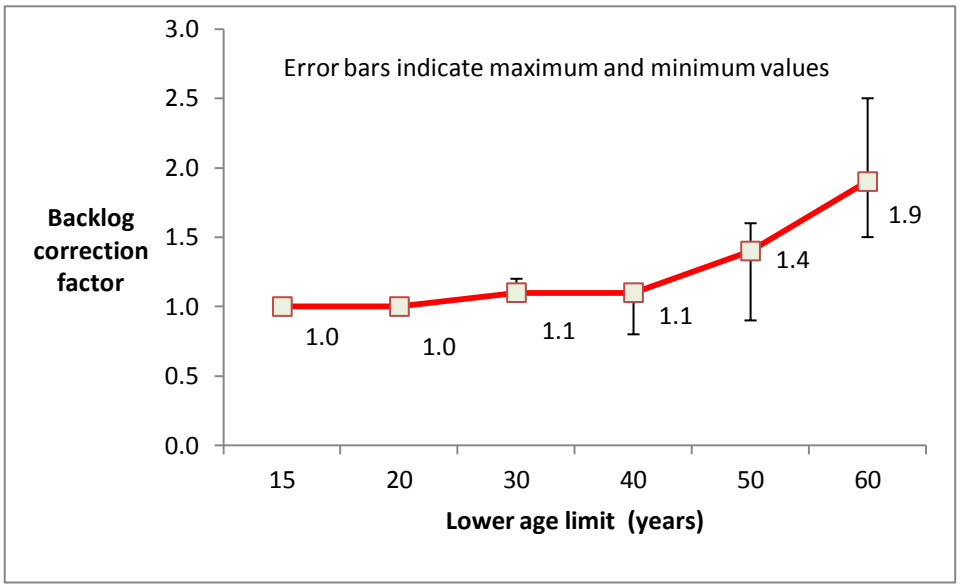


Figure 4.21: The mean and range for the backlog of TT correction factors for the six districts

4.4.2 TT40 survey in a hyper-endemic setting

4.4.2.1 Study population

Two thousand nine hundred and sixty-two subjects aged ≥40 years were examined in Turkana administrative district (*Table 4.32*) and the study participation rate was 98.7%. The number of participants and TT cases reported using the daily tallies transmitted via mobile telephone messages and the survey data sets were the same. The participation rate by segments was: Western Turkana 99.4%, Northern Turkana 100%, Southern Turkana 98.3%, Central Turkana 100%, and the refugee camp 94.7%.

Table 4.32: Distribution of the survey participants aged ≥40 years in Turkana district

Segment	Number of clusters	Sample size	Number examined		
			Men	Women	Total
Western Turkana	23	690	205 (18.7 %)	481 (25.8 %)	686 (23.2 %)
Northern Turkana	21	630	231 (21.1 %)	399 (21.4 %)	630 (21.3 %)
Southern Turkana	21	630	266 (24.3 %)	354 (19.0 %)	620 (20.9 %)
Central Turkana	20	600	239 (21.8 %)	361 (19.3 %)	600 (20.3 %)
Refugee camp	15	450	154 (14.1 %)	272 (14.6 %)	426 (14.4 %)
Turkana district	**100**	**3,000**	**1,095(100%)**	**1,867(100%)**	**2,962(100%)**

The distribution of the study participants by age and gender is shown in *Table 4.33* and the male to female ratio was 1.0:1.7. The male to female ratio by segments was: Western Turkana 1.0:2.3, Northern Turkana 1.0:1.7, Southern Turkana 1.0:1.3, Central Turkana 1.0:1.5 and the refugee camp 1.0:1.8.

The 1999 census (Table 4.*33*) reported that male to female ratio in Turkana district was 1.0:1.2. This indicates that women could have been over-represented in this study, especially in the Western and Northern segments and the refugee camp. Turkana population structure may be affected by the perennial influx of refugees. In addition, the district is insecure and young men are killed in the conflicts. Men also move from place to place with cattle looking for pastures and to towns in search of jobs.

Table 4.33: Distribution by age and sex of the study population and 1999 census

Age	**Adults ≥40 years old examined**			**Total population (1999 census)**	
(years)	Men	Women	Total	Men	Women
40-49	391(35.7%)	856(45.8%)	1,247(42.1%)	12,953(48.3%)	16,921(54.6 %)
50-59	257(23.5%)	439(23.5%)	696(23.5%)	8,087(30.1 %)	8,405(27.1 %)
60-69	273(24.9%)	378(20.2%)	651(22.0%)	3,923(14.6 %)	3,889(12.6 %)
70-79	153(14.0%)	154(8.2%)	307(10.4%)	1,431 (5.3 %)	1,343(4.3 %)
80+	21(1.9%)	40(2.1%)	61(2.1%)	440 (1.6 %)	412(1.3 %)
Total	**1,095(100%)**	**1,867(100%)**	**2,962(100%)**	**26,834(100%)**	**30,970(100%)**

The distribution of men and women by age in the study population correlated well with the distribution of men (r= 0.97, p= <0.01) and women (r= 0.99, p= <0.01) respectively in the census.

Men (mean age 55.7 years, standard deviation 11.2 years) were older than the women (mean age 53.1 years, standard deviation 10.9 years, χ^2= 89.9, df= 52, p= <0.01. *Figure 4.22* displays the age of the study participants by segments. The participants from the refugee camp were younger (median age of 46 years) than those from the other segments. The Turkana is a polygamous community and the men live with their youngest wives.

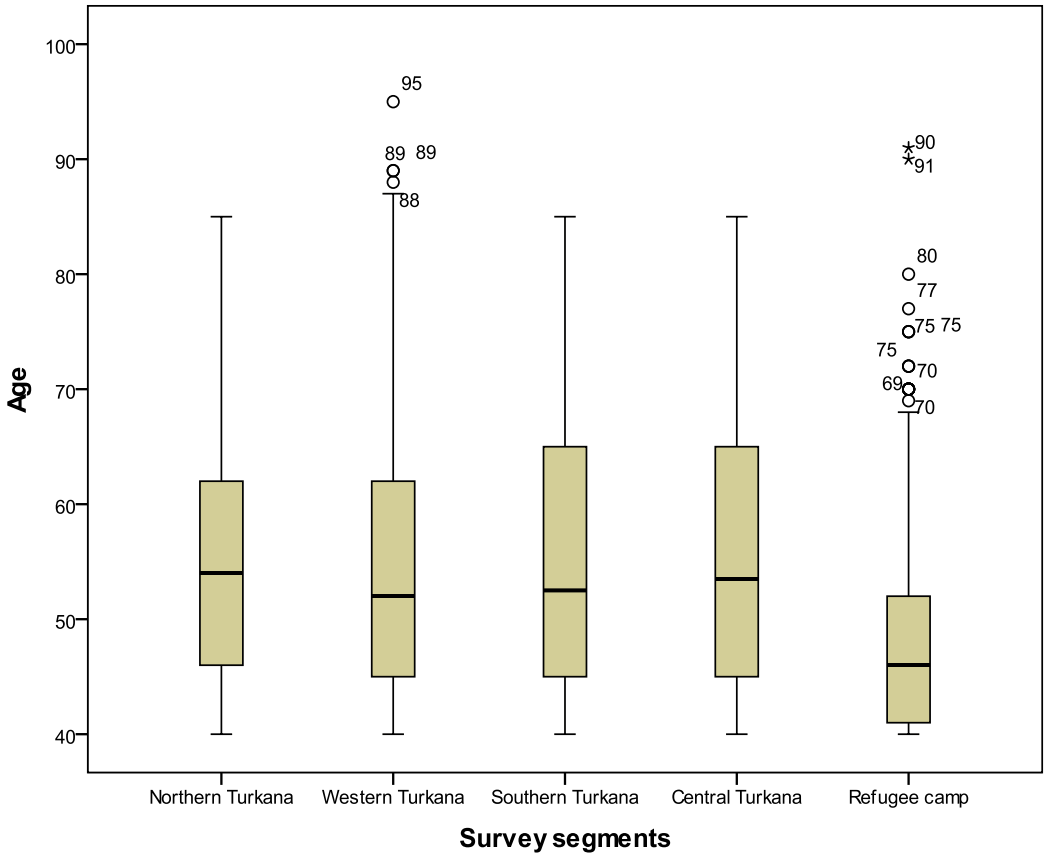


Figure 4.22: Age of the Turkana TT survey subjects by segments

4.4.2.2 Formal education

Most (97.1%) of the adult subjects from Turkana had no formal education. The percentage of men without formal education (95.7%) was lower than of women (98.5%), χ^2= 40.6, df= 3, p= <0.01. The education status of two subjects was not recorded.

4.4.2.3 Prevalence of TT in Turkana

Two hundred and thirty-one subjects out of 2,962 study participants aged ≥40 years old had TT (*Table 4.34*) and the prevalence of TT in the district was 7.8% (95%CI: 6.8%-8.8%). The subjects recorded as having TT included those who were epilating their eye lashes and those with recurrent TT after surgery.

The lowest prevalence was recorded in the refugee camp (1.2%, 95%CI: 0.1%-2.3%) while the highest was in Western Turkana (13.3%, 95%CI:10.7%-15.9%). The distribution of TT by segments was parallel to the one for TF.

Table 4.34: Distribution of TT by segments in Turkana district

Segment	Adults ≥40 year old					
	Total examined	People with TT				
		One eye	Both eyes	Total	Percentage	95% CI
Western	686	24	67	91	13.3	10.7-15.9
Southern	620	25	30	55	8.9	6.5-11.1
Northern	630	32	23	55	8.7	6.6-11.2
Central	600	14	11	25	4.2	2.6-5.8
Refugee camp	426	1	4	5	1.2	0.1-2.3
Turkana district	**2,962**	**96**	**135**	**231**	**7.8**	**6.8-8.8**

The prevalence for age ≥40 years was divided by the correction factor of 2.4 to extrapolate the likely prevalence of TT in the population ≥15 years as follows: 7.8%/2.4 = 3.3%. The prevalence estimates for age ≥15 years by segments were: Western Turkana 5.5%, Northern Turkana 3.6%, Southern Turkana 3.7%, Central Turkana 1.8%, and the refugee camp 0.5%. TT surgical services were thus needed in all the surveyed segments because none had achieved the ultimate intervention goal of having <1 case of TT per 1,000 people in the general population.

One hundred and sixty-six women ≥40 years old had TT and the prevalence in women was 8.9% (95%CI: 7.6%- 10.2%). Sixty-eight women had TT in one eye while 98 had it in both eyes. Sixty-five out of 1,095 men ≥40 years old had TT and the prevalence of TT in men was 5.9% (95%CI: 4.5%-7.3%). Twenty-eight men had TT in one eye while 37 had it in both eyes. The prevalence of TT in women was higher than in men (χ^2=8.4, df=1, p= 0.01).

The distribution of people aged ≥40 years who were examined in Turkana district by age was as follows: 40-49 years 1,247, 50-59 years 696, 60-69 years 651, 70-79 years 307 and 80+ years 61 people. *Table 4.35* shows the distribution of the people who had TT by age and survey segments. There were no people aged ≥70 years with TT in the refugee camp and ≥80 years in the Central segment.

As expected the prevalence of TT increased with advancing age (*Figure 4.23*).

Table 4.35: Distribution of TT by age in the surveyed segments

Age (years)	Adults ≥40 years old with TT					
	Western	Northern	Southern	Central	Camp	Turkana district
40-49	26(28.6%)	10(18.2%)	8(14.6%)	5(20.0%)	2(40.0%)	51(22.1%)
50-59	24(26.3%)	11(20.0%)	7(12.7%)	4(16.0%)	1(20.0%)	47(20.4%)
60-69	26(28.6%)	22(40.0%)	23(41.8%)	9(36.0%)	2(40.0%)	82(35.5%)
70-79	10(11.0%)	11(20.0%)	13(23.6%)	7(28.0%)	0(0.0%)	41(17.7%)
80+	5(5.5%)	1(1.8%)	4(7.3%)	0(0.0%)	0(0.0%)	10(4.3%)
Total	**91(100%)**	**55(100%)**	**55(100%)**	**25(100%)**	**5(100%)**	**231(100%)**

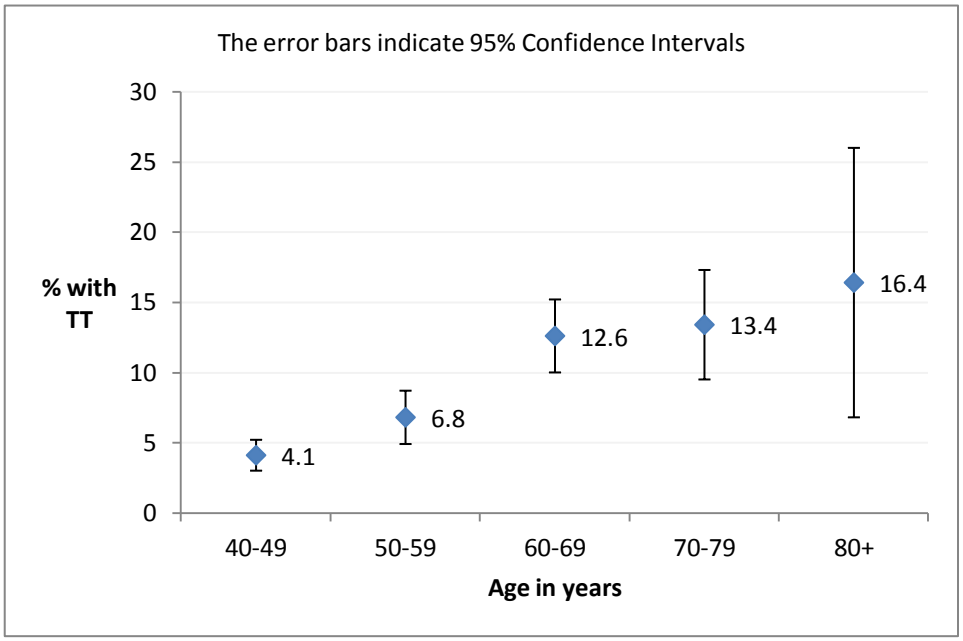


Figure 4.23: Prevalence of TT by age in Turkana district

The backlog of people with TT in Turkana district was calculated as follows: 7.8% prevalence of TT x 69,365 people aged ≥40 years in the district = 5,410 people with TT. The sum of the backlog of TT in the five segments was 5,661, which is higher than the backlog calculated using the mean prevalence for the entire administrative district (*Table 4.36*). This difference could be due to errors in the estimation of the population in the segments since the population estimates for Turkana were projected from an old 1999 census report.

The backlog of TT for the standard age ≥15 years was extrapolated using the correction factor of 1.1 derived from the re-analysis of the data sets for previous TT surveys as follows: 5,410 people ≥40 years with TT x 1.1 = 5,952 people ≥15 years old with TT in Turkana district. The 95% confidence limits indicated that the backlog of TT was likely to range between 4,717 to 6,104 people.

Table 4.36: Backlog of people ≥40 years old with TT in Turkana district

Segments	Population ≥40 years old	Prevalence of TT	95%CI		Backlog of TT		
			Lower limit	Upper limit	Mean (%)	Lower limit	Upper limit
Western Turkana	18,176	13.3	10.7	15.7	2,417(44.7)	1,945	2,854
Southern Turkana	14,566	8.9	6.5	11.1	1,296(24)	947	1,617
Northern Turkana	14,566	8.7	6.6	11.2	1,267(23.4)	961	1,631
Central Turkana	13,872	4.2	2.6	5.8	583(10.8)	361	805
Refugee camp	8,186	1.2	0.1	2.3	98(1.8)	8	188
Turkana district	**69,361**	**7.8**	**6.8**	**8.8**	**5,410(100)**	**4,717**	**6,104**

*The population projected from the 2009 census. ^The sum for the segments = 5,661

4.4.2.4 Prevalence of Corneal Opacity

In Turkana, 67 subjects (2.2%, 95%CI: 1.8%-2.9%) had CO. Fifty-five of them had CO in one eye while 12 it in both eyes. Twenty (29.9%) of the people with CO had TT in the eyes with CO. Forty-seven (69.1%) had neither TT in the eyes with CO nor evidence that they were epilating the eye lashes. This indicates that there are other non-trachomatous causes of CO in Turkana district.

Forty-six of the people with CO were women and 21 were men.

4.4.2.5 TT surgical coverage

In the Turkana survey, 11 subjects (0.4%, 95%CI: 0.2%-0.6%) had TT surgical scars, one man and 10 women. Out of the 11 subjects, 8 had TT surgical scars in one eye and 3 had TT surgical scars in both eyes. The number of eyes with surgical scars was 8 + (3 x 2) = 14 eyes. Seven subjects with TT surgical scars in one eye had recurrent TT. The TT recurrence rate was 50% (7 eyes with TT surgical scars divided by 14 eyes). Two subjects with TT surgical scars in one eye had CO in the same eye.

The TT surgical coverage for people aged ≥40 years was 4.5%. This was calculated using *Equation 2*; where: a = number of subjects ≥40 years old with TT scars in both eyes (3 subjects); b = number of subjects with TT scar in one eye and TT in the other eye (8 subjects); and c = total number of subjects with TT (231 subjects).

Equation 2: Estimation of the TT surgical coverage for people $= \frac{a+b}{a+b+c}$

The TT surgical coverage for eyes was 3.7%. It was calculated using *Equation 3*; where x = the number of eyes with TT surgical scars (14 eyes) and y = number of eyes with TT (366 eyes).

Equation 3: Estimation of the TT surgical coverage for eyes $= \frac{x}{x+y}$

4.4.2.6 Barriers to TT surgery

The subjects who had TT (n=163) were asked why they had not gone for TT surgery. The main reasons given for not going for TT surgery were: hospitals being too far, not knowing that TT could be surgically corrected and lack of money (*Table 4.37*).

Table 4.37: Barriers to TT surgery in Turkana district

Reason why subject had not gone for surgery	Number of respondents	Percentage
Hospital is too far	66	40.5
Does not know it is operable	55	33.7
No money	22	13.5
Fear of surgery	11	6.7
Too old to go for surgery	4	2.5
Busy, no time	4	2.5
No permission from husband	1	0.6
Total	**163**	**100**

4.4.3 TT40 survey in a meso-endemic setting

4.4.3.1 Study population

Three thousand subjects aged ≥40 years were examined in Narok administrative district. The ages of three subjects were not recorded; hence they were excluded from analysis. The study participation rate was virtually 100% (*Table 4.38*). The number of participants and TT cases reported using the daily tallies transmitted via mobile telephone messages and the survey data sets were the same.

Table 4.38: Distribution of the survey clusters and adults ≥40 years old in Narok district

Segment	Number of clusters	Sample size	Number examined		
			Men	Women	Total
North Western	20	600	311 (22.9 %)	289 (17.6 %)	600 (20.0 %)
North Eastern	20	600	294 (21.7 %)	306 (18.6 %)	600 (20.0 %)
Central	20	600	305 (22.5 %)	295 (18.0 %)	600 (20.0 %)
South Eastern	20	600	214 (15.8 %)	386 (23.5 %)	600 (20.0%)
South Western	20	600	232 (17.1 %)	365 (22.2 %)	597 (19.9 %)
Narok district	**100**	**3,000**	**1,356(100%)**	**1,641(100%)**	**2,997(100%)**

The male to female ratio was 1.0:1.1, which is approximately equal to the 1:1.2 in the 2009 census report (*Table 4.39*).

The distribution of men and women by age in the study population correlated well with the distribution in the 2009 census (r= 0.98, p= <0.01 for both men and women).

Table 4.39: Distribution by age and sex of the study population and 2009 census

Age	Adults ≥40 years examined			Total population (2009 census)	
(years)	Men	Women	Total	Men	Women
40-49	754(55.6%)	989(60.3%)	1,743(58.2%)	17,433(47.1 %)	16,445(47.2 %)
50-59	263(19.4%)	262(16.0%)	525(17.5%)	9,275(25.1 %)	7,936(22.7 %)
60-69	154(11.3%)	198(12.1%)	352(11.7%)	5,501(14.9 %)	5,179(14.9 %)
70-79	130(9.6%)	124(7.5%)	254(8.5%)	2,743(7.4 %)	2,782(8.0 %)
80+	55(4.1%)	68(4.1%)	123(4.1%)	2,037(5.5%)	2,529(7.2 %)
Total	**1,356(100%)**	**1,641(100%)**	**2,997(100%)**	**36,989(100%)**	**34,871(100 %)**

The mean age for the adults was 51.1 years with a standard deviation (SD) of 11.8 years. Men (mean age 51.6 years, SD±11.9 years) were older than women (mean age 50.7 years, SD±11.8 years) (χ^2= 82.6, df= 56, p= 0.01). Five participants were aged >100 years (*Figure 4.24*). The participants from the southern segments had a median age of 47 years and those from the central and northern segments 46 years.

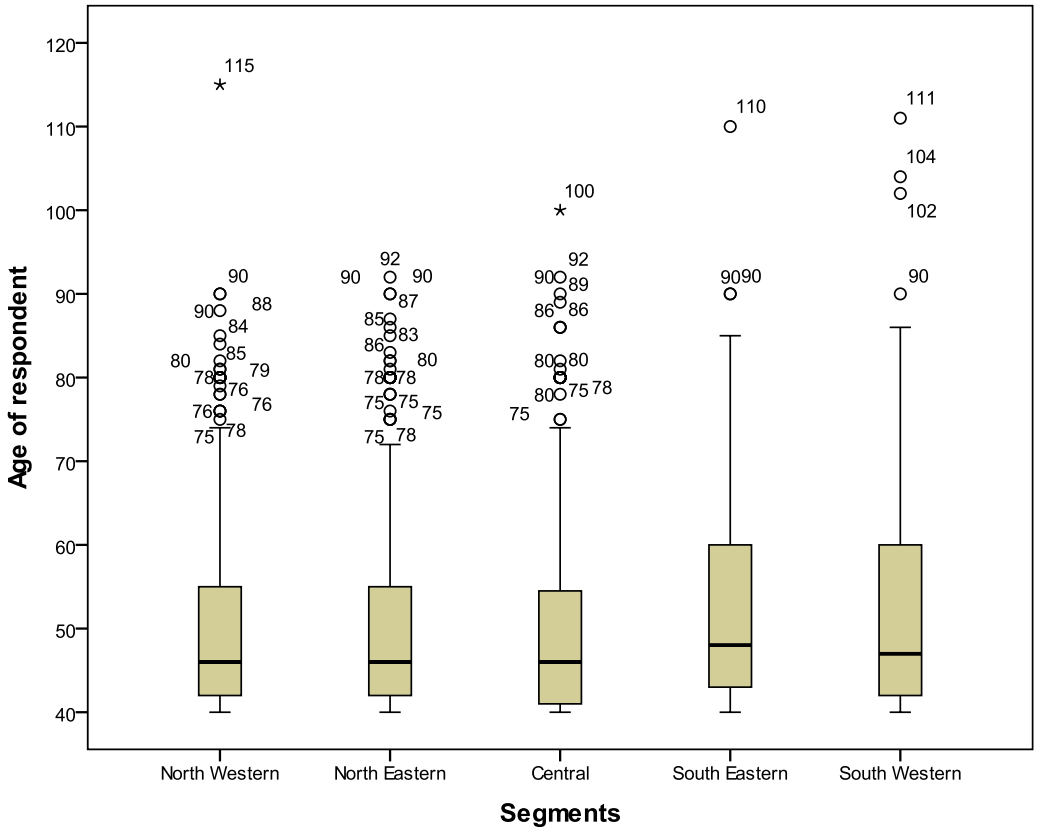


Figure 4.24: Age of the Narok TT survey subjects by segments

4.4.3.2 Formal education

Most (60.9%) of the adult subjects from Narok had no formal education; 49.9% of the men and 70.0% of the women (*Table 4.40*). The difference between the school attendance by men and women was statistically significant (χ^2= 153.4, df= 3, p= <0.01).

Table 4.40: Education level of the Narok TT survey subjects

Education level	**Adults 40+ years old**		
	Men	Women	Total
Did not attend school	676(49.9%)	1,148 (70.0 %)	1,824(60.9%)
Primary	410(30.2%)	366(22.3%)	776(25.9%)
Secondary	191(14.1%)	101(6.2%)	292(9.7%)
College	79(5.8%)	26(1.6%)	105 (3.5 %)
Total	**1,356(100%)**	**1,641(100%)**	**2,997(100%)**

4.4.3.3 Prevalence of TT in Narok

Eighty-seven out of 2,997 participants aged ≥40 years had TT (*Table 4.41*). The prevalence of TT in the entire district was 2.9% (95%CI: 2.2%-3.6%). The Southern Eastern segment had the highest prevalence of TT (5.3%), while the North Eastern Segment had the lowest (1.7%). The distribution of TT by segment was parallel to the one of TF.

Table 4.41: Distribution of TT by segments in Narok district

Segments	**Adults ≥40 years old**					
	Total*	With TT				
		One eye	Both eyes	Total	Percentage	95% CI
South Eastern	600	21	11	32	5.3	3.5-7.1
South Western	597	14	14	28	4.7	3.0-6.4
Central	600	6	8	14	2.3	1.1-3.5
North Eastern	600	7	3	10	1.7	0.6-2.8
North Western	599	0	3	3	0.5	0.0-1.1
Narok district	**2,996**	**48**	**39**	**87**	**2.9**	**2.2-3.6**

**The examination findings for one subject were not recorded*

The prevalence of TT in the population aged ≥15 years was extrapolated using the correction factor of 2.4. The mean prevalence for Narok district was 2.9 divided by 2.4 = 1.2%. The 2004 survey reported a prevalence of 2.3% (95%CI: 1.3%-3.7%)(25). There was therefore a 47.8% drop in the prevalence of TT between 2004 and this study in 2010. The prevalence of TT in the population aged ≥15 years in the survey segments in this study was: South Eastern 2.2%, South Western 2.0%, Central 1.0%, North Eastern 0.7% and North Western 0.2%. TT was therefore a public health problem (prevalence ≥1%) in the southern and the central

segments. The ultimate intervention goal is to lower the prevalence in the entire district to <1 TT case per 1,000 people in the general population.

Twenty-three out of 1,355 men had TT and the prevalence was 1.7% (95%CI: 1.0%-2.4%). Nine had TT in one eye while 14 in both eyes. Sixty-four out of 1,641 women had TT and the prevalence was 3.9% (95%CI: 2.9%-4.9%). Thirty-nine had TT in one eye and twenty-five in both eyes. The prevalence of TT in women was higher than in men (χ^2= 12.7, df= 1, p= <0.01).

Table 4.42 shows the distribution of people with TT by age and survey segments. The prevalence of TT increased with advancing age of the survey participants (*Figure 4.25*).

Table 4.42: Distribution of TT by age in the survey segments

Age (years)	**Adults ≥40 years old by segments**					
	South Western	South Eastern	Central	North Eastern	North Western	Narok district
40-49	10(35.7%)	6(18.8%)	5(35.7%)	1(10.0%)	1(33.3%)	23(26.4%)
50-59	3(10.6%)	5(15.6%)	0(0.0%)	0(0.0%)	0(0.0%)	8(9.2%)
60-69	5(17.9%)	10(31.3%)	5(35.7%)	1(10.0%)	2(66.7%)	23(26.4%)
70-79	5(17.9%)	7(21.9%)	2(14.3%)	5(50.0%)	0(0.0%)	19(21.9%)
80+	5(17.9%)	4(12.5%)	2(14.3%)	3(30.0%)	0(0.0%)	14(16.1%)
Total	**28(100%)**	**32(100%)**	**14(100%)**	**10(100%)**	**3(100%)**	**87(100%)**

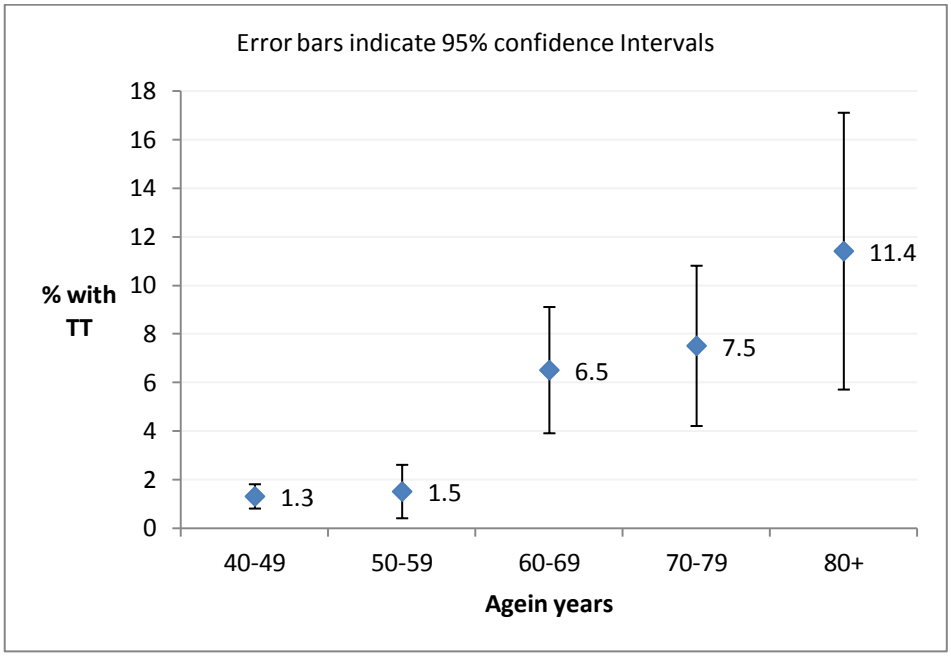


Figure 4.25: Mean prevalence of TT in Narok by age

The backlog of people with TT in Narok district was 2.9% of the total population aged ≥40 years = 2.9% of 71,860 people = 2,084 people with TT. The number ranged between 1,581 and 2,587 people (*Table 4.43*). The backlog in people ≥15 years old was extrapolated using the correction factor of 1.1 as follows: 2,084 people ≥40 years with TT x 1.1 = 2,292 people ≥15 years old with TT Narok district. The range was 1,739 to 2,846 people with TT.

Table 4.43: Backlog of people ≥40 years old with TT in Narok district

Segments	**Population ≥40 years old**	**Prevalence of TT**	**95% CI**		**Backlog of TT**		
			Lower limit	Upper limit	Mean (%)	Lower limit	Upper limit
South Eastern	14,372	5.3	3.5	7.1	762(36.6)	503	1,020
South Western	14,372	4.7	3.0	6.4	675(32.4)	431	920
Central	14,372	2.3	1.1	3.5	331(15.9)	158	503
North Eastern	14,372	1.7	0.6	2.8	244(11.7)	86	402
North Western	14,372	0.5	0.0	1.1	72(3.4)	0	158
Narok district	**71,860**	**2.9**	**2.2**	**3.6**	**2,084(100)**	**1,581**	**2,587**

4.4.3.4 Prevalence of CO

Thirty-three subjects (1.1%, 95%CI: 0.7%-1.5%) had CO; 11 men and 22 women. Only 3 subjects had TT in the eyes with CO, indicating that there are other causes of non-trachomatous CO in the district.

4.4.3.5 TT surgical coverage

Ten subjects (0.5%, 95%CI: 0.2%-0.8%) had TT surgical scars: 1 man and 9 women. Only one subject had both a TT surgical scar and CO in the same eye. None of the subjects with TT surgical scars had recurrent TT.

The TT surgical coverage for people aged ≥40+ years old was 15.5%, calculated using the *Equation 2* as follows:

$$\frac{3 \text{ TT scars both eyes} + 13 \text{ TT scars one eye and TT other eye}}{3 \text{ TT scars both eyes} + 13 \text{ TT scars one eye and TT other eye} + 87 \text{ with TT}} \text{x } 100 = 15.5\%$$

The TT surgical coverage for eyes was 13.1%, calculated using *Equation 3* as follows:

$$\frac{([3 \text{ subjects x2}] + 13) \text{ eyes with TT scars}}{([3 \text{ subjects x2}] + 13)\text{eyes with scars} + (48 + [39 \text{ subjects x2}])\text{eyes with TT}} \text{ x } 100 = 13.1\%$$

4.4.3.6 Barriers to TT surgery

The subjects who had TT (n=60) were asked why they had not gone for TT surgery. Most (80.0% of the subjects) said they did not know that TT could be corrected surgically (*Table 4.44*).

Table 4.44: Barriers to TT surgery in Narok district

Reason why subject had not gone for surgery	Number of subjects	Percentage
Does not know it is operable	48	80.0
no money	4	6.7
Too old to go for surgery	3	5.0
Fear of surgery	3	5.0
Busy, no time	2	3.3
Total	**60**	**100**

4.5 Costs analysis

All the data for cost analysis were collated from project reports. They represent the incremental costs of trachoma surveys and mass antibiotic treatment. In Kenya, both trachoma surveys and administration of mass treatment are conducted within an ongoing National Trachoma Control Programme. The term incremental cost refers to the additional funds that the programme needed to undertake the two activities. This included the allowances for travel, food and accommodation. Salaries and capital items were not included. The antibiotics were donated free of charge by the International Trachoma Initiative (azithromycin) and the Government of Kenya (tetracycline eye ointment).

4.5.1 Cost of trachoma surveys

The reports for previously-conducted trachoma surveys(25, 31) and for the surveys conducted by the TSS method during this study in 2010 were reviewed to determine the cost of trachoma surveys. In the previous surveys 20 clusters were selected in each district while in this study 100 clusters were selected in each district. The surface area and population density of the surveyed districts were also not equal (*Table 4.45*).

The composition of the data collection teams was the same in all the surveys. Each team comprised of a team leader (Ophthalmologist or Ophthalmic Clinical Officer) who conducted the trachoma grading, a nurse or clinical officer to assist the grader in recording the findings, a public health officer who inspected the households for environment risk factors, a driver and local a guide. The 2004 surveys were conducted by 8 data collection teams, supervised

by two survey supervisors. The 2007 Laikipia survey had 4 teams and one supervisor. Both Turkana and Narok surveys in 2010 had four teams supervised by two supervisors.

Table 4.45: Area and demographic characteristics of the surveyed districts

District	Year	Number of clusters surveyed^	Area in KM^2	Population	Population density (persons/KM^2)
Samburu	2004	20	21,127	143,547	7
West Pokot	2004	20	9,064	308,086	34
Baringo	2004	20	8,646	264,978	31
Kajiado	2004	20	21,903	406,054	19
Meru North	2004	20	3,942	604,050	153
Narok*	2004	20	15,098	365,750	24
Laikipia	2007	20	9,667	415,136	43
Turkana	2010	100	77,000	533,837	7
Narok*	2010	100	15,098	576,388	38

**Narok district was surveyed in 2004 and in 2010*
^In 2004 and 2007 the number of subjects in a cluster was not constant but proportional to the population size of the sub-location where the cluster was selected.

The instruments, consumables and medicines used in all the surveys were also the same. They included: loupes/torches for clinical examination, gloves, spirit swabs, pain killers and tetracycline eye ointment. The loupes and first aid medicines for the 2004 survey were purchased using the survey budget but in subsequent surveys the loupes were provided by the Division of Ophthalmic Services while the local health facilities provided the medicines.

The total cost of survey for one administrative district using the survey by administrative district method ranged between US$15,726 (US$94,361/6 districts) per district in 2004 and US$23,586 for the 2007 Laikipia district survey (*Table 4.46*). In 2004 the cost per district surveyed was lower because several districts were pooled and surveyed together; with joint planning meetings, training workshop and logistics.

The cost of a survey by the TSS method ranged between US$31,917 in Narok district and US$40,610 in Turkana district. The cost of a trachoma prevalence survey by the TSS method was 22% and 40% higher than a survey by the administrative district method in Narok and Turkana districts respectively. The area of Turkana district is five times larger than of Narok district (*Table 4.45*). In addition, Turkana did not have an established eye care project thus the cost of preparation was higher because it needed more support from the headquarter

than Narok. Turkana is located 900 kilometres from the headquarters in Nairobi compared to Narok district which is only 145 kilometres from Nairobi.

Table 4.46: The costs of trachoma surveys in Kenya

Expenditure items	**Money spent in US$ and (percentage of the total cost)**			
	Six districts (2004)	Laikipia (2007)	Turkana (2010)	Narok (2010)
1. Preparation				
Meetings	844(0.9)	386(1.6)	296(0.7)	250(0.8)
Per diem	3,390(3.6)	429(1.8)	1,316(3.2)	563(1.8)
Transport	779(0.8)	343(1.5)	678(1.7)	325(1.0)
Sub-total	***5,013(5.3)***	***1,158(4.9)***	***2,290(5.6)***	***1,138(3.6)***
2.Comm. Mobilisation				
Transport	4,061(4.3)	814(3.5)	776(1.9)	938(2.9)
Per diems	1,652(1.8)	303(1.3)	835(2.1)	794(2.5)
Sub-total	***5,713(6.1)***	***1,117(4.7)***	***1,611(4.0)***	***1,732(5.4)***
3. Workshop/Pre-test				
Hiring hall	78(0.1)	57(0.2)	53(0.1)	50(0.2)
Accommodation	3,896(4.1)	2,143(9.1)	1,461(3.6)	1,500(4.7)
Out of pocket allowance	1,876(2.0)	368(1.6)	452(1.1)	393(1.2)
Transport	1,639(1.7)	729(3.1)	1,451(3.6)	475(1.5)
Stationery	272(0.3)	268(1.1)	39(0.1)	92(0.3)
Consumables	672(0.7)	59(0.3)	120(0.3)	87(0.3)
Medicines and loupes	933(1.0)	0(0)	0(0)	0(0)
Sub-total	***9,366(9.9)***	***3,624(15.4)***	***3,576(8.8)***	***2,597(8.1)***
4. Data collection				
Transport	8,306(8.8)	2,686(11.4)	8,005(19.7)	5,225(16.4)
Per diems	30,346(32.2)	6,228(26.4)	14,510(35.7)	10,470(32.8)
Data entry clerks	123(0.1)	514(2.2)	947(2.3)	1,050(3.3)
Stationery	1,633(1.7)	669(2.8)	237(0.6)	414(1.3)
Consumables	4,029(4.3)	148(0.6)	718(1.8)	392(1.2)
Administration	10,339(11.0)	1,940(8.2)	322(0.8)	256(0.8)
Sub-total	***54,776(58.0)***	***12,185(51.7)***	***24,739(60.9)***	***17,807(55.8)***
5. Consultancies	15,000(15.9)	5,000(21.2)	7,500(18.5)	7,125(22.3)
Total	**89,868(95.2)**	**23,083(97.9)**	**39,717(97.8)**	**30,397(95.2)**
6. Contingencies*	***4,493(4.8)***	***503(2.1)***	***893(2.2)***	***1,520(4.8)***
GRAND TOTAL	**94,361(100)**	**23,586(100)**	**40,610(100)**	**31,917(100)**

**The money for contingencies was spent in all the surveys*

Data collection was the most expensive cost item, accounting for 51.7% to 60.9% of the total cost of a survey in Laikipia and Turkana respectively. Most of the money was spent on per diems and transport. The administration charges for the 2004 and 2007 surveys were higher than those for the 2010 surveys because a local non-governmental organisation was

contracted to manage the survey funds. The local organisation provided statistical services at a subsided cost.

The second most expensive cost item was consultancy/technical services, accounting for 15.9% of the total cost in the 2004 survey in six districts and 22.3% in the Narok survey. This was attributed to the fact that most trachoma-endemic districts in Kenya do not have staff who can conduct trachoma surveys without external support.

The cost of a training workshop ranged between 8.1% and 15.4% of the total cost of the Narok and Laikipia surveys respectively. The money was spent on accommodation, transport (to venue and for pre-test), allowances and stationery.

All the stakeholders involved in trachoma control in a district (government departments, non-governmental organisations and community leaders) were involved in community mobilisation in their respective areas of operation. However, the money spent on routine activities was neither reported in the survey budgets nor captured in this cost analysis.

The cost of conducting a survey in one cluster in a survey by the TSS method was lower than in a survey by the standard method (*Table 4.47*) because the clusters for the TSS method were many and nearer to each other than for a survey by the administrative district method. The cost of surveying one cluster in the 2004 survey in six districts was US$786 while in the 2007 Laikipia district survey was US$1,179 due to economy of scale. The cost of surveying one cluster by the TSS method was US$319 in the Narok district survey and US$406 in the Turkana district survey.

Table 4.47: Calculation of the unit costs (US$) for trachoma surveys

Variables	**Surveys**			
	Six districts (2004)	Laikipia (2007)	Turkana (2010)	Narok (2010)
Money spent	94,361	23,587	40,610	31,917
Number of administrative districts	6	1	1	1
Cost per administrative district	15,726	23,587	40,610	31,917
Number of segments per district	1	1	5	5
Mean cost per segment	15,727	23,587	8,122	6,383
Number of clusters per segment/district	20	20	20	20
Mean cost per cluster	786	1,179	406	319

The survey segments were equivalent to the recommended WHO "*trachoma district*" hence comparison of the cost of survey by segments is more appropriate than by administrative

district with different population size. However, some factors which influenced the costs of surveys could not be fully accounted for or standardised. These include the surface area of the segments, terrain, security, climatic conditions and infrastructure. For example Turkana and Samburu districts had harsh climate, very poor infrastructure and security escort was needed in some areas.

4.5.2 Treatment coverage and cost of administering mass treatment

Mass treatment and financial reports for the three districts (Narok, Kajiado and Samburu) which were conducting mass antibiotic treatment for active trachoma in 2009 were reviewed to determine the treatment coverage and the cost of mass treatment. The entire populations in the districts were supposed to be treated with antibiotics once a year for three consecutive years followed by impact assessment surveys. In Kajiado district the treatment commenced in 2007 and was completed in 2009. However, a project review conducted in 2009 revealed that some parts of the district were trachoma-endemic and the treatment was extended by another one year (2010). In Narok mass treatment commenced in 2008 and was completed in 2010 followed by this study. In Samburu, it commenced in 2009. Azithromycin was donated by Pfizer through the International Trachoma Initiative and tetracycline eye ointment by the Government of Kenya.

The treatment was conducted at designated treatment sites which included health facilities, schools, churches and water points. In the “hard to reach” places, mobile outreach was conducted. The drug distributors used motorbikes or walked to the sites. The “door to door” method was tried in 2008 and abandoned because it was too expensive. Therefore, “campaign method” where the communities are mobilised to go for treatment at the treatment sites is the method of choice for mass treatment in Kenya.

Teams for each administrative division organized a one day training workshop for the drug distributors in the respective sub-locations. The training materials which were modified to suit the local situations were provided by the International Trachoma Initiative. The trainers were the district health and eye care team members. The trainees were recruited from the local communities (sub-locational level) and they were supervised by health workers who were pharmaceutical technologists, nurses and public health technicians.

Adults were treated with a standard dose of 4 tablets (1 gram) of azithromycin and the doses for children were estimated using the standard height stick. Pregnant women and children

<6 months old were given two tubes of tetracycline eye ointment each, to apply twice a day at home. The application of the eye ointment was not supervised by health workers.

4.5.2.1 Treatment coverage

The ultimate intervention goal for mass antibiotic treatment for trachoma ("A" component of the SAFE strategy) is to ensure that the whole population in the targeted district is treated(8). The treatment is successful when at least 80% of the total population is treated(17). Therefore, 80% antibiotic treatment coverage was the threshold used to determine success of mass antibiotic treatment in this study.

Table 4.48 shows the treatment coverage for 2009 when Kajiado, Narok and Samburu were conducting their third, second and first rounds of mass treatment respectively. The target population refers to the total population estimated by the District Statistics Officers at the time of mass treatment. The target for treatment coverage was achieved in Kajiado and Samburu districts but in Narok district the coverage was 74.5%.

Most (97.2%) of the people treated were given oral azithromycin (tablets for adults and syrup for children). Those treated with tetracycline eye ointment (children <6 months and pregnant women) were few (2.8%). Consequently, when calculating the costs of mass treatment for this study, it was assumed that everybody received azithromycin.

Table 4.48: Treatment coverage for three districts in Kenya (2009 project reports)

District	**Targeted population***	**Number of people treated**			**Population treated**
		Azithromycin	Eye ointment	Total	
Kajiado	601,661	488,123(99.0%)	4,736(1.0%)	492,859(100%)	81.9%
Samburu	184,519	139,759(94.1%)	8,779(5.9%)	148,538(100%)	80.5%
Narok	506,209	362,063(96.0%)	14,926(4.0%	376,989(100%)	74.5%
Total	**1,292,389**	**989,945(97.2%)**	**28,441(2.8%)**	**1,018,386(100%)**	**78.8%**

**Population estimated by the district teams before mass treatment*

The productivity of the drug distributors was measured by the number of people each distributor treated in a day (*Table 4.49*). Samburu district had the lowest productivity with 48 people treated by a distributor per day. Though the district had the smallest population, a relatively large number of drug distributors were recruited. Due to insecurity in the district, the local communities (Samburu, Turkana, Rendille, Somali, Borana) could not accept drug distributors from outside their own communities. Samburu district is also sparsely populated and the distances between the communities are long. The other challenges included difficult terrain, poor road network and harsh climatic conditions. Kajiado had the most experienced

drug distribution team and the highest productivity (88 people treated per distributor per day) followed by Narok with 60 people treated per distributor per day. Kajiado and Narok districts did not have insecurity and the Masai communities in the two districts accepted drug distributors from other communities.

Table 4.49: Productivity of the drug distributors (data from project reports)

District	Total number of distributors	Working days	Distributors days	People treated	People treated/ distributor/ day
Kajiado	960	6	5,760	508,254	88
Narok	1,251	5	6,255	376,989	60
Samburu	430	7	3,010	145,375	48
Total	**2,641**	**5**	**13,205**	**1,030,618**	**78**

If the desired 100% antibiotic treatment coverage was achieved using the same number of drug distributors and assuming the population estimates in the 2009 census report, the average number of people treated per distributor per day would have been: Kajiado 687,312 people/5,760 distributors = 119, Narok 576,388 people/6,255 distributors = 92 and in Samburu 225,956 people/3,010 distributors = 75.

The National Trachoma Control Programme reports indicated that the treatment coverage for the first year of mass treatment was generally higher than for subsequent years. In Kajiado district the treatment coverage was 91% in 2007, 75% in 2008, 82% in 2009 and 80% in 2010. In Samburu it was 84% in 2009 and 82% in 2010. Narok district had the highest decline in treatment coverage from 83% in 2008 to 74% in 2009 and 62.4% in 2010. This decline in antibiotic treatment coverage was attributed to some people declining to go for treatment.

The other challenges recorded in the project reports included the perennial migration of the nomadic communities, poor road networks, limited budgets, and the expected side effects of azithromycin, which include mild diarrhoea and vomiting in some people.

The Narok district reported that the communities in the northern parts of the district with low prevalence of trachoma were more unwilling to go for treatment than those in the endemic southern areas. The 2010 treatment coverage and baseline prevalence of TF were analysed to investigate this claim. At the time of the mass treatment in early 2010 there were 522,775 people (*Table 4.50*) in Narok but a census conducted in late 2009 indicated that the population was 576,388 people. If the census was used, the treatment coverage

would have been 57%. The difference between the two population estimates was 9%. Narok district population fluctuates due to nomadic migrations across the Kenya-Tanzania border.

The analysis showed that divisions in the southern areas had higher prevalence of TF and treatment coverage than those in the northern areas like Okurto and Mulot (*Table 4.50*).

Table 4.50: Treatment coverage in Narok district by divisions (2010 project report)

Division	Target population	People Treated	Treatment coverage	Baseline prevalence of TF (2004 survey)
Osupuko	32,579	29,760	91.3	81.5
Loita	22,235	17,741	79.8	86.3
Mara	59,956	39,384	65.7	58.2
Mau	109,054	73,118	67.0	35.2
Central	60,807	36,832	60.6	17.5
Mulot	97,805	59,612	61.0	2.2
Ololulung'a	76,987	32,375	42.1	15.5
Olokurto	63,352	37441	59.1	0.0
Narok district	**522,775**	**326,263**	**62.4**	30.5

The correlation between baseline prevalence of TF and the 2010 treatment coverage is displayed in *Figure 4.26*. Most of the points on the scatter plot are close to the "best fit line" that shows the mean trend of the data on the plot (r= 0.81, p= 0.02).

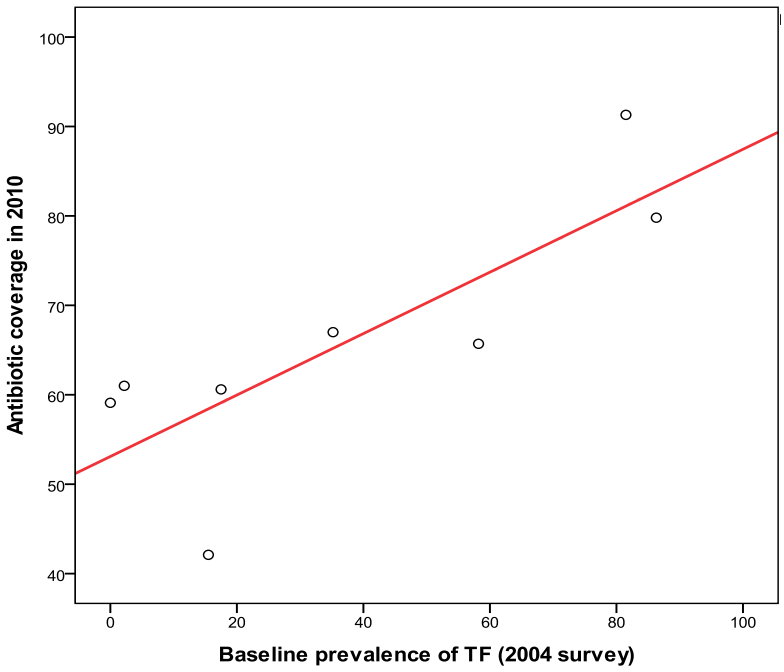


Figure 4.26: Prevalence of TF and treatment coverage in eight divisions in Narok district

Key: The eight points on the plot represent the eight administrative divisions

The correlation between the prevalence of TF determined in this study and the 2010 mass treatment coverage by administrative divisions was moderately positive (r= 0.62, p= 0.10). This was due to the effect of mass antibiotic treatment since the rate of decline of the prevalence of TF may not be equal in all the divisions.

4.5.2.2 Cost of mass treatment

The data collection form in *Appendix 11* was used as a checklist to ensure that no items were omitted when collating the cost of mass antibiotic treatment. The district projects paid for transportation of the drugs from the Government depot to the distribution sites and for the administration of mass treatment.

Table 4.51 shows the 2009 costs of mass treatment when Kajiado, Narok and Samburu were conducting their third, second and first rounds of mass treatment respectively. Payment of the drug distributors was the most expensive item, accounting for 58.5%, 56.1% and 46.2% of the total cost of mass treatment in Kajiado, Narok and Samburu respectively. Training was the second most expensive item with 15.1% to 24.8% of the total cost in Kajiado and Samburu respectively. The third was vehicle running costs with 14.6% and 17.1% in Kajiado and Narok respectively. Samburu district had the highest percentage expenditure on training and community mobilisation because of the large number of workers recruited from all the local tribal grouping after they rejected "outsiders".

Money for community mobilisation was spent on meetings, hiring public address systems, radio announcements; lunches for the mobilisers/announcers (town criers) and the per diems for the District Health Management Teams. All the trachoma control stakeholders were involved in the community mobilisation. However, the money reported in this study is what was paid directly from the mass treatment budget.

Table 4.51: Cost of administering mass antibiotic treatment in Kenya (2009 project reports)

Cost items	**Cost in US$ and (percentage of the total cost)**		
	Kajiado	Narok	Samburu
Per diem for drug distributors	60,496(58.5)	49,869(51.6)	28,338(46.2)
Training distributors	15,655(15.1)	15,739(16.3)	15,211(24.8)
Vehicle running	15,132(14.6)	16,513(17.1)	9,843(16.0)
Community mobilisation	6,852(6.6)	4,950(5.1)	6,295(10.3)
Consumables	5,258(5.1)	9,635(10.0)	1,700(2.8)
Total	**103,393(100)**	**96,705(100)**	**61,387(100)**

Consumables for mass antibiotic treatment (2.8% to 10% of the total cost) included: height sticks for estimating the antibiotic doses for children, water (for dissolving the azithromycin powder and swallowing the tablets), water containers, posters, fliers, banners, T-shirts/caps and stationery. Among the three districts, Narok spent the highest percentage (10%) of the total cost on consumables. This is partly because after completion of the mass treatment a balance of $1,636 was donated to the Narok eye clinic to replenish their depleted stock of consumables (printing and photocopying of reports done at the clinic).

The amount of money spent was divided by the number of people treated to derive the cost per person treated (*Table 4.52*). The cost of distributing a single dose of antibiotic in Kajiado district was $0.20 ($103,393/508,254 people), in Narok district $0.26 ($96,705/376,989 people) and in Samburu district $0.42 ($61,386/145,375 people).

The mass treatment was to be administered for 3 years in all the districts. Therefore, the cost per person treated for 3 years in Kajiado was $0.60, Narok $0.72 and Samburu $1.26.

Table 4.52: Cost per person treated

Variable	**Districts**		
	Kajiado	Narok	Samburu
Total project costs	103,393(100)	96,705(100)	61,386(100)
Number of people treated	508,254	376,989	145,375
Cost per person treated per year	0.20	0.26	0.42
Cost per person treated x 3 years*	**0.60**	**0.78**	**1.26**

**Mass treatment was to be administered annually for 3 years in all the three districts*

The treatment coverage affects the cost per person treated. The higher the number of people treated per drug distributor per day, the lower the cost for a single treatment. If the three districts had achieved a 100% treatment coverage as per the 2009 census, the project cost for a single treatment would have been $0.15 ($103,393/687,312 people) in Kajiado, $0.17 ($96,705/576,388 people) in Narok and $0.27 ($61,386/ 225,956) people in Samburu. The total cost would have been $96,224 (687,312 people x $0.14) in Kajiado, $103,750 (576,388 people x $0.18) in Narok and $61,008 (225,956 people x $0.27) in Samburu.

4.5.3 Cost comparison

In both Turkana and Narok districts the cost of a survey by the TSS method were known but the costs of a survey by the standard method was to be estimated. Reports for previous surveys provided two estimates, the mean cost per district for the 2004 survey in six districts

and the 2007 Laikipia district survey. The 2007 estimate was considered to be more appropriate for the comparison because the surveys by the TSS method were also conducted in single administrative districts. However, Laikipia district had a smaller area (9,667 square kilometres) than Narok (15,098 square kilometres) and Turkana (77,000 square kilometres). Therefore, the cost of transport for data collection in Laikipia was expected to be lower than in Narok and Turkana. The cost of preparation for the Turkana survey by the TSS method was high because district teams needed support from the headquarters. In future this expenditure will reduce as the local team gain experience.

To make adjustment for the differences in the surface area, it was assumed that the data collection teams had to visit all the areas in a district irrespective of the survey method but TSS method had more stopovers because the clusters were many. Therefore, the amount of money needed for the transport during data collection in Turkana and Narok was assumed to be approximately equal for the two surveys methods. The total cost of the Laikipia survey was $23,586; minus the money spent on transport during data collection ($2,686) = $20,900. This amount was added to the $5,225 spent on transport for data collection in the Narok survey, to derive the cost of a survey by the standard method in Narok district as follows: $20,900 + $5,225 = $26,125. The cost of a survey by the standard method in Turkana district was $20,900 + $8,005 = $28,905.

Mass antibiotic treatment had not commenced in Turkana district but it being conducted in the neighbouring Samburu. It was anticipated that the cost of mass treatment in Turkana would be the same as in Samburu ($0.42 per person treated) since they have similar challenges. Therefore, the money needed to administer mass antibiotic treatment Turkana district was: 533,837 people x $0.42 = $224,212 per year and for 3 years $672,636.

Two out of five segments in Turkana district needed treatment for three years, followed by repeat surveys to justify further treatment. The other three segments needed treatment for five years. The total number of people who will need treatment after three years will depend on whether the two segments will be “knocked out” of mass treatment or not.

4.5.3.1 Cost of a survey plus administration of mass antibiotic treatment

In the initial 3 years, mass treatment was needed in Turkana district, irrespective of the survey methods used (*Figure 4.27*). In the initial 3 years, the cost of a trachoma survey and administration of mass treatment by the TSS method was $11,705 (1.7%) more expensive

than by the administrative district method. There-after the costs will be determined by the outcome of the surveys in the refugee camp and Central Turkana segments.

In Turkana district, the cost of a survey by the standard survey by administrative district method was $28,905/$701,541 x 100 = 4.1% of the cost of a survey plus administration of mass treatment while for a survey by the TSS method it was $40,610/713,246 x 100 = 5.7%.

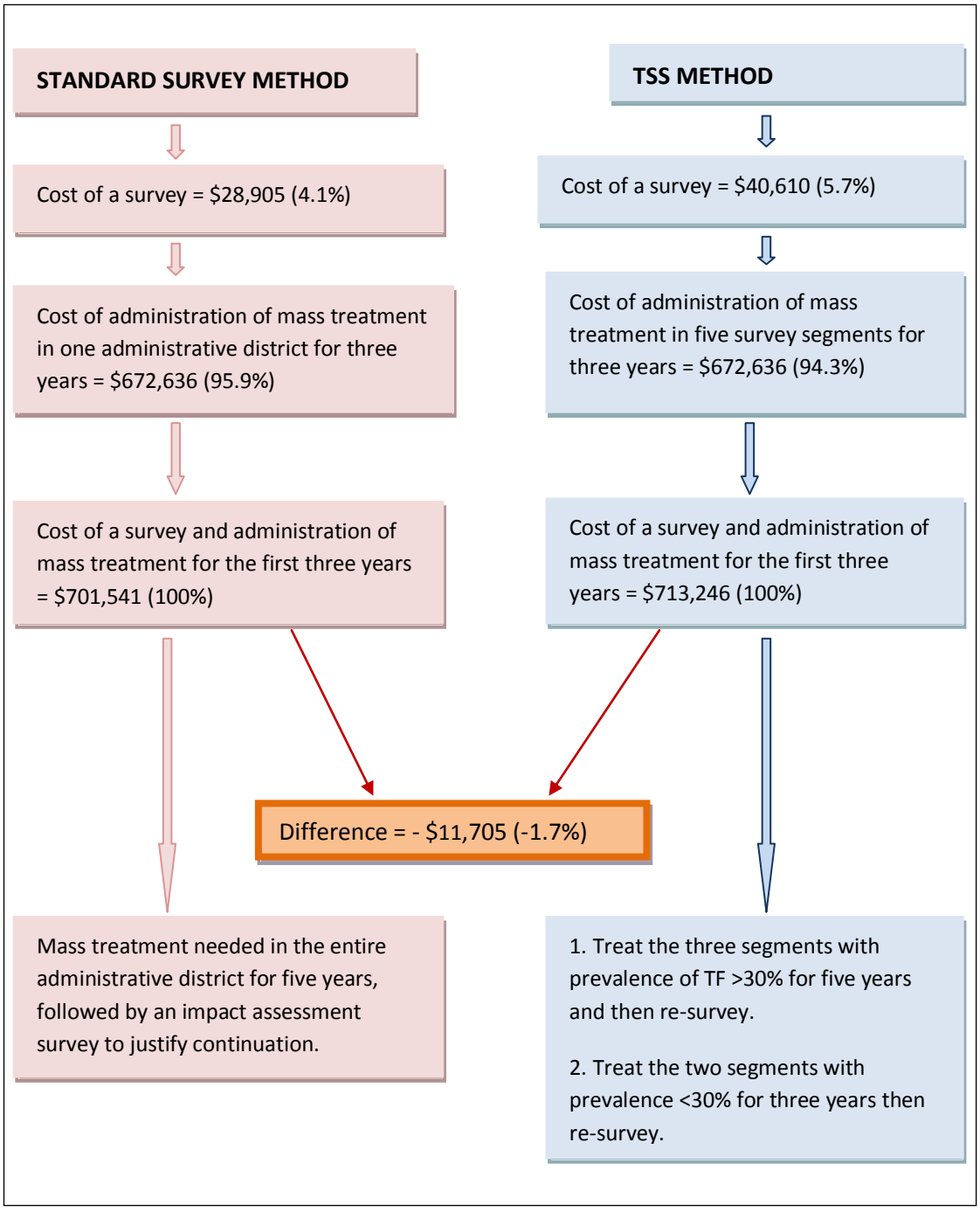


Figure 4.27: Cost comparison for the initial 3 years in Turkana district

In Narok district the cost of a trachoma survey by the standard method plus administration of mass treatment for 3 years was $26,125 + $290,115 = $316,240 (*Figure 4.28)*. The cost of a TSS survey plus administration of mass treatment in the two endemic segments for three years was $31,917 + ($290,115)/5 segments x 2 = $147,965. The cost of the survey was not divided by the number of segments because the entire district was surveyed to identify the two endemic segments. The money saved = $316,240 - $147,965 = $168,275 (53.2%). It should be noted that mass treatment may be more expensive in the remote and sparsely populated segments that the average cost per segment. However, it was difficult to determine the exact cost for individual segments because treatment was conducted by administrative divisions whilst the segments were created by aggregation both divisions and smaller administrative units. Future treatment will be administered by survey segments.

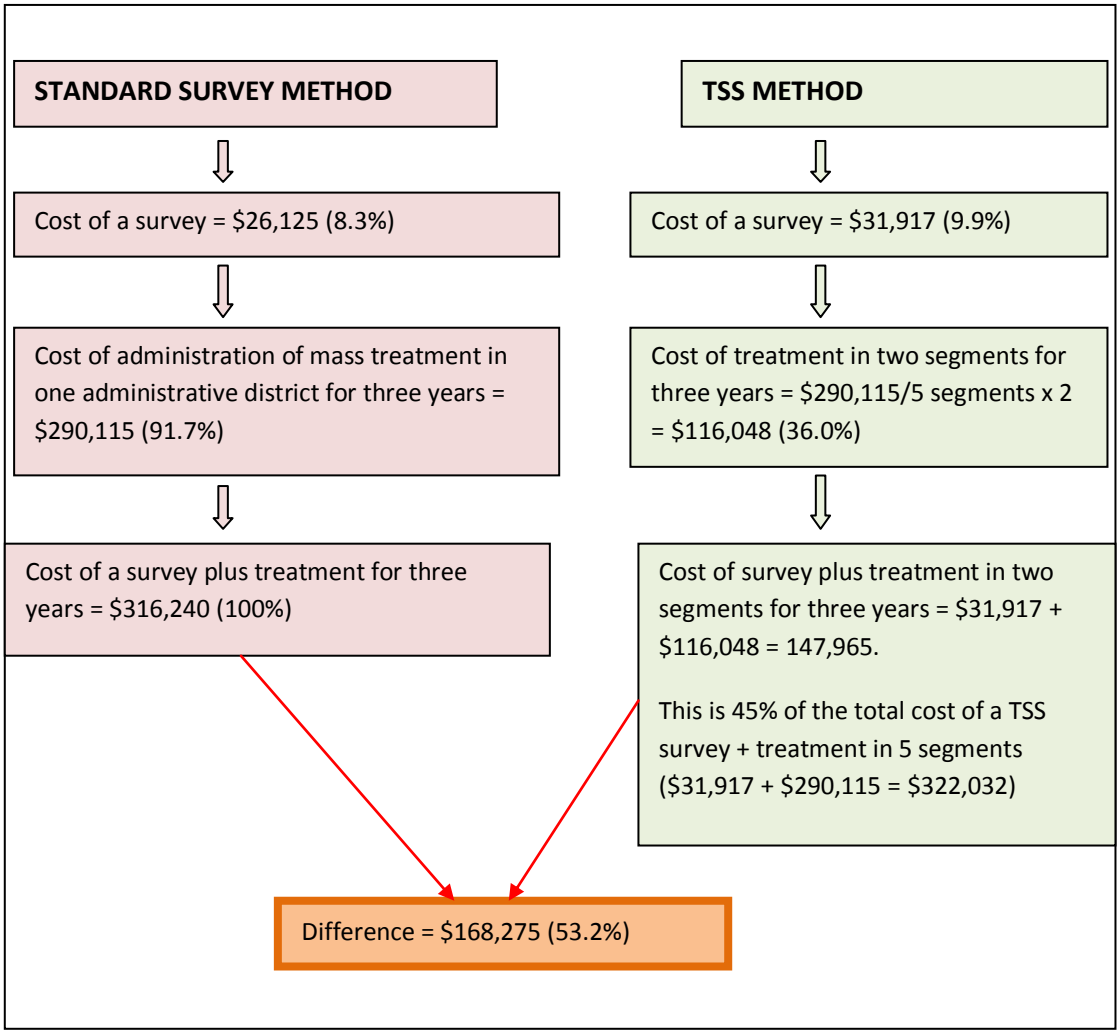


Figure 4.28: Cost comparison for Narok district

The cost of a survey by the standard method in Narok was $26,125/$316,240 x 100 = 8.3% of the cost of a survey plus mass treatment in the entire district. If all the segments were treated the cost of a TSS and treatment would have been = $31,917 + $316,240 = $322,032. Therefore, the cost of a TSS was $31,917/$322,032 x 100 = 9.9% of the total cost of a survey and administration of mass treatment.

CHAPTER FIVE

5 Discussion

This Chapter synthesises the information in the preceding Chapters in line with the objective of the study. It relates the methods used and the results of this study to those of previous studies. It further discusses the implications of the findings on trachoma control policy, highlighting the strength and weaknesses of the new methods. Suggestions on how the methods can be applied in different settings are provided. The Chapter starts with a discussion of the new methods, followed by the field testing of the methods. It ends with a discussion of the three roll-out surveys conducted by the staff of the Kenya National Trachoma Control Programme using the new survey methods after this study.

5.1 Overview of the new trachoma survey methods

This study provided two new trachoma survey methods: the "Trachoma Survey by Segment" (TSS) to justify administration of mass antibiotic treatment and the TT40 method to estimate the backlog of people requiring TT surgery. The methods had an impact on trachoma control policy since they provided effective and efficient prevalence survey methods which are likely to replace the existing methods. Prevalence surveys are used to assess the need for intervention. Therefore, a change in survey methods has a direct impact on implementation of the SAFE strategy.

The TSS and TT40 methods were adopted by the Government of Kenya and the roll-out of trachoma surveys using the two methods commenced in 2011. The roll-out was sponsored by the Government of Kenya in collaboration with Sightsavers and Fred Hollows Foundation. Additionally, the results of the surveys conducted in Turkana and Narok districts were implemented as recommended in this study.

In March 2011, the International Coalition for Trachoma Control (ICTC) conducted a planning workshop at the African Medical and Research Foundation (AMREF) headquarters in Nairobi,

Kenya. The aim of the workshop was to provide context for the two new GET 2020 documents: the 2020 InSight, a global strategic plan for trachoma control and the Trachoma Action Plan (TAP) template to be used by the trachoma-endemic countries to develop their country specific action plans. The Narok survey report and implementation of SAFE by segments in the district was used as a case study. The TSS method was recommended for subsequent trachoma surveys in Kenya.

The third WHO global scientific meeting on trachoma elimination was held in Baltimore in July 2010(8). The aim of the meeting was to review the recommendations and antibiotic treatment directives for active trachoma and to clarify the recommendations on certification of elimination of blinding trachoma. Some of the recommendations made at the meeting were influenced by the earlier reports from this research project, which advocated that large districts should be surveyed by segments. The meeting re-defined the population size of a "*trachoma district*" to be 100,000 to 250,000 people. The previous definition of a "*trachoma district*" had no upper limit(17). It was recommended that trachoma surveys conducted in hypo-endemic areas and all impact assessment surveys should be conducted at district level (100,000 to 250,000 people) and not in larger aggregates(8). This means that districts with >250,000 people should be sub-divided into two or more survey segments. This effectively replaces the standard survey by the administrative district method with the TSS method. It was added that a survey to inform start of a new programme can be conducted in large hyper-endemic areas if trachoma is suspected to be prevalent through-out the area.

By the time this thesis was written, implementation of the above recommendations had not been commenced. However, the results of the two surveys conducted during this study and other survey reports from Kenya discussed below provided a preview of the likely outcomes for areas with different trachoma endemicity levels.

5.1.1 Method to justify administration of mass antibiotic treatment

In a survey by administrative district method the prevalence of trachoma is estimated in at the district level while the TSS method provides prevalence estimates for both the district and sub-district (segment) levels. Therefore, a TSS allows localised trachoma interventions by segments. A standard survey can be used to estimate the prevalence of trachoma of any level(9, 10, 16). Conversely, a TSS is powered to detect a prevalence of TF 10%, which is the threshold for of administration of mass antibiotic treatment.

The search for a new survey method was triggered by the clustered distribution of trachoma and wide variation of the population size of administration districts in Kenya. In large districts, standard surveys either masked the prevalence in the endemic communities or resulted in inclusion of non-endemic areas in mass treatment. As a result, there was need for a survey method that can be used to determine the prevalence at levels lower than the district level (sub-district level). The TSS method introduced the concept of conducting trachoma prevalence surveys by segments. This allowed localised estimation of the prevalence of trachoma. Additionally, the number of segments surveyed in an administrative district was proportional to the population size of the district. This ensured that the effectiveness of a TSS to locate the endemic areas was not influenced by the population size of an administrative district.

When the study commenced in 2009, the recommended intervention unit for trachoma control was an administrative districts with approximately 100,000 people(10). However, in practice surveys were conducted by administrative districts, irrespective of the population size. Also, the review of literature revealed that the population size of the study areas is not critically addressed in the review articles on trachoma survey methods(11, 66, 152).

This study specifically addressed large administrative districts because it was the setting where challenges were encountered in the Kenya Trachoma Control Programme. However, small districts can be merged to create a segment. Also, a district with same population as a segment can be surveyed as a single segment.

5.1.1.1 Surveys in a large hypo-endemic districts with clustered trachoma

The challenge in hypo-endemic administrative district was failure to identify and treat some endemic areas ("hot spots"). The baseline trachoma survey data for Baringo and Laikipia districts presented in Chapter 2 (*pages 48-49*) to indicate that some endemic areas which were left un-treated because the surveys could not accurately locate the areas. In such settings the TSS method is more effective than a standard survey.

The failure of the standard surveys to identify the "hot spots" in administrative districts stems from the mathematical formulae used to calculate the samples for population-based prevalence survey and the variation in the population size of the districts. The population size of the study areas is not included in the formula(9, 14, 16) hence both the large and the small districts are allocated equal samples. The systematic sampling method is commonly used to select trachoma survey clusters(9, 16). In this method the total population is divided

by the number of survey clusters to calculate sampling interval hence the sampling intervals for small districts are lower than for large districts. Consequently, the survey clusters are closely packed in small districts and widely scattered in large districts. The only way to avoid this inconsistency is to standardise the population size of the study area.

In the TSS method the segments have approximately equal population and the number of segments in a district is proportional to the population size of the district. The populations in both small and large districts are thus equally represented in trachoma surveys. Therefore, in large districts surveys conducted by the TSS method are as effective as those conducted in small districts. This reduces the failure to identify the endemic areas.

5.1.1.2 Surveys in large meso-endemic districts with clustered trachoma

The challenge in meso-endemic administrative districts was inclusion of non-endemic areas in mass treatment. The results of Narok district demonstrate that the TSS is an effective method to minimise the inclusion of the non-endemic areas in mass treatment. The data for the 2004 baseline trachoma survey(25) presented in Chapter 2 (*page 51*) indicated that there were some non-endemic clusters in the northern highland areas. However, the survey could not differentiate the endemic and non-endemic areas in the district. Therefore, mass antibiotic treatment was administered to the whole population in the district for 3 years followed by this study.

The results of this study show that the prevalence of TF in Narok district was 11.0%. The 3 segments with <10% prevalence of TF were “knocked-out” of further mass treatment. If this survey was conducted using the administrative district method the whole population in the district would have been treated for another 3 years.

5.1.1.3 Surveys in large hyper-endemic districts

By the time this thesis was submitted in July 2012, all baseline trachoma prevalence surveys had been completed in all suspected endemic areas in Kenya. The National Trachoma Control Program reports indicate that Turkana was the last hyper-endemic district to be surveyed. It is therefore evident that successive surveys will all be conducted to assess impact of ongoing interventions in meso and hypo-endemic settings.

The prevalence of TF in the entire Turkana district was >30%, indicating that the whole population needed mass treatment for 5 years. However, two segments (Kakuma Refugee camp and Central Turkana) had a prevalence of 10% to 30% and needed treatment for 3 years. Therefore, in the initial 3 years, the TSS method had no advantage over the standard

method. In the long term (>3 years), the TSS method may reduce the cost of treatment if the 2 meso-endemic segments are "knocked-out" of treatment after 3 years. What this implies is that in a hyper-endemic setting a baseline trachoma prevalence survey to trigger short-term mass treatment can be conducted by either the TSS or the standard survey by administrative district method. However, the TSS method is needed in the subsequent surveys because the clustering of active trachoma increased by administration of mass treatment.

5.1.1.4 Consideration of rapid assessment methods

Rapid assessment methods were also reviewed to check whether they could be used to improve the TSS method. The commonly used rapid assessment methods are: the Trachoma Rapid Assessment and the Acceptance Sampling Trachoma Rapid Assessment. The methods are used to ascertain the presence or absence of trachoma in an area which is suspected to be trachoma endemic(11, 36, 162-165).

In a Trachoma Rapid Assessment, risk assessment is conducted and then the sample is selected in the high-risk areas(11, 66). In the TSS method, trachoma risk assessment is conducted and then both the high and low risk areas are surveyed. The option of conducting a rapid assessment first and then followed by a prevalence survey in the likely endemic areas was considered. However, this option was dropped because it is lengthy and could delay administration of mass antibiotic treatment and increase the cost of surveys. The TSS method provides immediate prevalence estimates for all the surveyed segments hence it does no delay mass treatment.

The Acceptance Sampling Trachoma Rapid Assessment methods(168) were also reviewed to determine whether they could be used to improve the TSS method. Acceptance Sampling Trachoma Rapid Assessment does not have a fixed sample size and sampling may stop once the number of "defects" or cases allowed has been exceeded(164, 165). In the initial proposal of this study it was suggested that some "stopping rules" could also be built-into the TSS method to reduce the cost of surveys. The "stopping rules" were based on the fact that trachoma usually clusters in the poorest communities(2). It is thus argued that if active disease is not found among "the communities living in the worst places", meaning the areas with the highest risk scores, then there is no need to look for it in "the best places"(66). The proposed "stopping rules" were as follows:

1. Begin the survey in the "worst places" in a segment and plan to examine all the 800 children selected in a segment (20 clusters of 40 children each). Tally the number of TF cases diagnosed on daily bases.
2. After examining the first 200 children (5 clusters, 25% of the sample) check the number of TF cases diagnosed. If <20 cases (prevalence ≥10%), discontinue the survey in that particular segment. If ≥20 cases (prevalence ≥10%), continue with the survey.
3. After 400 children (10 clusters, 50% of the sample) are examined, check the number of TF cases again. If <40 cases (prevalence ≥10%), discontinue the survey in that particular segment. If ≥40 cases (prevalence ≥10%), complete the survey.
4. In a complete survey 800 children 1- 9 years were to be examined in a segment. If the final tally indicated that <80 children had TF (prevalence <10%) the recommendation was that the segment should be excluded (knocked-out) from mass antibiotic treatment. If ≥80 children had TF (prevalence ≥10%), trachoma was declared to be a public health problem in that segment meaning it needed mass treatment(17). Additionally, targeted treatment was to be administered in the endemic clusters in hypo-endemic segments(8).

These "stopping rules" were rejected by the Kenya National Trachoma Task Force on the basis that the local communities were aware of the collateral benefits of the SAFE strategy, such as provision of water and improvement of health and eye care services. It was feared that a political backlash could be triggered by the exclusion of a segment before completion of a survey. This concern shows importance of social-political considerations during the selection of a study design for an operational research project. The other concern about the rules was academic in that prevalence of TF could only be estimated in the segments where surveys were completed. In this study the prevalence estimate for the entire administrative district was needed for comparison of the TSS and the standard survey methods.

The data for this study were analysed to determine how the "stopping rules" may have affected the decisions on mass treatment. All the segments in Turkana district were trachoma-endemic and the mean prevalence in the 10 survey clusters with the highest prevalence ("worst places") was >10% in all the segments. This shows that the survey could not have been stopped in any of the segments in the district, even if the "stopping rules" were applied. This was also the case in the two endemic segments in Narok. The other three

segments in Narok district had prevalence of TF <5% and they were “knocked-out” of mass antibiotic treatment. The “worst ten clusters” in the three segments had a mean prevalence of <10%, meaning that the survey would have been stopped before completion if the rules were applied. This shows that the “stopping rules” would not have changed the decisions on mass treatment in all the segments in this study. Therefore, the rules should be re-considered in future studies to determine whether they can reduce the cost of the trachoma prevalence surveys conducted in large geographical areas.

The “stopping rules” can also be applied at the district level instead of segment level as follows: conduct risk assessment, divide the administrative district into segments and then survey the segments intermittently. Start with the segment(s) with the highest risk scores (worst places in the district) and survey the segment(s) with low risk scores (best places) last. Stop the surveys in the “best places” if the prevalence of TF in the “worst places” is <10%. This method may not delay mass treatment because it provides the required prevalence estimates by segments. In a TSS all the segments are surveyed first and then they are sorted into those that need mass treatment and those to be “knocked-out”.

5.1.2 Disadvantage of administrating mass treatment a small area

The main disadvantage of treating a single survey segment is risk of re-emergence of active infection; especially if there are nomadic migrations from surrounding endemic areas(122). However, more research is needed in this area since it is not clear how wide the geographical area under treatment should be to eliminate the risk. Assessment of the pilot project that preceded the roll-out of the SAFE strategy in Kenya indicted that migration of the Masai communities from untreated areas in Tanzania re-infected the communities in the project(30). Burton et al conducted a longitudinal study to measure the effect of mass treatment on the conjunctival burden of Chlamydia trachomatis in a Gambian community with low to medium trachoma prevalence and investigated the rate, route, and determinants of re-emergent infection. They administered mass azithromycin treatment to the community at baseline and took conjunctival swabs for Chlamydia Polymerase Chain Reaction test at baseline, 2, 6, 12, and 17 months. The study revealed that the effect of mass treatment was heterogeneous in the studied villages and the risk of return of infection was increased by contact with other untreated communities. They concluded that after mass treatment, communities need to be monitored for treatment failure and control measures should be implemented over wide geographical areas(124).

5.1.3 Method to estimate the backlog of TT

The need to address the TT survey sample size was triggered by the delays experienced in previous surveys where in each cluster data collection for TF survey was completed in a shorter time period than for TT survey(25, 30-32). Such delays were expected to be longer in TSS method where several surveys were conducted in several segments in the same district. For example during this study five segments per administrative district were surveyed in Narok and Turkana. The number of clusters surveyed per administrative district was five times more than in the previous surveys by the administrative district method.

In a standard trachoma prevalence survey both TF survey in children 1-9 years old and TT survey in adults ≥15 years are conducted simultaneously. When these age criteria are used, the sample size for a TT survey is usually (but not always) larger than for a TF survey because the prevalence of TT is lower than the prevalence of TF(9, 10). To overcome this limitation, researchers often trade-off small TT survey sample sizes for low precision in estimation of TT prevalence(10, 16).

In this study, the precision of a TT40 survey was the equivalent to that of the TSS method. The sample size was reduced by increasing the lower age limit of the TT survey participants from 15 years to 40 years. The re-analysis of the previous survey data sets established that the prevalence of TT in people ≥40 years was 9.4%. This was nearly equal to the 10% prevalence used to computing the sample size for the TSS method. Therefore, with other factors being equal, the sample size for a TT40 survey and a TSS survey were approximately equal.

The limitation with the TT40 method was that it estimated 87% of the backlog of TT since people aged <40 years were excluded from TT surveys. Therefore, correction factors were needed to extrapolate the backlog in the whole population. If the lower age limit of 50 years (TT50) used in Rapid Assessment of Avoidable Blindness surveys was used TT survey, the survey sample size would have been smaller than for TT40. However, a higher backlog of TT (27%) would have been missed.

Rapid Assessment of Avoidable Blindness surveys are increasingly being used for both needs assessment and assessment of the impact in blindness control programmes. In Kenya, three Rapid Assessment of Avoidable Blindness surveys have been conducted(33) but none has been done in a trachoma-endemic district. Therefore, there is need to harmonize the age of participants for Rapid Assessment of Avoidable Blindness and TT surveys to avoid possible

duplication of surveys in trachoma-endemic districts. For example, in a trachoma-endemic district with no eye care programme, a Rapid Assessment of Avoidable Blindness and a TF survey in children 1-9 years could be conducted in place of a TT and a TF survey. Such a survey would provide data for both comprehensive eye care services and the SAFE strategy.

5.2 Field testing of the survey methods

The survey methods were field tested during two surveys conducted in Turkana and Narok districts in Kenya. Turkana represented a hyper-endemic setting while Narok represented a meso-endemic setting with clustered trachoma. The study was supported by both the Government of Kenya and a wide range of non-governmental organisations This influenced the immediate adoption of the new survey methods by the government and the willingness of the non-governmental organisations to sponsor the subsequent roll-out surveys. Proper planning is vital in population-based prevalence surveys(9, 16, 166) and engagement of the project implementers and other stakeholders enhances the scale-up of public health interventions(158).

During planning a detailed trachoma risk assessment was conducted to inform the division of the administrative districts into survey segments. This was followed by identification of the survey clusters, community mobilisation, training and data collection.

5.2.1 Validity of the risk assessment form

A simplified trachoma risk assessment form was developed and used in this study. The risk scores were used to minimise the mixing of endemic and non-endemic communities in the same segment. This increased the chance of either inclusion or exclusion (knock out) of an individual survey segment from mass antibiotic treatment. The total risk scores for Turkana and Narok districts were generally high. This was not surprising since there was evidence indicating that the districts were likely to be trachoma-endemic. However, the findings of this study could not be compared with previous studies due to lack of a standardised trachoma risk assessment tool.

All the areas in Turkana district were trachoma-endemic hence the correlation between the total risk scores and the prevalence of TF was poor. Therefore, the risk assessment form could not accurately differentiate the endemicity of trachoma in the district. This indicates that in a large hyper-endemic districts where active trachoma found in all the areas the risk scores were not useful in defining the survey segments.

In Narok, the correlation was strong (though not statistically significant) since there was a big difference in the prevalence of TF in the northern highlands and the southern arid areas. However, the results indicated the correlation would have been very poor if the northern and southern areas were assessed separately. This means the risk assessment parameters used could only differentiate endemicity of trachoma in large areas with big difference in prevalence of TF. Moreover, the results were confounded by mass antibiotic treatment and nomadic migrations.

It was anticipated that the risk assessment form would be revised from time to time using experiences from this and subsequent studies. The revision will include critical appraisal of the risk assessment parameters to justify their continued use, modification or replacement with more accurate ones. The Kenya trachoma survey team suggested that a question on face washing practices should be included in the form after it was discovered that some Muslim communities in the arid Northern Kenya region did not have active trachoma, probably due to their religious face washing practice. There is evidence that a dirty face (*Figure 5.1*) is the final common pathway through which a variety of environmental factors affect the risk of trachoma. Moreover, availability of water may not automatically result in clean faces(1).

It was also suggested that a question on ownership of pit latrines should be included since it has been associated with reduced occurrence of active trachoma(77, 89). It is well documented that Musca sorbens, the eye-seeking flies, breeds in human excrement and are known to play a significant role in transmission of active trachoma(10, 76-78, 84).

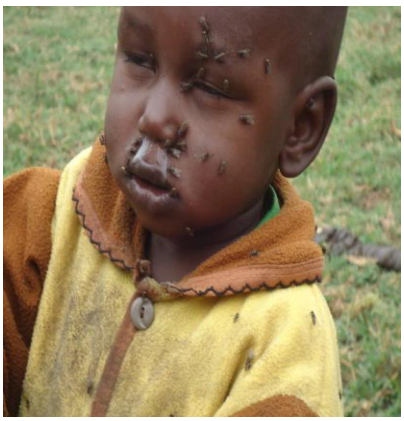


Figure 5.1: A child with a dirty face with many flies

The first risk parameter on evidence of trachoma was redundant because both districts had evidence indicating they were likely to be trachoma endemic. As a result, the risk scores

were nearly equal in all the assessed areas. The other challenge was use of old reports. It is recommended that the documents used in risk assessment should not be old, since trachoma disappears with improving social-economic development(1, 143). The WHO defines old documents as those >7 years old, but adds that such documents may be used if the district has not experienced any substantial social-economic development(166). This was the case in Turkana district where a 1989 blindness survey report was used(171). The baseline trachoma prevalence survey report for Narok was 6 years old(25).

5.2.2 Division of administrative districts into the survey segments

In this study segmentation was preferred to stratification in the sampling design. In his article on sample size calculation for eye surveys, Darwin Minassian advised that it is safer to ignore the possible gain that might arise from stratification as the complex equations used demand that fairly accurate assumptions are made about the prevalence in each stratum, and about the stratum-specific design effects. These are difficult and often virtually impossible to foretell with any confidence(14). Also, it is recommended that in operational research, the research methods should be simplified as much as possible so that the project teams can be able to replicate them, especially in the developing nations where there are very few experts(157). Simplified research methods and interventions are key predictors of the success of the scale-up of global public health interventions(158).

The second reason why segmentation was preferred was the need to create standardized population units for both surveys and implementation of the SAFE strategy. Both the strata and the segments are geographical areas with similar risk of trachoma. However, the population size of the strata is not specified. The segments in this study had the same population as the WHO recommended "*trachoma districts*"(10).

The aim of a standard survey with stratification is to determine the prevalence of trachoma while the aim of a TSS is to detect a TF prevalence of 10%, to justify administration of mass antibiotic treatment. Therefore, stratification is done to inform the allocation of the sample size in areas with different risk of trachoma(11, 14, 66). The strata with low risk of having trachoma are allocated larger samples than for the strata with high prevalence and the aim is to determine the prevalence of trachoma of any level. In a TSS all the segments were allocated equal sample. The sample for a TSS is also adequate to detect a prevalence of 30%, which is the prevalence level to justify mass treatment for 5 years, since a smaller sample is required to detect a prevalence of 30% than of 10%.

Adoption of the systematic sampling method made it easier to create the segments than in simple random sampling because the former is self-weighting(9, 10, 16). In systematic sampling method the sampling interval between any two successive clusters is constant. As a result, geographical areas with equal number of survey clusters have approximately equal population sizes. This means that survey segments with equal number of clusters have equal population sizes. This made it possible to construct a single sampling frame for an entire administrative district, from which the survey clusters for the respective segments were selected.

Trachoma risk scores were used to inform the creation of the segments. In Turkana district, the refugee camp and the Central Turkana segments were created first since they were the only areas with relatively low risk scores. The refugee camp is centrally located in Turkana district and at the time of this study it had <100,000 people. As a result, it was not possible to create segments with equal population sizes in Turkana. The camp was surveyed as a separate segment with 15 clusters. The 5 clusters selected in the communities around the camp were distributed to the rest of the segments. However, none of the 5 segments in Turkana had >200,000 people. These results indicate that in special settings one may be forced to create segments which are smaller or larger than anticipated. The same may happen if there are physical barriers like in a country comprising of several islands of different sizes.

In Narok district, the 5 survey segments had 20 survey clusters each and approximately equal population as planned. Two segments were created in the arid southern lowlands (high risk scores), 2 in northern highlands (low risk scores) and 1 in the Narok Central (transition zone).

5.2.3 Sampling

A sample size is defined as an approximate minimum number of persons that should be selected and examined during a survey(14). The factors taken into consideration when computing the sample size include: available resources, expected prevalence, anticipated design effect, the confidence level and the desired precision(9, 10, 14, 15).

5.2.3.1 Prevalence estimate

The prevalence of TF estimate assumed when computing the sample size for this study was influenced by the minimum threshold for mass antibiotic treatment since the aim of the study was to develop an effective survey method to justify mass treatment. The WHO

recommends the age of 1-9 years for TF surveys(8, 17) and a prevalence of 10% is the starting threshold for mass antibiotic treatment(17). Therefore, the outcome variable for this study was presence of trachoma as a public health problem, with a predictor variable of 10% prevalence of trachoma TF in children 1-9 years.

The implication of this is that a TSS could not be used to precisely estimate a prevalence of <10%. Large samples are needed for to detect low prevalence of disease, which can be calculated using Equation 1 and factoring in the desired prevalence estimate. For example to calculate the sample size for a survey to certify of elimination of TF (prevalence <5%), a prevalence estimate of 4% is recommended, with an absolute precision of at least ±2%(8).

The segments with a prevalence of <5% in Narok district had very wide confidence intervals because a large survey sample size is needed to accurately determine a low prevalence(9, 14, 15). The sample sizes for the TSS method were to determine a prevalence of ≥10%.

5.2.3.2 The design effect

A design effect of 2.0 and 3.0 was for TF and TT surveys respectively. A low design effect means a relatively small survey sample size can be used to detect the specified prevalence estimate. This can be achieved by selection of small survey clusters(14), as was the case in TSS. A survey with many small clusters has wide geographical coverage hence can identify clustered disease more effectively that a survey with few large clusters. The major limitation many small clusters is it increases the distances travelled by the survey teams and fuel costs. It is therefore necessary to balance the benefit of small survey clusters and the cost of a survey when selecting the design effect.

5.2.3.3 Precision

The confidence level for this study was 95%, which is the standard in population-based prevalence surveys(9, 15, 16). However, a relative precision for both the TSS and TT40 methods was 30%. A higher precision could have resulted in large samples which could have been too expensive. The Ideal precision for surveys is 20%(9) and >50% is considered to be too low for meaningful statistical inference(8, 14). In surveys to certify elimination of active trachoma, it is recommended that the sample size should be adequate to detect a TF prevalence of 4% ±2%(8). This corresponds to precision of 50% (50% of 4% = 2%). Large sample sizes are required to estimate a prevalence of <5% with the ideal precision of 20%, which is expensive for programmes with limited resources. Therefore, we considered the

30% relative precision used in this study adequate to accurately determine the prevalence of both TF and TT.

The 95% confidence intervals for the prevalence of TF were examined to determine whether the 30% precision was achieved. In Turkana, the Kakuma refugee camp and Central Turkana segments had wider 95% confidence intervals than anticipated because trachoma was highly clustered. In the refugee camp the disease was found only among the Southern Sudanese. The refugee communities from other countries were non-endemic. In Central Turkana the communities near Lake Turkana had a lower prevalence than the other communities in the segment. Therefore, larger samples were required in the two segments.

In Narok district the confidence intervals for the three segments with prevalence <5% were wide because the samples were not adequate to determine a prevalence of <10%.

With the 10% prevalence estimate and 95% Confidence Interval of 7% to 12% there was a chance of a segment with prevalence of 7% to <10% being included in mass antibiotic treatment. Additionally, the chance of the true prevalence being higher or lower than the confidence limits was 5% (100-95%): a 2.5% chance of being higher than the upper limit (over-estimate) and 2.5% chance of being lower than the lower limit (under-estimate). Being above was not a concern since it was above the threshold for mass treatment. This chance cannot be completely avoided in sample surveys. The only prevalence without a confidence interval is the true prevalence in the population, which remains unknown and is expensive to determine. However, it can be minimised by adopting the highest precision possible. The 5% chance of the true prevalence being outside the confidence interval is usually considered to be small enough to be ignored(14, 15).

All the 95% Confidence Intervals estimated in this study were adjusted to account for potential clustering using the generalized estimating equations (GEE) modelling developed by Bennett et al(161). This is required because the prediction of the design effect is not an exact method.

5.2.3.4 Sampling plan

The survey clusters selected by this method are distributed proportional to the population size in the entire study area. In this study, a frame was constructed using the census report for each administrative district (*Appendix 2-3*) and the survey clusters for all the segments selected using the systematic sampling method(9, 10, 16). The sub-locations were the

Primary Sampling Units since they were the smallest administrative units in the census. In Kenya villages are not included in census reports.

The sampling frame for Narok district was based on the August 2009 census, which was conducted one year prior to this study. The frame for Turkana district was based on population estimates projected from the 1999 census by the District Statistics Office because the government had nullified the 2009 census for the district due to influx of refugees. It is recommended that a census report which is >5 years old should be updated using more recent information before it is used for a survey(9).

The simple random sampling method was used to select two villages in each cluster. The selection of the households was done by spinning an object to indicate the direction of the household to be visited. In Rapid Assessment of Avoidable Blindness this method of selecting households has been replaced with the compact segment method (https://www.iceh.org.uk) on grounds that it is: more complicated than the compact segment method, less objective and hence has a higher risk of bias (preferential inclusion of blind people). In the compact segment method, the area where a survey cluster is to be selected is divided into several segments with approximately equal population sizes and well-demarcated boundaries. One segment is then randomly selected. All households in the segment are included in the sample sequentially until the sample size is achieved. Trachoma is more clustered than blindness and cataract, the main conditions of interest in Rapid Assessment of Avoidable Blindness surveys. It is not clear how the compact segment method may work in trachoma, especially in surveys with large clusters.

Geographical coverage is important for a highly clustered disease like trachoma, because selection of the sample in only one segment may either underestimate or overestimate the number of trachoma cases in a cluster. This is especially true in standard surveys where large clusters of 100-300 individuals are selected(9, 10, 16). In this study, the clusters were small (40 children each) and two villages were selected in each cluster to ensure the widest geographical coverage possible. The compact segment method is more convenient because it minimises the distances travelled during a survey. Therefore, it should be tested before it is adopted in trachoma surveys since it may limit the geographical spread of the sample in surveys with large clusters.

5.2.4 Validation of the trachoma graders

The inter-observer agreement was high because the most experienced trachoma graders in the Kenya Trachoma Control programme were recruited to collect the data for this study. Similar findings were reported in Tanzania where a nurse with extensive experience in trachoma field work was evaluated against another experienced grader and the kappa score for TF was 1.0, which implies an agreement of 100%(69).

The WHO trachoma grading slides (photographs) were used for the Inter-observer testing in the Turkana survey but in Narok it was done with people during the pilot study. Photographs have been used to grade the clinical signs of trachoma grading(67, 68). However, their use in inter-observer agreement testing is controversial(69). Also, quality photographs require high resolution cameras, which may increase the cost of a survey. However, with the rapid growth in electronic industry we may soon have a mobile phone which can take gradable photos. The graders can then send the photos via text messages to a central grading centre for data entry and storage.

5.2.5 Diagnostic methods and effectiveness of mass treatment

In this study trachoma clinical examination findings were graded according to the WHO simplified trachoma grading scheme(65). The revision of the grading scheme published in 2006(5, 10) was also adopted. In the revised version, only 3 clinical signs are recommended as the monitoring indicators for trachoma control, namely: TF, TT, and CO.

Laboratory tests for Chlamydia trachomatis were not performed because they are expensive(39). However, this had not consequences on implementation of the study findings because WHO prevalence thresholds and ultimate intervention goals for mass antibiotic treatment are based on clinical diagnosis(8, 9, 16, 17). Moreover, laboratory testing is not a mandatory requirement for donation of azithromycin. Most countries in Sub-Saharan Africa, Kenya included, do not have the capacity to perform laboratory tests for Chlamydia trachomatis. As a result, specimens are sent to oversees laboratories for processing(28, 46, 106, 116, 120, 173). This requires complex logistics, including a cold chain. So far, only one small scale sero-epidemiological study was conducted in Kenya in the 1980s using direct fluorescent antibody test (DFA). Two hundred and twenty one children were examined and 25 isolates reported. The Chlamydia trachomatis serotypes isolated were A, B and Ba(48).

In trachoma surveys where Nucleic Acid Amplification Tests have been used to determine the prevalence of infection, there was poor correlation between the prevalence of active

infection as detected by the tests and the prevalence of active disease (TF) as determined by clinical methods(41, 42). The clinical signs tended to under-estimate the prevalence of infection because the clinical signs take time to develop and a mild disease (<5 follicles) is not recognised in the simplified trachoma grading scheme(46). This implies that in the three segments in Narok district with <5% prevalence of TF, the reliability of clinical examination was likely to be poor. Therefore, Nucleic Acid Amplification Tests are needed in subsequent impact assessment surveys(43, 44).

In Narok, the duration of time between administration of mass antibiotic treatment and clinical examination is likely to have influenced the prevalence of TF and prevalence of active infection in the segments. This is attributed to the fact that trachoma clinical signs take time to develop after infection and to resolve after administration of antibiotic treatment(60).

Available evidence indicates that the correlation between the prevalence of active trachoma infection and of TF in a hyper-endemic district like Turkana is likely to be stronger than in a meso-endemic district like Narok(41, 42, 45). This means that the likelihood of treating people who are not infected was lower in Turkana than in Narok. Therefore, there is need to conduct laboratory tests in subsequent impact assessment surveys in both districts.

Children aged 1-9 years were also examined for facial cleanliness. A dirty face was defined as a face with eye and/or nasal discharges(1, 4). However, it is usually difficult to accurately define what constitutes a dirty face(81) because facial cleanliness may vary depending on the time the children's faces are washed. Therefore, the timing of the clinical examination may influence the prevalence of a dirty face. Furthermore, the mood of the child may affect the findings since crying increases nasal discharges. The other contentious issue is whether the presence of food particles and dust on the face should be graded as a dirty face. Children feed frequently and the endemic areas are dusty. In some Kenyan communities application of clay on the body and face is part of beautification (*Figure 5.2*).

Figure 5.2: A beautiful Turkana girl decorated with clay

5.2.6 Active trachoma in children 1-9 years old

5.2.6.1 Participation rate

The participation rates reported for Turkana and Narok districts were high. In both districts the male to female ratio was approximately 1:1, same as in the respective census reports. Generally, studies conducted in predominantly rural communities with house-to-house visits, dedicated survey teams, good public relations and rigorous community mobilisation, have high participation rates(15). This study was considered to be one of the top trachoma control activities in Kenya as it was addressing some critical operational challenges affecting the National Trachoma Control Programme. That is why the government allowed this study to be embedded in the Kenya National Trachoma Control Programme. The programme has a well established co-ordination structure from National to community level, which is funded by the government and non-governmental organisations.

5.2.6.2 Age of the children

The difficulties encountered when estimating the age of some children in Turkana district may have introduced errors in estimation of the prevalence of TF. Over-estimation increases the chance of administration of mass treatment in non-endemic communities whilst under-estimation results in failure to treat endemic communities and recurrence of infection in treated areas.

Children <5 years old are the reservoir of the active trachoma(1, 46, 57, 58) hence erroneous increase in the prevalence could be recorded if they are over-represented in a TF survey. In Turkana district, they constituted 63.6% of the children 1-9 years old in this study and 50% in

1999 census report. A pre-survey census could have provided accurate population estimates but its cost was prohibitive.

Estimation of age in Turkana was also compounded by undernourishment due to raging famine. A study conducted in Ethiopia to investigate the relationship between malnutrition and clinical trachoma established that malnourished children are more likely to have active trachoma with more severe clinical manifestation than the well nourished ones(28).

In Narok district estimation distribution of the studied children by age was the same as in the 2009 census. Therefore, it was unlikely that the prevalence was influenced by errors in determination of age.

5.2.6.3 School attendance

Thirty three point nine percent of the children who had attained the school going age (5-9 years old) in Turkana district and 20.2% in Narok district were not attending school. The percentage was even higher in the segments with high prevalence of trachoma. This indicates that school based trachoma screening programme may not be effective in the endemic communities. Furthermore, in Kenya most hygiene and face washing programmes are school based and innovative methods are required to deliver trachoma interventions at the household level to reach the children who are not in school.

School attendance in Turkana was reported to improve when there was famine relief food, which implies that some interventions like promotion of facial cleanliness and antibiotic treatment may be more effective if administered together with the school feeding programme. Additionally, the Government of Kenya was rolling-out the National Community Health Strategy, which aims to delivering health care at the household level(174). It is important that trachoma control interventions are included in the activities of the Strategy.

5.2.6.4 Prevalence of TF and the need for mass treatment

This study was about survey methods to justify mass treatment and TT surgical services. However, it was taken into consideration that the prevalence of TF is used as the monitoring indicator for the “AFE” components of the SAFE strategy(8). Therefore, the “FE” components were recommended in all the areas with TF. These components disrupt transition of active infection by improving facial cleanliness and eliminating the environmental risk factors(1, 19, 40, 77, 142, 175). This reduces the risk of recurrence of infection in the treated areas.

In Turkana district 1,507 out of the 3,962 children who were examined had TF. The prevalence of TF was 38.0% (95%CI: 32.2%-43.9%). This is the only prevalence which would have been estimated if the district was surveyed using the administrative district method and the whole population would have received mass treated for 5 years(8). However, the TSS method made it possible to administer differentiated mass treatment, informed by the endemicity of active trachoma in the five segments. The Western, Northern and Southern Turkana segments had a prevalence of >30% and needed mass treatment for 5 years, while the refugee camp and Central Turkana had a prevalence of 10% to 30% and needed treatment 3years. All the segments in Turkana districts needed mass treatment for the initial 3 years, irrespective of the survey method. In the long term (>3 years), the TSS method will reduce the number segments under mass treatment if the 2 segments with a prevalence of <30% are "knocked-out" of mass treatment.

The survey by segment method further revealed that the Western Turkana segment may need a long term project plan of >5 years. The prevalence of TF in this segment was 67.6%, which is extremely high. West et al assessed the trachoma control project in Tanzania and suggested that, for communities with baseline trachoma prevalence of >50% and average annual treatment coverage of 75%, >7 years of annual mass treatment will be needed to reach a prevalence of trachoma of <5%(120). The segment is one of the "difficult to reach areas" in Kenya where the treatment coverage will most likely be low. Also, there is a high risk of cross-border re-infection from the neighbouring hyper-endemic areas in Southern Sudan and Northern Uganda. Therefore, the segment may need a 10 year trachoma control project plan.

In the Narok impact, 440 out of the examined 3,998 children had TF and the prevalence of TF was 11.0% (95%CI: 8.0%-14.0%). In 2004 a baseline prevalence survey was conducted using the standard survey methods and the prevalence of TF in the entire district was 30.5% (95%CI:25.6%-35.8%)(25). This is a 65% decline in prevalence of TF between the baseline survey and this study. These results concur with what is reported in literature that 3 rounds of mass treatment are not adequate for a district with >30% prevalence of TF(8, 120).

If this study was conducted using the administrative district method, the total population in Narok would have been treated for another three years. The TSS method revealed that active trachoma was confined in the two southern segments which had a prevalence of 10% to 30%. The two segments needed mass treatment for another 3 years, followed by a repeat survey assessment survey to justify continuation. The North Western, North Eastern and

Central segments had a prevalence of <5%. This implies that mass antibiotic treatment is no longer needed in the three segments. The maximum threshold for certifying elimination of active trachoma as a public health problem is <5% prevalence of TF in children aged 1-9 years(8, 17). After this level is attained, mass treatment is not needed, but surveillance and family based/individual case treatment is required(1).

Only 3 cases of TF were diagnosed in the North Western segment hence the prevalence of TF in all the 20 clusters was <5%. Therefore, this segment may not need further antibiotic treatment. However, the "FE" components of the SAFE strategy should be continued because the segments can be re-infected. Available evidence indicates that when the area under mass antibiotic treatment is reduced, the risk of re-emergence of infection increases if there are nomadic migrations(30, 122, 124). So far, it is not clear how wide the area under treatment should be to eliminate this risk. In the North Eastern and Central Narok segments there were few clusters with a prevalence of >5%, which should be specifically monitored to ensure that they do not re-infect the areas "knocked-out) of mass treatment. The villages in those clusters should be re-surveyed and mass treatment administered where prevalence of TF is >10%(1, 8, 17). The "FE" components should also be continued in the entire district.

The prevalence level at which trachoma may no longer recur after mass antibiotic treatment is not clear. A study conducted in hyper-endemic communities in Ethiopia reported re-emergence of active trachoma after four annual rounds of mass treatment with high treatment coverage and reduction of the prevalence to 2.6%(116). Re-emergence of active trachoma was also reported three years after stopping mass treatment in eight out of the thirteen districts treated in Mali. Mass treatment was administered for three years but in several districts the coverage was low and inconsistent, ranging between 20.9% and 108.6%. The inconsistencies in the mass treatment coverage were attributed to problems with the distribution and/or estimation of the target population(117). The other limitation was that the "FE" components were not implemented in all the areas.

5.2.6.5 Prevalence of TF by age and sex

The prevalence of TF increased slightly between the age of 1 and 2 years and then declined with increasing age. The prevalence of TF in Narok was lower than in Turkana but the trends were similar, with peak prevalence at age 2 years. These findings concur with what is reported in literature. Trachoma is predominantly found in young children below the age of five years and it becomes less frequent with increasing age(46, 57, 58). The peak prevalence of TF among the Australian Aborigines is in children aged 30 to 36 months(1). A study

conducted in a hyper-endemic area in Sudan indicated that 48% of the children under the age of one year had clinical signs of active trachoma(59).

In both Turkana and Narok districts, the prevalence of TF was higher in girls than in boys but the difference was not statistically significant. The high prevalence of active trachoma in girls is attributed to their close contact with young children(18, 44, 46, 57, 58). In all the previously-conducted surveys in Kenya the prevalence of TF was higher in girls than in boys, except in Narok district where the opposite was reported(25, 30-32).

In this study the prevalence of TF was not associated with school attendance because of the low and irregular school attendance by the studied children. This was more evident in Turkana where in some areas the school attendance depended on the availability of food at school. Interventions for active trachoma may have a greater impact if they are linked to the famine relief food distribution instead of the school programmes.

5.2.6.6 Prevalence of TI

Trachomatous inflammation – Intense (TI) is the severe and highly infectious stage of active trachoma. It is associated with increased risk of conjunctival scaring and TT(1, 176). The prevalence of TI in the entire Turkana district was 8.6% (95%CI: 6.3%-10.9%). Most (91.2%) of the had TF as well and the TF:TI ratio was approximately 4:1. This ratio was within the range of 3:1 to 10:1 reported in literature(1). The prevalence of TI is not an indicators for trachoma control(5, 10), but it can be used to monitoring the effect of mass antibiotic treatment since it is more sensitive to treatment than the prevalence of TF(177).

Narok district had received annual mass antibiotic treatment for three years and the prevalence of TI in this study was low (1.0%). The TF:TI ratio was 12:1 higher than the expected(1) but it was not surprising because TI responds faster to treatment than the TF(177). The distribution of TI by segment age and sex was in was parallel to that of TF as expected.

The distribution of TI by segment age and sex was in both districts parallel to that of TF. This was as expected since they are both signs of active disease.

The distribution of TI by age in Turkana district indicated a small second peak in children aged 6 years. The reason for this unexpected finding could not be explained using the information collected in this survey. In the roll-out surveys conducted in 2011, the same phenomenon was observed in the Marsabit segment in Upper Eastern (*Figure 5.3*). It was

speculated that the mothers could be having younger babies and were neglecting those aged 5-6 years when they are not old enough to take care of themselves. Further investigation is needed to verify whether these are truly "neglected children with a neglected disease".

The second peak could also be a hint of a more serious co-morbidity like severe malnutrition. In neighbouring Ethiopia, it was reported that children with malnutrition are more likely to develop more severe signs of active trachoma than the well nourished children(28).

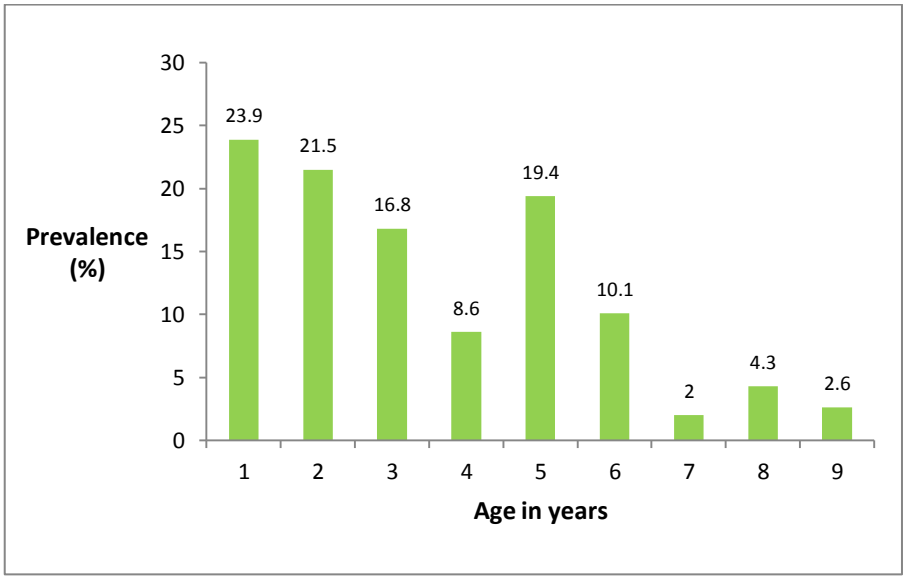


Figure 5.3: Distribution of TF by age in the Marsabit in 2011 (survey report)

5.2.7 Prevalence of a dirty face

A dirty face is an important risk factor of trachoma(1, 4, 81). The prevalence of a dirty face in Turkana was 54.6% (95% CI: 48.9%-60.2%) and it ranged between 16.0% (95% CI: 6.3%-25.7%) in the refugee camp and 76.9% (95% CI: 67.9%-85.9%) in Western Turkana. This shows that the ultimate intervention goal ensuring that ≥80% of the children in a community have clean faces(10, 16) had not been achieved in all the surveyed segments, except in the refugee camp. However, the prevalence of TF in the refugee camp was >10%, which means the "AFE" components were needed. Therefore, implementation of the "FE" components of the SAFE strategy was required in the entire Turkana district.

The refugee camp has adequate water supply but availability of water alone may not eliminate active trachoma. Health promotion is needed and it should be specifically targeted at the trachoma-endemic Southern Sudanese communities. A randomized control trial conducted in Tanzania by West et al reported that improving the hygiene of children was

effective in reducing the prevalence of active trachoma(175). However, Cochrane review by Rabiu et al indicated that the current evidence does not support a beneficial effect of face washing alone or in combination with topical tetracycline in reducing active trachoma(86) and it underscored the importance of implementing the full SAFE strategy. The limitation with Cochrane reviews is that they only include evidence from clinical trials, not other study designs(141).

In Narok district the prevalence of a dirty face was 42.8% (95%CI: 37.4%-48.1%).The segments located in the arid southern lowlands had higher prevalence than the rest of the segments but none of the segments had achieved the ultimate intervention goal. Therefore, implementation of the "FE" is needed in the entire district. In 2004 the prevalence of a dirty face in the entire Narok district was 53.5% (95% CI: 50.8%-56.2%)(25) hence there was an 11% decline in prevalence between the baseline survey and this study. This rate was lower than the 65% decline in the prevalence of active trachoma (TF). Facial cleanliness and environmental sanitation, take longer to implement since they require behavioural change. The components are also more expensive and difficult to implement than the medical interventions(1, 30, 117).

In both Turkana and Narok districts, the prevalence of a dirty face in boys was slightly higher than in girls but the difference was not statistically significant. The clusters with high prevalence of active trachoma had high prevalence of a dirty face. There was a positive and statistically significant correlation between the prevalence of TF and the prevalence of a dirty face in both districts. This is the expected trend since the dirty face is has been associated with increased risk of active trachoma(1, 4).

5.2.8 Age criterion for TT surveys

The lower age limit of a TT survey is important because TT increases with advancing age and this influences the size of the sample for TT surveys. WHO reports indicates that the number of people with active trachoma was decreasing while the number of people with TT was increasing(4). This means that active trachoma will be eliminated sooner than TT. In places where active trachoma has been eliminated TT is found in people >40 years old(24).

In this study, the data sets for six previously-surveyed districts were re-analysed to calculate the optimum lower age limit for TT surveys(35). The six surveys were conducted using the standard lower age limit of 15 years(8-10, 17) and the participation rates were >95%(25, 31). A total of 7,944 adults aged $\geq$15 years old were examined and 316(4.0%, 95%CI: 3.6%-4.4%)

had TT. The prevalence of TT increased with advancing age as reported in literature(1, 24). The prevalence of TT in the subjects ≥30 years, ≥40 years and ≥50 years old was 6.7%, 9.4% and 13.0% respectively. Therefore, the prevalence for the lower age limits of 40 years and 50 years was close to the 10% prevalence of TF used when computing the sample size for the TSS method. This meant that if the two limits were used, the sample sizes for TT and TF surveys could be equalised; other factors being constant.

The second consideration was the amount of TT backlog which could be missed. The re-analysis indicated that people aged ≥40 years had 69.6% to 93.3% (average 87.0%) of the total TT backlog while people ≥50 years old had 52% to 86.7% (average 73.1%) of the backlog. The limit of 40 years fulfilled this criterion since it estimated a higher percentage than the limit of 50 years. Ideally, the backlog of TT in the whole population should be determined. However, this is not feasible since it would require a large survey sample, which is expensive. The purpose of a TT survey is to establish the likely backlog against which services can be planned and performance measured but not to case find(35). All the people with TT are operated on, irrespective of the age of the TT survey participants.

The final consideration which supported the selection of the age limit of 40 years in the TT40 survey method how precise the correction factors for a specified age limit were.

5.2.9 Correction factors

A major challenge faced when extrapolating the burden of TT is that not all TT surveys are conducted using the recommended lower age limit of 15 years because of the need to balance the number of people found and those examined during a survey(2, 17). For example in the six TT surveys whose data were re-analyzed were conducted using the limit of 15 years(25, 31). In this study the limit of 40 years was adopted. Additionally, there were three Rapid Assessment of Avoidable Blindness surveys conducted in Nakuru district, Kericho district and South Nyanza region in Kenya where the limit of 50 years was used(33). In a TRA conducted in the Pacific Islands by Mathew et al the limit of 40 years was used(36) while a 2008 trachoma surveillance report for Australia indicated that a lower age limit of 30 years was used for screening(34). Because of these variations in the age limits used to estimate the prevalence of TT, the WHO recommended the following correction factors to be used for extrapolating the prevalence of TT for the population >14 years old: 1.05 for age-specific prevalence determined for both sexes over 30 years old and 1.1 for age-specific prevalence determined for both sexes over 40 years old(2, 17).

In this study the correction factor for the lower age limit of 40 years calculated was 2.4, which is higher than the WHO estimate(8, 17). The data for the re-analysis were all from baseline surveys conducted in districts with no trachoma control projects(25, 30). The data used by the WHO were from trachoma control projects in Gambia and Tanzania(2) which were offering TT surgical services. TT surgical services could decrease or increase the value of the prevalence correction factors, depending on the age of the people undergoing surgery. For example if most of the people operated on are old, the value of the correction factor may decrease. In areas with poor infrastructure, few health facilities and no eye care outreach services like Turkana, the distances are too long for elderly people hence they may not go for TT surgery. Also, the population structure and the natural history of trachoma varies in different communities (1, 4, 13, 24, 26, 35, 63, 178). This may explain the wide variations in the prevalence of TT in the different age categories in the re-analysed data sets.

The difference between the highest and the lowest prevalence correction factors (range) widened as the lower age limit of TT survey participants increased. The range for the age limits of 15 years, 40 years and 50 years was 0.0, 0.9 and 1.4 respectively. A wide range was interpreted to indicate that the correction factor had low precision. This shows that the precision of the mean correction factors decreased with increasing age limit. This implies that the accuracy of the extrapolated prevalence for the whole population decreased as the lower age limit of the survey participants increased.

The correction factors for the backlog of TT were also determined. This was the first study to provide backlog correction factors hence there are no other findings to compare with. The correction factors for all age limits <30 years were 1.0 for all the six districts whose data were re-analysed. This implies that the lower age limits for TT surveys could be increased from 15 years to 30 years without the need for backlog correction factors since the backlog of TT in people <30 years was a small proportion (6.3%) of the total backlog.

The mean correction factors for the age $\geq$40 years was 1.1 for all districts except Kajiado which had 1.4. For the age $\geq$50 years the mean correction factor was 1.4 and ranged between 1.2 in two districts and 1.9 in Kajiado district. The range increased as the lower age limit increased. Therefore, the higher the age limit of the TT survey participants, the less accurate the extrapolated backlog for the whole population is likely to be.

The range and the ratios indicated that the correction factors for the backlog of TT were generally more accurate than those for the prevalence of TT. This implies that extrapolation

of the total number of people with TT is more accurate when the backlog of TT correction factor is used than when the prevalence of TT is used. Extrapolation using backlog of TT correction factor is a one stage calculation while for a prevalence of TT correction factor it requires two stages. The first stage is to estimate the prevalence in the whole population while the second is to multiply total population with the extrapolated prevalence to calculate the burden of TT. Extrapolations with multiple stages are likely to introduce more errors than those with a single stage, especially where large populations are involved(2). Currently prevalence of TT correction factors are recommended for the extrapolation of the burden of TT(8, 17). The results of this study indicate that the backlog correction factors should be used instead of the prevalence because they are more precise.

The limitation with the above re-analysis was that the data were from only six districts in one country hence the results could not be generalised. The population structure and the natural history of TT may vary from one endemic community to the other.

5.2.10 Blinding trachoma in adults

5.2.10.1 Participations

The participation rate for Turkana TT survey was high and women were slightly over-represented. In this and previous studies women were reported to have a higher prevalence of TT than men(30, 61, 74). Therefore, it is likely that the prevalence for Turkana was over-estimated. The over-representation of women may also have resulted from errors in projection of target population from an old census report and alteration of the population structure by influx of refugees from neighbouring countries. Turkana is an insecure district where some men get killed during combat. Also, men move from place to place looking for pastures for their cattle and migrate to urban areas in search of paid jobs.

This study and the 2009 census indicated literacy level in Turkana was very low. The implication of this was two fold: first it was difficult to accurately determine the age of some survey participants and second health promotion will be challenging. Prevalence of TT increases with advancing age(1, 24, 35, 101) and errors estimation of age could introduce errors in estimation of the prevalence. When developing health promotion materials for the SAFE strategy, it is important to simplify it to ensure that it is understood by the target audience. These include promotion of TT surgery, facial cleanliness and environmental sanitation.

In Narok district the sample size was achieved and the male to female ration was the same as in the 2009 census. The level of illiteracy was higher among women (70.0%) than among men (49.9%). It is women who are affected most by TT, take care of the young children and fetch water. Therefore, it is important to support education of women as part of trachoma control to hasten development of positive attitudes and practices towards TT surgery, personal hygiene and environmental sanitation.

5.2.10.2 Prevalence of TT

Trachomatous trichiasis is the potentially blinding stage of trachoma and it requires immediate lid surgery to avert blindness(53, 62, 102, 104, 106, 178). TT is considered to be a public health problem if its prevalence is ≥1% in people aged ≥15 years(17). In this study, eyes with either epilated lashes or recurrent TT were reported as having TT since they also require surgery. The prevalence of TT in people ≥40 years old in Turkana district was 7.8% (95%CI: 6.8%-8.8%). As expected, the segments with the highest prevalence of TT had the highest prevalence of TF. The prevalence of TT in the population aged ≥15 years was 3.3%. This was extrapolated by dividing the 7.8% prevalence in persons ≥40 years by the correction factor of 2.4 derived from the re-analysis of the previous TT survey data sets. This shows that TT was a public health problem in Turkana hence TT surgery is needed in the entire district.

The prevalence of TT in persons ≥15 years ranged between 5.5% in Western Turkana and 0.5% in the refugee camp. The ultimate intervention goal of <1 case of TT per 1,000 people in the general population(8, 17) had not been achieved in all segments.

The prevalence of TT in Narok was 2.9% (95%CI: 2.2%-3.6%). The segments with highest prevalence of TF had the highest prevalence of TT. The prevalence of TT in the population ≥15 years was 2.9% divided by the correction factor of 2.4 = 1.2%. This implies that TT was still a public health problem in the district and delivery of TT surgical services should be continued. The prevalence of TT in persons ≥15 years in the 2004 baseline survey was 2.3% (95%CI: 1.3%-3.7%)(25). The drop in prevalence between the 2004 baseline survey and this study was 47.8%.

The prevalence in the persons ≥15 years was <1% in the North Eastern (0.7%) and the North Western 0.2% segments. This indicates that the ultimate intervention goal had not been achieved. These two segments and the Central segment had achieved the ultimate intervention goal for the “A” component of the SAFE strategy. However, they cannot be

certified as having eliminated blinding trachoma as a public health problem before the ultimate intervention goal for the "S" component is achieved.

In both Turkana and Narok districts the prevalence of TT in women was higher than in men and the difference was statistically significant. The prevalence of TT also increased with advancing age. These findings are in agreement with what is reported in other studies(30, 61, 74).

5.2.10.3 Backlog of people with TT

The aim of a TT survey is to estimate the backlog of people with TT for planning TT surgical services(35). The backlog of TT in Turkana district was 5,410 people ≥40 years old. The sum of the backlog of TT in the five segments was 5,661 people, which was 5% higher than the 5,410 people computed using the mean prevalence of TT for the entire district. The likely cause of this discrepancy was the projection of the population sizes from an old census. The backlog of TT in the population ≥15 years was extrapolated using the correction factor of 1.1 derived from the re-analysis of the previous TT survey data sets as follows: 5,410 people ≥40 years with TT x 1.1 = 5,951 people ≥15 years with TT in the entire Turkana district. The project reports indicated that on average 100 TT surgeries were being performed in Turkana annually. Furthermore, some of the people with TT will die before they are operated on. At this rate it would take about 40 years to address the backlog, whilst the WHO Global initiative for Elimination of blinding Trachoma by 2020 (GET 2020) target is only 8 year away(4). Therefore, there is urgent need to accelerate provision of TT surgery.

The backlog of people with TT in Narok district was 2.9% of 71,860 people aged ≥40 years in the district = 2,084 people ≥40 years old with TT. The backlog in the population aged ≥15 years was 2,084 x 1.1 = 2,292 people aged ≥15 years with TT in the entire district. The district had an ongoing trachoma control project which was performing an average of 200 surgeries per year. At this rate Narok would take 10 years to address the backlog. Therefore, the barriers reported in this study should be address to improve the delivery of TT surgical services. In Turkana they were: hospitals being too far, lack of knowledge that TT could be surgically corrected and having no money to pay for the services. This means that health services and surgical outreach services are needed. Narok has an established trachoma control project and it was surprising that 80% of people with TT said they had not gone for surgery because they were not aware that TT could be surgically corrected. This implies that health promotion should be intensified.

5.2.10.4 Corneal opacities

In both Turkana and Narok districts CO was more prevalent in women than in men, which is in agreement with published literature(1, 30, 61). Some of the eyes with CO had neither TT nor evidence of epilation indicating that the CO was trachomatous. In Narok some of the examined children had signs of vitamin A deficiency, an important cause of corneal blindness. Traditional medical practices are also commonly practiced in both districts. This means there are other causes of CO in the two districts. Therefore, ocular morbidity studies are needed to provide baseline data for common eye diseases and major causes of visual loss. Additionally, comprehensive eye care projects are needed to address trachoma and other eye diseases. A study conducted in Gambia, a trachoma endemic Sub-Sahara African nation, reported that the causes of non-trachomatous CO were: corneal infection, measles/vitamin A deficiency, harmful traditional practices and trauma (unilateral scarring)(56).

5.3 Costs of surveys and mass treatment

The costs presented in this thesis are incremental and not the total costs. An incremental cost is the additional cost a programme incurs to undertake an additional unit of output, using the programme's resources. In Kenya, trachoma surveys and administration of mass antibiotic treatment are planned activities of the National Trachoma Control Programme. The Government provides the staff, equipment, drugs (tetracycline eye ointment and drugs), vehicles and storage facilities for antibiotics. The non-governmental organisations provide money for transport and allowances, staff, drugs (azithromycin) and vehicles. The local communities provide unskilled labour like guides, drug distributors and community mobilizers. Therefore, the salaries of the Government and non-governmental organisations workers were not included in this study since the workers were performing their normal duties.

5.3.1 Cost of trachoma surveys

The cost of surveying one district using the standard survey by administrative district method ranged between and $15,726 per district in 2004 when the six districts were surveyed together and $23,587 in 2007 when Laikipia was surveyed as a single district. The cost of surveying one administrative district using the TSS method was $31,917 in Narok district and $40,610 in Turkana. A survey by the TSS method was more expensive because several segments were surveyed in the same district.

Table 5.1 compares the costs determined in this study with those from an economic analysis conducted in 2006-10 by Chen et al to estimate the incremental cost of trachoma surveys conducted in 165 districts in eight national trachoma control programmes in sub-Saharan Africa. The national programmes included: Ethiopia, Ghana, Mali, Niger, Nigeria, Sudan, Southern Sudan and the Gambia(152). The incremental cost of surveying one administrative district ranged between US$1,511 in Ethiopia and $25,000 in Southern Sudan. The median cost was S$4,784, inter-quartile range $3,508-$6,650. Therefore, the costs of the 2004 and 2007 trachoma surveys conducted in Kenya were within the range of the cost of a trachoma survey in sub-Saharan Africa. The cost of surveying an administrative district with five segments (five surveys) by the TSS method was above the range for Africa.

In both Turkana and Narok the cost of surveying one segment was within the range for Africa. A segment corresponds to a WHO recommended "trachoma district". Five segments were surveyed in each district and this reduced the cost per segment due to economy of scale, as it was the case when six districts were surveyed in 2004. The population of the districts included in the economic analysis was not reported hence the districts with same population as a segment could not be identified for comparison with this study.

Table 5.1: The costs of trachoma surveys in Sub-Saharan Africa(152) and in this study

Study	**Number of districts**	**Number of survey segments**	**Cost of a survey in US$ per**		
			District	Segment	Cluster
Africa, 2006-2010(152)*	165	None	1,511-25,000^	None	84-739
Kenya, six districts 2004(25)	6	None	15,726	None	786
Kenya, Laikipia 2007(31)	1	None	23,586	None	1,179
Kenya, Turkana 2010#	1	5	40,610	8,122	406
Kenya, Narok 2010#	1	5	31,917	6,383	319

**Consultancy charges were not included in the African study*
^The median cost was US$4,784 and inter-quartile range was $3,508-$6,650
#Each segment was surveyed separately

The wide variation in the costs of trachoma surveys in African countries was attributed to: number of administrative districts surveyed in a single survey (economy of scale), vastness of the district/distances between the clusters, terrain, population density, security and the status of the road networks. In some hard to reach areas in countries such as Southern Sudan, the survey teams had to use air transport. Likewise, the administrative districts reported in this study had different population sizes, terrain, road network and level of insecurity. The six districts surveyed in 2004 included Kajiado, Narok, Baringo, West Pokot,

Samburu and Meru North. Their surface areas ranged between 3,942 in Meru North and 21,903 in Kajiado districts(25). The area of Laikipia district (surveyed in 2007) is 9,667 square kilometres. Turkana and Narok were surveyed by TSS method in 2010 and their areas were 77, 000 and 15,098 square kilometres respectively. Turkana, Samburu and West Pokot are marginalised districts with rampant insecurity, poor infrastructure and famine. They are comparable to the neighbouring Southern Sudan.

A review of the items included in the economic analysis indicated that the following costs were not included: consultancy charges and technical assistance (including travel) for headquarters staff. However, it was noted that the average cost for airfare, hotel, meals and incidentals per person-trip was US$1,779, standard deviation $2,027. In this study these costs were included since they were accounted for in the survey budgets and financial reports.

Consultancy charges accounted for 15.9% to 21.2% of the total cost of a trachoma survey while the preparatory meetings and travel by the headquarters teams accounted for 3.6% to 5.3% of the total cost. Most of the trachoma-endemic districts in Kenya are marginalised, poorly staffed and do not have the capacity to conduct trachoma prevalence surveys without support. The consultants are sourced from within the country and usually there is no expenditure on air travel. Most Ophthalmologists in Kenya are clinical and they are not interested in trachoma work, especially the activities which take a lot of their time like report writing. There is need to develop computer software to simplify management of trachoma survey data and reporting. The TSS method is more suitable for such software than the survey by administrative district method since it has the standardised population units, samples and survey clusters. Also, the TSS method can be adjusted to suit different survey settings.

In this study, data collection was the most expensive survey cost item with 51.7% to 60.9% of the total cost of a survey in Laikipia and Turkana respectively. This was the same in the other African countries, where field work comprised on average 69.9% and ranged from 44.9% to 90.5% of the total cost of a survey(152). The second most expensive cost item was consultancy/technical services. The training workshops spent between 8.1% and 15.4% of the total costs of the Narok and Laikipia surveys respectively. The costs of the training workshops in the other African countries varied widely from 1.0% to 29.6% of total cost of a trachoma survey.

Personnel costs for data collection (per diems) accounted for 26.4% to 35.7% of the total cost of a survey, followed by transport for data collection with 8.8% to 19.7% of the total cost. These findings were similar to those for other African countries where the personnel costs in field work accounted for 40.4% of the total survey costs reported by the national programmes, followed by transportation during field work with 22.4%.

The cost per person examined in a trachoma survey was not reported in this study because it does not make sense. This unit cost is often used to make the misleading conclusion that surveys are more expensive than mass antibiotic treatment. Mass antibiotic treatment is an annual community intervention where the whole population is targeted. A survey is neither an intervention nor an annual event. In a survey there is no intention to examine the entire population. If the cost per person examined in a trachoma survey has to be calculated, then the denominator should be the total population, the same as for mass treatment since that is the reference population for the two activities. In the cluster random sampling methods, a survey cluster is the sampling unit, not individuals. Likewise, data analysis and inference should be done by clusters and not by individuals. The people examined during a survey should not be referred to as “people screened”, since a trachoma prevalence survey is not a case finding exercise and it does not fulfil the WHO criteria for screening(15, 35).

5.3.2 Cost of mass antibiotic treatment

Data on the cost of mass antibiotic treatment are scanty in peer reviewed literature. However, there are several publications which indicate that mass treatment with donated azithromycin is cost effective(18, 155, 179-183).

This study established that in 2009, the cost of administration of mass antibiotic treatment for active trachoma was: US$0.20 per person treated in Kajiado district, US$0.26 in Narok and US$0.42 in Samburu. Majority (97.2%) of the people who were treated received azithromycin. During the preparation of the 2020 INSight Global Plan for elimination of trachoma in 2011, the International Coalition for Trachoma Control estimated that the average cost of administering a single dose of azithromycin for mass treatment was US$0.25(154). The cost per person treated in Kajiado and Narok districts were approximately equal to the ICTC estimate. However, the cost for Samburu district was almost double.

Samburu is a “hard to reach district” with insecurity and very poor infrastructure. Also, in 2009 Samburu district team administered the first round of mass treatment hence the team was not as experienced as those for Kajiado and Narok districts. An economic analysis

conduted in 2010 by Kolaczinski et al in a remote setting in Southern Sudan, indicated that the cost of an initial round of mass treatment with donated azithromycin was US$1.5 per person treated(22). However, the analysis included the cost of tetracycline eye ointment (3.7% of total cost) because the drug was purchased by the project, capital costs (5.9% of total cost) and overheads (25% of total cost). The authors noted that in remote settings the cost per person treated was three times higher than the previous estimate of $0.5 they were using for project planning in Southern Sudan.

In Kenya, communities were mobilised to go for treatment at designated treatment sites (the campaign method). The “house to house” method was tested in Narok district in 2008 and abandoned because it was expensive. In December 2011 an “integrated method” which involved administration of mass antibiotic treatment during a vaccination campaign was tested in Turkana but the treatment coverage was low. Also, the administration of antibiotic treatment is supervised by health workers because azithromycin is a prescription medicine. Community directed treatment is not allowed in Kenya.

Kenya is included in the global effort towards integration of trachoma control with control of other Neglected Tropical Diseases(21, 22). Therefore, operational research is needed to develop a cost-effective method or combination of methods to administer mass antibiotic treatment. The first step for such a research project is to audit all the activities undertaken in mass treatment to identify where improvements can be made.

The core expenditure items for the administration of mass treatment in this study were: allowances for the distribution teams (46.2%-58.5% of the total cost), training workshops (15.1%-24.8%), transport (14.6%-17.1%) and community mobilisation (14.6%-10.3%). In the Sudan study personnel costs accounted for 37.0% of the total costs and travel 25.3%(22).

The total amount of money spent was divided by the number of people treated to derive the cost per person treated. As a result, low treatment coverage could increase the cost per person treated. The ultimate intervention goal for mass treatment is to treat everybody in the targeted population with antibiotic annually(2) and a treatment coverage of $\geq$80% is considered successful(17). In 2009 the treatment coverage for Kajiado, Samburu and Narok districts were 81.9%, 80.5% and 74.5% respectively. This shows that in Narok the treatment coverage was low. However, the calculation of the treatment coverage could have been affected by the fluctuations in population due to nomadic migrations. The population estimates for the three districts were extrapolated from the 1999 census since the 2009

national census report had not been published at the time the treatment was administered. A similar challenge was encountered by Bamani et al in a study conducted in 16 districts in Mali where the treatment coverage ranged between 20.9% and 108.6%. The main cause of this discrepancy was difficulties in estimation of the target population(117).

The three districts reported in this study would have required additional resources to achieve treatment coverage of 100%. Keenan et al conducted a study in Ethiopia to determine whether individuals who are difficult to locate were more likely to be infected with ocular Chlamydia than those who were easier to locate. They established that after approximately 80% of individuals in a community have been located, extra efforts to find absent individuals may not yield significantly more cases of ocular Chlamydia in a setting with repeated annual mass azithromycin treatments. The findings of that study did not support the increase of antibiotic treatment coverage target beyond 80%(184). Therefore, additional resources may be required in Narok district to achieve 80% treatment coverage. Kajiado and Samburu had achieved the goal.

The projects reports indicated that the factors which influenced the treatment coverage in the three districts were: experience of the district teams, nomadic migrations, poor road networks, limited budgets and the expected side effects of azithromycin. The drug distributors in Samburu had the lowest productivity, with 48 people being treated per drug distributor per day, compared to Kajiado and Narok where 88 and 60 people were treated by one distributor per day respectively. In Samburu district a relatively large number of drug distributors were recruited because there was a security alert and none of the local communities could accept distributors from outside their own communities.

This study also established that the antibiotic treatment coverage could also be affected by the attitude of the communities in the non-endemic areas. Project reports for Narok indicated that the communities in the non-endemic areas in the northern highlands were reluctant to participate in mass antibiotic treatment since they did not see the need to do so. The results of this study revealed a strong positive and statistically significant correlation between the 2004 baseline prevalence of TF and the treatment coverage ($r= 0.81$, $p= 0.02$). This meant that the areas with low baseline prevalence of TF had lower coverage than those with higher prevalence of TF. The correlation between the prevalence of TF in this study (impact assessment survey) and the mass treatment coverage was also positive but not statistically significant ($r= 0.62$, $p= 0.10$). This was due to the lowering of the prevalence of TF in the entire district due to ongoing “AFE” interventions.

The costs determined in this study could not be generalised because of the many factors which could influence them. The factors were similar to those discussed under the cost of trachoma survey in Sub-Saharan Africa(22, 152), including: whether a country has a national trachoma control programme or not, availability of skilled manpower, state of the road network, climate, terrain, population density and security.

5.3.2.1 Comparison of the costs of surveys and mass treatment

The results of this study confirmed that administration of mass treatment for active trachoma is more expansive than a trachoma prevalence survey. The cost of a standard survey by the administrative district method was 4.1% and 8.3% of the total cost of a survey plus mass treatment in Turkana and Narok respectively, while by the TSS method it was 4.7% to 9.9% respectively.

A major limitation to the implementation of the SAFE strategy is that the resources available for trachoma control are limited(5). The costs of trachoma surveys and mass antibiotic treatment are often considered separately leading to the common believe that trachoma surveys are expensive thus the money for surveyed should be minimised and the savings used for interventions. This is particularly the case in Africa where the need for intervention is high and the resources are inadequate. However, the problem with this argument is that it ignores the large amount of resources wasted on administration of mass treatment based on the results of trachoma prevalence surveys with low resolution. As discussed earlier, it is also incorrect to compare the cost per person examined during a survey with the cost per person treated during mass treatment.

Prior to the 2010 recommendation that districts with prevalence of TF >30% should be treated for five years before impact assessment(8), administration of mass treatment was based on a three year project cycle. This was the case in all the districts reported in this study. In Narok district a baseline trachoma prevalence survey was conducted in 2004, followed by mass antibiotic treatment from 2007 to 2009. The impact assessment survey conducted by the TSS survey method during this study reduced the cost of administering mass antibiotic by 53.2% after three non-endemic survey segments were excluded from further treatment. The savings made ($193,219) can be used to fund more trachoma surveys or the other components of the SAFE strategy. If the Narok survey was conducted using the standard method there would have been no savings since the whole population would have been included in mass treated for another three years.

Turkana district represented a hyper-endemic setting and there were no savings expected in the initial three years of mass treatment. The cost of administering mass treatment by the TSS methods was $11,705 more expensive than by the standard method. This extra cost was incurred in the survey since the TSS method was more expensive than the standard method. After three years, the cost of administration of mass treatment will depend on whether the two meso-endemic segments are excluded from mass treatment or not. It was not possible to forecast the outcome of the impact assessment surveys in the two segments after 3 years hence the cost comparison for Turkana was done for three years only.

5.4 Lessons learnt

The lessons learnt from the surveys conducted during this study and the roll-out surveys about the new survey methods were:

1. In large administrative districts, the TSS method is more expensive than by administrative district method. However, mass antibiotic treatment by segments is cheaper than by administrative districts.
2. In large meso-endemic districts like Narok the TSS method minimises inclusion of non-endemic communities in mass antibiotic treatment.
3. For short-term (3 years) administration of mass antibiotic treatment in a large hyper-endemic administrative district like Turkana, the TSS method is more expensive than the standard method. However, for long treatment the TSS method is cheaper because it allows differentiated administration of mass treatment by segments.
4. The TT40 method eliminates the delays caused by large TT samples and improves the efficiency of both TT and TF prevalence surveys. However, it requires correction factors to extrapolate the total backlog of TT.

CHAPTER SIX

6 Conclusions

This study addressed some challenges encountered when conducting trachoma prevalence surveys in large districts in Kenya and the National Trachoma Control Programme was able to roll-out the new trachoma survey methods developed during this study. The challenges included large variation in the population of administrative districts and in most of the endemic districts the disease was clustered. An effective "Trachoma Survey by Segment" (TSS) was developed to identify the areas that need mass antibiotic treatment for active trachoma. Also, the TT40 method was developed to improve the efficiency of the surveys by ensuring that both TT and TF surveys were completed within the same period of time.

6.1 The "Trachoma Survey by Segment" (TSS) method

The results of this study confirmed that the TSS is an effective trachoma prevalence survey method to identify the areas that require mass antibiotic treatment in large administrative districts. The two factors that improved its effectiveness were:

1. The method standardises the population size of the geographical areas where the surveys are conducted (segments). As a result, the number of participants selected for a trachoma prevalence survey is proportional to the population size of the study area, irrespective of the population size of the administrative district.
2. A TSS has many small survey clusters which increase the geographical coverage of the study area.

The TSS method reduces the cost of mass antibiotic treatment by exclusion (knock-out) of the segments with <10% prevalence of TF from treatment.

In Turkana district, a standard survey could have justified administration of mass treatment to the whole population for five years. However, TSS method made it possible to administer differentiated mass treatment guided by the endemicity of active trachoma in the segments.

In Narok district, a standard survey by administrative district method could have justified continuation of mass antibiotic treatment in the whole population for another three years. The TSS method revealed that there were three out of five segments which did not need further mass treatment. Consequently, the three segments were "knocked out" of mass treatment. However, they had some clusters with <5% prevalence of TF which required targeted treatment to avoid spread of infection to the successfully treated areas.

Pre-survey trachoma risk assessment was conducted to inform creation of survey segments. In the hyper-endemic setting (Turkana) the correlation between trachoma risk scores and prevalence of TF was positive but not statistically significant. It was therefore difficult to differentiate the risk of trachoma in the different areas in the district since all the segments were trachoma-endemic.

In the meso-endemic setting (Narok), it was possible to differentiate between large areas (segments) with a big difference in prevalence of TF. However, it was not possible to accurately differentiate the risk of trachoma in the smaller areas within a segment with small differences in the prevalence of TF. Moreover, risk assessment was confounded by nomadic migrations and preceding mass antibiotic treatment.

It was suggested that in future surveys questions on face washing practices and ownership of pit latrines should be included to improve the effectiveness of the risk assessment form.

6.2 Incremental costs of surveys and mass treatment

6.2.1 Cost of trachoma prevalence surveys

When several administrative districts were pooled and surveyed together the cost per administrative district was lower than for a single administrative district survey. The pooling of several districts reduced the expenditure on logistics, training workshops and consultancy.

In a large administrative district with five segments, the cost of surveying an entire district by the TSS method was 22% to 40% higher than a survey by the by administrative district method. However, the cost per segment ($6,383 to $8,122) was lower than the average cost per administrative district in 2004 ($15,726), when six districts were pooled and surveyed together. Both the costs surveying one segment by the TSS method and one administrative district by the standard method were within the range for the cost of trachoma surveys in sub-Saharan Africa.

Data collection was the most expensive cost item, accounting for 51.7% to 60.9% of the total cost of a survey. This was followed by consultancy/technical services (15.9% to 22.3%) and training workshop (8.1% to 15.4%).

The factors which influenced the cost per administrative district surveyed were: the sample size (the TSS had a bigger sample size than a standard survey), number of districts or segments surveyed together (economy of scale), vastness of the district, population density, insecurity and infrastructure.

6.2.2 Costs of administering mass antibiotic treatment

In 2009, the cost of administration of mass treatment in Kenya ranged between $0.20 and $0.42 per person treated per year. The treatment coverage target of ≥80% was achieved in Kajiado and Samburu districts but in Narok the coverage was 74.5%.

The most expensive cost item was allowances for the drug distribution team, accounting for 46.2% to 58.5% of the total cost of mass treatment. This was followed by training (15.1% to 24.8%) and vehicle running costs (14.6% and 17.1%).

The cost of a survey by the standard method was 4.1% to 8.3% of the cost of a survey plus administration of mass treatment while by the TSS method it was 5.7% to 9.9%.

In Narok district the TSS method reduced the cost by 53.2% because three segments were "knocked-out" of mass treatment. In Turkana district, mass treatment was needed in all the segments for an initial 3 years hence in the short term the TSS method was more expensive than a survey by administrative district method. The extra $11,704 spent on a survey by TSS method in Turkana was 1.7% of the total cost of a standard survey and mass treatment for three years ($710,541). In the long term, the cost of treatment will reduce because two segments may be "knocked-out" of mass treatment after 3 years.

The factors which influenced the antibiotic treatment coverage and cost of mass treatment were: infrastructure, experience of the drug distribution teams, challenges in estimating the target population size in nomadic communities and security.

6.3 The TT40 survey method

The "TT 40" fulfilled the objective of having TF and TT surveys completed within the same time period and improved the precision of TT prevalence estimate. The 87% backlog of TT

estimated in a TT40 was considered adequate for planning in a district with low TT surgical coverage. A correction factor of 1.1 is required to estimate the total backlog of TT.

The lower age limit of 50 years used in Rapid Assessment of Avoidable blindness was not selected for this study because 27% of the backlog of TT could have been missed.

TT surgical services were needed in the entire Narok and Turkana administrative districts. The prevalence of TT in people ≥40 years old in Turkana district was 7.8% (95%CI: 6.8%-8.8%). The backlog of TT was 5,410 (minimum 4,717 and maximum 6,104 people). In Narok district the prevalence of TT was 2.9% (95%CI: 2.2%-3.6%) and backlog 2,084 (minimum 1,581 and maximum 2,587 people).

TT recurrence rate in Turkana district was 50%. In Narok districts there were no cases of recurrent TT reported during the survey.

The main barriers to TT surgical services were: long distance to hospital, lack of awareness and poverty.

6.4 Correction factors for prevalence and backlog of TT

Correction factors are commonly used to extrapolate the prevalence of TT for the whole population using data from surveys with different lower age limits. In this study, both the correction factors for prevalence and backlog of TT were determined.

The results indicated that backlog of TT correction factors were more precise and easier to use than the prevalence of TT correction factors. Extrapolation of the total backlog using a backlog correction factor is done in a single stage. This includes multiplication of the backlog of TT for a specified age limit by the respective correction factor to derive the total backlog. When a prevalence correction factor is used the extrapolation is done in two stages: first, the prevalence in a specified age limit is multiplied by correction factor to derive the prevalence of TT in the whole population and then the total population is multiplied by the extrapolated prevalence to derive the total backlog. Extrapolations with multiple stages are likely to introduce more errors, especially when dealing with large populations and multiple data sets, as is the case with national and global programmes.

These results could not be generalised because the data used to calculate the correction factors were from six districts in one country. The natural history of trachoma varies from one community to the other.

6.5 Need for the SAFE strategy in Turkana and Narok

Trachoma control includes simultaneous implementation of the four components of the SAFE strategy.

The entire Turkana administrative district needed all the components of the SAFE strategy.

All the segments Narok district needed the "SFE" components since they had not achieved the ultimate intervention goals. The two endemic segments needed the "A" component. Additionally, in the three hypo-endemic segments had some clusters with ≥5% prevalence of TF which needed targeted antibiotic treatment.

6.6 Application of the TSS method in other situations

In this study the TSS method was used to solve a specific challenge of how to conduct effective trachoma prevalence surveys to justify administration of mass antibiotic treatment in large administrative districts. This option was referred to as the "segment knock-out" to signify the exclusion of the non-endemic segments from mass treatment. However, the TSS method can also be modified to suit other situations as follows:

- The "Segment knock-in" survey method: this modification includes survey of an endemic segment in large hypo-endemic district and including the segment in a trachoma control project of neighbouring endemic district.
- Survey with mini segments: a survey can also be conducted using segments with <100,000 people each in special settings, as was the case in the Kakuma refugee camp. In some settings physical barriers may not allow creation of segments with equal population sizes, for example in countries comprising of several small Islands. Small districts without physical barriers should be merged into segments.
- A "jigsaw survey": this modification is appropriate for rolling out a project which starts as a small scale pilot project. The areas bordering the project can be segmented, surveyed and the endemic segments added into project area in a "jigsaw" manner.
- A "segment scatter" survey method: this modification is suitable for a prevalence survey in a vast area with several large districts which are suspected to be trachoma-endemic. The surveys start in the high risk segments and end in the low risk segments as follows: conduct trachoma risk assessment to identify the low and high risk segments in each district and then survey one or two high risk segments in each

district. If trachoma is present in the surveyed segments, complete surveying the remaining segments in the district. If trachoma is not present, there is no need to survey the segments with low risk. Unlike a Trachoma Rapid Assessment, this option ensures prompt prevalence estimates and administration of mass treatment by segments.

6.7 Contribution to trachoma control policy

This study contributed to trachoma policy in Kenya and in the world as follows:

1. The Government of Kenya in collaboration with the Sightsavers and the Fred Hollows Foundation adopted the new trachoma prevalence survey methods in all the subsequent surveys conducted in Kenya.
2. The implementation of the SAFE strategy in Narok district using the surveyed segments was used as a case study during the development of the 2020 InSight (a global strategic plan for trachoma control) and the Trachoma Action Plan (TAP) template. The workshop was held in Kenya in 2010. It was sponsored by the International Coalition for Trachoma Control (ICTC).
3. The results of this study were added to the WHO data bank and used to update the world trachoma atlas (www.trachomaatlas.org).
4. In 2010 the third global scientific meeting on trachoma elimination recommended that outcome surveys should be conducted in districts with 100,000 to 250,000 people, meaning that large districts with >250,000 people should be sub-divided into survey segments, as advocated for in this research project since 2009.

6.8 Further research

Operational research is needed to develop effective methods or combinations of methods to administer mass antibiotic treatment for active trachoma. In this study the productivity of the drug distributors was low in Samburu district due to poor infrastructure, insecurity and inexperienced team since this was their first round of mass treatment. However, there could be other reasons which were not established in this study because the data were collated from project reports. A detailed assessment of the planning, management and implementation processes may shed some light on how they can be improved. The treatment coverage for the first year of mass treatment was reported to be higher than for

subsequent annual distribution in all the districts, an indication of possible change of attitudes by the communities, which will need further investigation.

So far, three methods of administration of mass treatment have been tried in Kenya. The "house to house method" was used in 2008 and abandoned because it was expensive. This was replaced with the "campaign method" where treatment is administered at designated treatment centres. In December 2011, an "integrated method" where mass antibiotic treatment was administered during a vaccination campaign was tested in Turkana but the treatment coverage was low. In Kenya mass treatment with azithromycin is supervised by health workers. Community directed treatment is not allowed.

So far, there is no standardised method for trachoma risk assessment. Therefore, there is need to develop and validate a standard data collection form for pre-survey trachoma risk assessment.

6.9 New links collaborations

The author of this thesis is an academic staff at the Department of Ophthalmology of the University of Nairobi. He was the first Kenyan to undertake a postgraduate degree in ophthalmology course in Australia, which opened the doors for new collaborations and links between the two countries. The Centre for Eye Research Australia, where the Department of Ophthalmology of the University of Melbourne is based, has both clinical and population health programmes which are appropriate for development of eye care in Kenya. The other avenue for such collaboration is the Ophthalmological Society for Eastern Africa annual conferences which offer a forum for scientists from all over the world to meet and discuss new discoveries. The Fred Hollows Foundation of Australia has a country office in Kenya which is funding the roll-out of the new trachoma survey developed during this study. The office can provide management support for the new links.

6.10 Recommendations

The following recommendations were drawn from the results of this study:

- In large administrative districts, the standard trachoma survey by administrative district method should be replaced with the TSS method.
- In large hyper-endemic districts, the survey by administrative district method can be used to trigger short-term (≤3 years) administration of mass antibiotic treatment. The TSS method is recommended for long-term mass treatment.
- The TT40 survey method with correction factors should be used to estimate the backlog of people requiring TT surgery.
- In Turkana district, mass antibiotic treatment should be administered for 3 years in the two meso-endemic segments and 5 years in the three hyper-endemic segments. After treatment the segments should be re-surveyed to justify further treatment.
- In Narok district mass antibiotic treatment should only be administered in two meso-endemic segments. Individuals and family treatment should be continued in the non-endemic segments.
- The “FE” components of the SAFE strategy should be implementation in the entire Turkana and Narok districts to stop further transmission of active infection.
- TT surgical services should be provided in all the segments in the two districts.
- The barriers to TT surgical services should be addressed.
- Operational research is needed to develop a cost-effective method or a combination of methods for administration of mass treatment.
- The risk assessment form should be improved and validated in subsequent studies.

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APPENDICES

Appendix 1: Trachoma risk assessment form

Name of division _____ Date _____

Fill one form for each administrative division and one for the entire district.

For each question, tick* [√] *<u>one (most appropriate) response</u>:

1. What evidence is there to indicate the area has trachoma?

a) It borders an endemic district (1 point) _____

b) Trichasis (TT) cases reported (2 points) _____

c) Rapid assessment (3 points) _____

d) Prevalence survey (4 points) _____

2. What is the main socioeconomic activity of communities in the area?

a) Majority are settled urban communities (1 point) _____

b) Majority are settled famers (2 points) _____

c) Both nomadic herders and settled farmers (3 points) _____

d) Majority are nomadic herders (4 points) _____

3. What about water availability?

a) Has piped water in most of the houses (1 point) _____

b) Has constant water supply: springs/rivers/dams/boreholes (2 points) _____

c) Dry less than 6 months in a year (3 points) _____

d) Dry most of the year (4 points) _____

4. And the average time period most people take to fetch water (one round trip)?

a) Does not fetch water; piped water in every house (1 point) _____

b) Less than one hour (2 points) _____

c) One to two hours (3 points) _____

d) More than two hours (4 points) _____

5. What is the poverty level of the communities living in the area, compared to those in other areas in the district?

a) Whole community is rich (1 point) _____

b) Majority rich; clusters of poor communities (2 points) _____

c) Majority poor (3 points) _____

d) Very poor; on famine relief supply (4 points) _____

TOTAL SCORE: Minimum = 5 points and maximum = 20 points _____

GRADING: 16-20 = high, 11–15 points = moderate and 5-10 points = low risk _____

Appendix 2: Sampling frame for the Turkana survey

DIVISIONS	Locations	Sub-locations	Cumulative Population	Cluster Codes	Segment
LOKICHOGIO	Songot	Lokalue	1,302		
		Songot	5,559	001	1
		Lopkwaurin	6,861		
	Lorau	Lotikipi	8,403		
		Lakangae	9,421		
	Mogila	Mogila	11,801	002	1
		Lopiding	14,615		
	Lotetelei tit	Lotetelei tit	17,049	003	1
		Loremeit	22,186	004	1
	Lokichogio	Lokichogio	31,086	005,006	1
		Lokariwon	40,559	007	1
	Nanam	Nanam	40,719		
		Lomeyan	41,145		
KAALING	Kaikor	Laitanit	43,694	008	1
		Nalita	44,814		
		Lokolio	46,096		
	Yapakuno	Malimtamu	47,172	009	1
		Kalem	50,860		
		Kakelae	51,378		
	Loruth	Loruth/Esogon	57,234	010	1
		Kotome	59,479	011	1
		Karachii	62,674		
	Kaeris	Kanakurudio	64,934	012	1
		Kaeris	67,049		
		Nadunga	68,043		
		Kangapur	69,516	013	1
		Nakalalei	70,831		
			70,831		
			70,831		
OROPOI	Letea	Loritit	73,572		
		Talabalamy	75,078	014	2
		Katelemot	77,115		
		Loito	79,407	015	2
		Lokipoto	80,395		
	Kalobeyei	Songot	80,861		
		Nalapatui	82,282		
		Natira	82,839		
		Kalobeyei	85,493	016	2
		Lonyuduk	87,218		
		Oropoi	90,079	017	2

DIVISIONS	Locations	Sub-locations	Cumulative Population	Cluster Codes	Segment
	Loreng	Loreng	91,796		
		Namukirionoki	92,468		
LOKORI	Lokori	Lokori	94,583		
		Kangeitit	98,418	018	5
		Lotubae	100,775	019-020	5
	Kochodin	Lopii	102,526		
		Kochodin	103,679		
	Katilia	Elelea	106,343		
		Katilia	109,827		
		Parkati	111,931	021	5
	Lochakula	Lochakula	112,615		
		Kakulit	113,174		
		Lokwamusing	113,710		
LOMELO	Napeitom	Napeitom	116,231		
	Lomelo	Lomelo	116,605	022	5
		Katir	116,750		
	Nadome	Ekipor	117,239		
		Nadome	117,721		
	Kamuge	Ngilukia	118,892		
		Kamuge	120,394		
	Kapedo	Kapedo	120,602		
		Silale	120,932		
KATILU	Katilu	Katilu	126,896	023	5
		Lokapel	129,714	024	5
		Kalemungorok	133,062	025	5
		Kanaodon	135,805		
	Kaputir	Kalomae	138,559	026	5
		Nakwamoru	144,866	027	5
KAINUK		Lorogon	145,514		
	Kainuk	Kainuk	148,968	028	5
		Loyapat	149,793		
		Kakong	150,607		
CENTRAL	Lodwar town	Lodwar town	164,043	029-030	4
		Nakwamekwi	171,605	031-032	4
		Napetet	178,578	033	4
	Kanamkemer	Kanamkemer	186,749	034-035	4
		Nawaitorong	193,176	036	4
KERIO	Kerio	Kerio	196,074		
		Nakurio	200,992	037	4
		Nadoto	203,244	038	4
	Kangirisae	Kangirisae	205,629		
		Nakoret	207,501	039	4
	Lorengelup	Lorengelup	208,627		

DIVISIONS	Locations	Sub-locations	Cumulative Population	Cluster Codes	Segment
		Kangegetei	210,067		
		Kakimat	211,443		
KALOCHOL	Kalochol	Kalochol	223,925	040-042	4
		Kapua	226,731		
		Namadak	230,686	043	4
	Namukuse	Namukuse	236,973	044	4
		Locher akeny	239,925	045	4
	Kangatotha	Eliye	242,806		
		Naoros	244,044		
		Lomopus	245,528	046	4
TURKWEL	Lorugum	Lorugum	248,948		
		Turkwel	254,569	047	5
		Kalemunyang	260,362	048	5
		Lobei	262,633	049	5
	Lomeyan	Lomeyan	273,955	050,051	2
		Nachuro	279,220	052	2
		Kapus	284,326	053	2
	Nadapal	Kawalathe	286,149		
		Tiya	288,449	054	4
		Napeikar	290,855		
		Nadapal	293,202	055	4
	Kotaruk	Kotaruk	299,378	056	5
		Lokipetot areng	302,130		
		Naipa	304,655	057	4
LOIMA	Loima	Lochor ekuyen	305,935		
		Lochor edome	307,527		
		Puch	316,949	058-060	2
		Namuroputh	319,169	061	2
	Lorengippi	Loya	319,423		
		Kaemanik	321,828		
		Nakurio	324,969	062	2
		Lodwat	326,019		
		Lorengippi	327,027		
	Lokiriama	Lokiriama	328,694		
		Atalamusio	330,888	063	2
		Lochor alomala	344,932	064,065	
KAKUMA	Kakuma (+camp)	Tarach	352,769	066,067	2
		Lopur	356,224		
		Nadapal	435,886	068-082	3
		Morungole	444,841	083-084	2
	Pelekech	Losupiki	448,072	085	2
		Namon	449,301		
		Lokore	451,377		

DIVISIONS	Locations	Sub-locations	Cumulative Population	Cluster Codes	Segment
	Nakalale	Nakalale	456,514	086	2
		Losanyait	458,065	087	2
		Kobwin	460,030		
LOKICHAR	Lokichar	Lokichar	464,637	088	5
		Kapese	469,785	089	5
	Kalapata	Loperet	473,497		
		Kalapata	474,955	090	5
		Nakalalei	476,250		
	Lochwangamatak	Lochwangamatak	481,921	091	5
		Napusimoru	485,470	092	5
LAPUR	Karebur	Karebur	487,756		
		Nabulukok	488,699		
	Meyan	Lewan	491,826	093	1
		Napeikar	493,865		
	Kokuro	Kokuro	496,056	094	1
		Sasame	497,437		
		Todonyang	500,392		
LOKITAUNG	Ngissinger	Lowerengat	504,578	095	1
		Kanamkonyi	506,429		
		Nachokui	508,864		
	Lokitaung	Nakalale	512,587	096	1
		Kachoda	513,840		
		Natoo	515,889		
	Kataboi	Kataboi	518,215	097	1
		Katiko	519,836		
		Lomekui	521,607		
	Riokomori	Riokomori	524,115	098	1
		Kokisele	526,763		
KIBISH	Naita	Nayasa	527,066	099	1
		Naita	527,905		
	Kibish	Lokamarinyang	529,636		
		Kibish	530,350		
	Natapal	Natapal	530,860		
		Karachii	532,605		
		Kaitede	533,837	100	1
TOTAL			**533,837**	**100**	

Appendix 3: Sampling frame for the Narok impact assessment survey

Division	Sub-location	Cumulative population	Clusters	Cluster code	Segment
CENTRAL	Narok town	42505	9	001-009	2 = 001-002 3 = 003-009
	Olopito	51015	1	010	2
	Naisoya	55855	1	011	2
	Nkareta	62711	1	012	2
	Oleleshwa	67723	1	013	3
	Enkorika	69364	1	014	4
	Enarmatishoreki	69665			
MAU	Keekonyokie	84316	2	015-016	2
	Enoosupukia	98850	3	017-019	4
	Oloombokishi	101659			
	Enooseiya	105203	1	020	2
	Mosiro	106498			
	Kilonkisa	107172			
	Enkoireroi	108210			
	Ololturot	108751			
	Anaibor-ajijik	113668	1	021	2
	Sakutiek	123887	2	022-023	2
	Ildamat	127426	1	024	2
	Olchorro	131790			
	Parkarara	136414	1	025	3
	Siayapei	140041	1	026	3
	Sonkoro	142208			

Division	Sub-location	Cumulative population	Clusters	Cluster code	Segment
	Olkinyei	146770	1	027	2
	Ilekaiki	149513			
	Ilaiser	153322	1	028	2
	Suswa	158025	1	029	4
	Olesharo	160410			
	Oloikarere	163987	1	030	4
	Ntulele	180955	3	031-033	4
	Ongata naado	183292			
	Nturumeti	187100	1	034	4
	Sosian	187902			
OLOKURTO	Olorropil	193643	1	035	2
	Topoti	201417	1	036	2
	Empatipati	205096	1	037	1
	Olokurto	211401	1	038	2
	Nkokolani	214450	1	039	1
	Naituyupaki	219760	1	040	2
	Entyani	222007			
	Iltuati	224059			
	Ilmolelian	226300	1	041	1
	Ilkeremisho	229190			
	Enengetia	236794	2	042-043	2
	Kisiriri	241558			
	Olposimoru	244115	1	044	1
	Olmariko	246818			

Division	Sub-location	Cumulative population	Clusters	Cluster code	Segment
	Kamurar	250455	1	045	1
	Olengape	253400			
	Ololongoi	256357	1	046	1
	Ilkiai	258544			
		258544			
OSUPUKO	Maji moto	261540	1	047	4
	Enkui	264027			
	Ntuka	266621	1	048	4
	Nkimpa	267415			
	Elangata enterit	270960			
	Enkutoto	274718	1	049	4
	Naroosura	282821	2	050-051	4
	Enturoto	284757			
	Oloiruwa	288621	1	052	4
	Olenkuluo	289968			
	Oldonyo rasha	291916			
MARA	Naikara	298280	1	053	5
	Leshuta	301827	1	054	5
	Osarara	303948			
	Koiyaki	309445	1	055	5
	Sekenani	312639	1	056	5
	Olkinyei	315809			
	Endoinyo narasha	320078	1	057	5
	Aitong	326511	1	058	5

Division	Sub-location	Cumulative population	Clusters	Cluster code	Segment
	Mararianda	330840	1	059	5
	Olderkesi	335044	1	060	5
	Esoit	341316	1	061	5
	Megwara	345744			
	Siana	353863	2	062-063	5
	Nkoilale	359281	1	064	5
LOITA	Morijo loita	363016			
	Olngarua	364954	1	065	4
	Orlorte	367652			
	Mausa	370563	1	066	4
	Entasekera	375100	1	067	4
	Olmesutie	377569			
	Imartin	378682			
	Nkopon	379753			
	Ilmarae	382154	1	068	4
OLOLULUNGA	Ololulunga	392428	2	069-070	5
	Nkorikori	402710	1	071	5
	Lemek	412939	2	072-073	5
	Olkiriane	419097	1	074	5
	Melelo	429321	2	075-076	3
	Oloshapan	454166	4	077-080	3
	Endonyi ngiro	469780	3	081-083	3
	Ereteti	476306	1	084	3

Division	Sub-location	Cumulative population	Clusters	Cluster code	Segment
	Nkoben	478525			
MULOT	Mulot	486876	2	085-086	1
	Olchoro oiruwa	490686	1	087	1
	Kuto	497510	1	088	1
	Nkiito	500375	1	089	1
	Sogoo	515880	2	090-091	1
	Nkaroni	529118	2	092-093	1
	Enelerai	532460	1	094	5
	Rogena	541328	1	095	5
	Ilmotiok	555331	2	096-097	1
	Sagamian	565499	2	098-099	1
	Mogoiwet	570640			
	Tendewet	576388	1	100	1
TOTAL		**576388**		**100**	

Appendix 4: Data collection form for children 1-9 years old

1. District: _____ 2. Division_____

3. Segment number _____ 4. Sub-location: _____

4. Village: _____ 5. Cluster code_____

6. Name of head of household _____

7. Team number: _____ 8. Date of visit: _____

Name (Use one form per household)	Age (yrs)	Sex 1 = male 2 = female	Is the child attending school? 0 = No, 1 = Nursery, 2 = Primary	Children's faces (Clean = No eye and/or nasal discharge on the face) 1 = Clean 2 = Dirty	Clinical findings (check in both eyes) 0 = Absent 1 = present	
					TF	**TI**

Appendix 5: Data collection form for adults ≥40 years old

1. District: _____ 2. Division_____

3. Segment number _____ 4. Sub-location: _____

4. Village: _____ 5. Cluster code_____

6. Name of head of household _____

7. Team number: _____ 8. Date of visit: _____

Name	Age (yrs)	Sex 1 = Male 2 = Female	Education level 0 = none, 1 = primary 2 = Secondary 3 = college	Clinical findings 0 = Normal 1 = TT 2 = CO 3 = TT scar		If with TT and not operated why? 1 = Does not know it is operable/where to go for surgery 2 = No money 3 = Hospital too far 4 = Too old for surgery 5 = Fear surgery 6 = No permission 7 = Busy, no time Others, specify_____	If operated for TT is he/she: 1 = Satisfied with surgery 2 = Not satisfied If not satisfied give **one** reason why? _____ _____ __
				RE	**LE**		

Appendix 6: Daily tally sheet

At the end of each day's work, please tally the number of subjects and the number of TF/TT you have diagnosed and report to the survey coordinator via mobile phone text message.

Division: _____ **Segment number: _____**

Date of visit	Cluster code	Children 1-9 yrs		Adults ≥40 yrs		% TF	% TT
		Number examined	TF cases	Number examined	TT cases		
Total							

Appendix 7: Guidelines for enumerators

1. **Survey area:** One hundred survey clusters have been selected and you have been provided with a list indicating the clusters to be surveyed by your team.

2. **Before you start:** Visit the local administration to introduce yourself and to ask for permission/guides.

3. **Daily checklist:** Confirm that you have adequate number of data collection forms, examination loupes and torches,) and supplies (fuel, water, tetracycline eye ointment, analgesics, money for guides, calling cards etc before you leave for field work.

4. **Request for one local guide from each village**: One guide may not know people in all the villages. The public health officers will advise you on how best to approach the local communities.

5. **Selecting villages:** In every cluster, randomly select two villages by ballot method (listing all villages on pieces of paper and blindly picking two). If the cluster falls in one large settlement, segment the settlement into three (using physical boundaries like paths, roads, rivers etc) and treat the segments as if they were villages.

6. **Selecting households:** Start at the centre of the village and spin a bottle or any other object to select the direction of the first household. After finishing with one household, spin the bottle again to identify the direction of the next household and so on.

7. **Informed consent:** Always take informed consent before examination. Read the consent form for details. Due to low literacy level, written consent will not be mandatory.

8. **Who is to be examined?** Only children **1-9 years** and adults **≥40 years** will be eligible for this survey (see instructions in the data collection form). Clean hands after every examination. Fill one environmental assessment form for the household whose children you have examined. A household = people who regularly eat from the same pot. VISITORS ARE EXCLUDED.

9. **Countercheck:** Check whether the forms are fully completed before you leave the household and tally the number of TF cases seen in children 1-9 years old on daily bases.

10. **Avoid excess:** Do not examine more than 40 children and 30 adults in a cluster.

Appendix 8: Daily checklist

Before living for the field, please make sure you have the following:

1. Enough data collection forms: children, adults, household environment and F&E

2. Magnifying loops (x 2.5 binocular).

3. Torches, batteries and bulbs

4. Trachoma grading cards.

5. TT registers.

6. medicines/supplies: Tetracycline eye ointment and analgesic, cotton wool, tissue paper, ear buds, spirit and disposable gloves

7. Water for drinking and washing hands

8. Money for guides

9. Others: Mobile phone, calling cards, food, fuel etc

10. Time table and route map

Appendix 9: Inter-observer agreement testing for TF

1. Sub-location: _____ Village: _____ 7. Date: _____

INSTRUCTIONS

Fifty children aged 1-9 years will be examined. At least 15 (but no more than 35) of the children should have TF. Each grader will examine all the children and complete this form.

Key: 0 = Normal eye, does not have TF 1 = Child has TF

Child number	Team A	Team B	Team C	Team D	Comments
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					

Child number	Team A	Team B	Team C	Team D	Comments
31.					
32.					
33.					
34.					
35.					
36.					
37.					
38.					
39.					
40.					
41.					
42.					
43.					
44.					
45.					
46.					
47.					
48.					
49.					
50.					
Agreement (%)					

Appendix 10: Instructions for verbal consent

The following information should be provided to all survey participants:

My name (enumerator) is _____. We have been sent by the Ministry of health to check whether there are people in your community with the eye disease called trachoma.

Trachoma is the leading infection causing blindness in Kenya. Communities living in the dry parts of the country are the most affected. Since 2002, Ministry of Health and partners have been conducting trachoma surveys in affected districts. The survey confirms the number of children (1-9 years) with active disease and the number of adults (40 years and older) blinded by the disease. This survey is to be followed by treatment of those affected.

To confirm whether you have trachoma or not, we will examine your eyes and those of your children using a torch. These examinations have no risk to your health or your eyes at all.

No laboratory examinations will be done. No medicines will be used during examination.

If trachoma is found to be present in your community, the Ministry of Health and partners will continue providing treatment and support community projects for water, personal hygiene, latrines, health education and cleanliness of the environment.

In this trachoma survey, experts from the University of Nairobi and the University of Melbourne have joined the Ministry of Health survey team. The information collected will be used for planning trachoma control and teaching. The researchers are: Dr. Jefitha Karimurio, Prof. Mutuku Mwanthi; Prof. Jill Keeffe, and Prof. Richard Le Mesurier.

Please note that:

1. Your participation is voluntary. You and your children are free to withdraw from the survey at any stage.
2. If you choose not to participate, you will not be disadvantaged in any way.
3. Your privacy will be protected. The answers you give and the results of your examination will be kept confidential. Your names will not appear in the survey report; only your identification number will be used.

4. You can call the Kenya Medical Research Institute using the following telephone numbers: 0722205901, 0733400003 and 0202722541 to confirm whether these examinations have been approved by the government of Kenya.
5. You can contact Dr. Karimurio (0733819955) if you want to know more about the study.

Appendix 11: Cost items for mass antibiotic treatment in Kenya

1. Antibiotic treatment coverage

Year:	
Month:	
District	
Population of the district:	
Population targeted for treatment with azithromycin and tetracycline eye ointment:	
No. Of people treated:	
Coverage (% of the target population treated):	

2. Financial report

Cost items	**Units**	**Unit cost**	**Total cost**		**Cost per person treated**	
		US$	US$	Shillings	US$	Shillings
1. AZITHROMYCIN						
1.1. Cost of antibiotic						
1.2. Importation						
1.3. Clearing/storage						
1.4. Transport to districts						
1.5. Redistribution among districts						
1.6. Distribution within a district						
2. TETRACYCLINE EYE OINTMENT						
2.1. Cost of antibiotic						
2.2. Importation						
2.3. Clearing/storage						
2.4. Transport to districts						
2.5. Redistribution among districts						
2.6. Distribution within a district						
3. PREPARATORY MEETINGS						
3.1 Travel/Accommodation						
3.2 Lunches/Teas						
3.3 Communication (Telephone, fax etc)						
4. TRAINING DISTRIBUTORS						
4.1 Travel/Accommodation						
4.2. Hiring training venue						
4.3. Training materials						
COMMUNITY MOBILISATION						
5.1 Travel/Accommodation						
5.4. Lunches/per diem/night outs						

Cost items	**Units**	**Unit cost**	**Total cost**		**Cost per person treated**	
		US$	US$	Shillings	US$	Shillings
5.5. Posters						
5.6. Announcements (Radio/Public address)						
5.7. T-Shirts, caps and name tags						
6. MASS TREATMENT						
6.1 Travel/Accommodation						
6.2. Vehicle repairs/maintenance						
6.3. Buying water/containers						
6.4. Stationery/photocopying						
6.5. Lunches/per diem/night outs						
6.6. Communication (Telephone, fax etc)						
6.7. Height sticks						
6.8 T-Shirts, caps and name tags						
6.9. Bags						
6.10. Announcements (Radio/Public address)						
7. REVIEW OF MASS TREATMENT/STOCK TAKING						
7.1 Travel/Accommodation						
7.2. Lunches/per diem/night outs						
7.3. Stationery/photocopying						
7.4. Communication (Telephone, fax etc)						
7.5. Collection of excess antibiotics						
8. REPORT WRITING						
8.1. Stationery/photocopying						
9. DEBRIEFING/DISSEMINATION OF REPORT						
9.1 Travel/Accommodation						
9.2. Hiring training venue						
9.3. Training materials						
9. FIXED COSTS?						
9.1. Storage facility						
Total						

Appendix 12: Inter-observer testing for TF

Child number (Age 1-9 years old)	**Diagnosis made by the 4 trachoma graders (0 = no TF, 1 = has TF)**			
	Grader 1	Grader 2	Grader 3	Grader 4
01	0	0	0	0
02	0	0	0	0
03	0	0	0	0
04	1	1	1	1
05	0	0	0	0
06	1	1	1	1
07	0	0	0	0
08	1	1	1	1
09	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	1	1	1	1
13	1	1	1	1
14	0	0	0	0
15	1	1	1	1
16	0	0	0	0
17	1	1	1	1
18	1	1	1	1
19	0	0	0	0
20	0	0	0	0
21	1	1	1	1
22	0	0	0	0
23	1	1	1	1
24	1	1	1	1
25	1	1	1	1
26	0	0	0	1
27	1	1	1	1
28	0	0	0	0
29	1	1	1	1
30	1	1	1	1
31	1	1	1	1
32	1	1	1	1
33	0	0	0	0
34	0	0	0	0
35	1	1	1	1
36	1	1	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0

Child number	Grader 1	Grader 2	Grader 3	Grader 4
41	0	0	0	0
42	0	0	0	0
43	1	1	1	1
44	0	0	0	0
45	0	0	0	0
46	0	0	0	0
47	0	0	0	0
47	0	0	0	0
49	1	1	1	1
50	0	0	0	0
Total with TF	**21**	**21**	**20**	**21**

Appendix 13: TF, TI and dirty faces in Turkana survey segments

Cluster coded	Children 1-9 years old						
	Total examined*	TF	TI	Dirty faces	% with TF	% with TI	% with dirty faces
001	40	38	5	14	95.0	12.5	35.0
002	40	26	5	25	65.0	12.5	62.5
003	40	22	11	32	55.0	27.5	80.0
004	40	24	13	33	60.0	32.5	82.5
005	40	18	7	16	45.0	17.5	40.0
006	40	9	8	14	22.5	20.0	35.0
007	40	35	4	32	87.5	10.0	80.0
08	40	29	5	29	72.5	12.5	72.5
009	40	14	4	14	35.0	10.0	35.0
010	40	11	2	19	27.5	5.0	47.5
011	40	9	1	27	22.5	2.5	67.5
012	40	18	1	12	45.0	2.5	30.0
013	32	6	1	13	18.8	3.1	40.6
014	40	20	2	25	50.0	5.0	62.5
015	40	27	9	36	67.5	22.5	90.0
016	40	39	9	33	97.5	22.5	82.5
017	40	40	32	39	100.0	80.0	97.5
018	40	13	3	30	32.5	7.5	75.0
019	40	4	2	17	10.0	5.0	42.5
020	40	7	3	12	17.5	7.5	30.0
021	40	16	2	28	40.0	5.0	70.0
022	40	12	2	17	30.0	5.0	42.5
023	40	18	1	31	45.0	2.6	77.5
024	40	14	1	34	35.0	2.5	85.0
025	40	13	1	30	32.5	2.5	75.0
026	40	21	5	17	52.5	12.5	42.5
027	40	17	6	25	42.5	15.0	62.5
028	38	1	0	16	2.6	0.0	42.1
029	40	1	0	9	2.5	0.0	23.7
030	40	5	5	3	12.5	12.5	7.5
031	40	5	1	13	12.5	2.5	32.5
032	40	1	1	4	2.5	2.5	10.8
033	40	4	1	29	10.0	2.5	72.5
034	40	5	1	26	12.5	2.5	66.7
035	40	12	0	29	30.0	0.0	74.4
036	40	6	0	38	15.0	0.0	95.0
037	35	3	1	4	8.6	2.9	11.4
038	40	31	13	26	77.5	32.5	65.0
039	40	31	3	33	77.5	7.5	82.5

Cluster code	Total examined	TF	TI	Dirty faces	% with TF	% with TI	% with dirty faces
040	40	14	1	17	35.0	2.5	42.5
041	39	3	0	16	7.7	0.0	41.0
042	40	6	1	14	15.0	2.5	35.0
043	40	1	0	35	2.5	0.0	87.5
044	41	0	0	30	0.0	0.0	73.2
045	40	4	0	7	10.0	0.0	17.5
046	40	10	3	25	25.0	7.5	62.5
047	40	12	4	24	30.0	10.0	60.0
048	40	18	0	29	45.0	0.0	72.5
049	40	24	2	30	60.0	5.0	75.0
050	41	7	0	39	17.1	0.0	95.1
051	38	7	0	14	18.4	0.0	36.8
052	40	12	1	34	30.0	2.5	85.0
053	40	5	1	3	12.5	2.5	7.5
054	40	13	3	26	32.5	7.5	66.7
055	40	8	3	21	20.0	7.5	52.5
056	25	13	1	19	52.0	4.0	76.0
057	40	18	6	29	45.0	15.0	72.5
058	40	32	7	33	80.0	17.9	82.5
059	40	38	14	29	95.0	35.9	72.5
060	40	34	13	32	85.0	32.5	80.0
061	39	28	4	33	71.8	10.3	84.6
062	37	9	5	22	24.3	13.5	59.5
063	40	26	7	21	65.0	17.5	52.5
064	40	38	11	40	95.0	27.5	100.0
065	40	39	13	38	97.5	32.5	95.0
066	40	37	5	40	92.5	12.5	100.0
067	40	20	2	28	50.0	5.0	70.0
068	40	1	0	10	2.5	0.0	25.0
069	40	0	0	2	0.0	0.0	5.0
070	40	3	1	2	7.5	2.5	5.0
071	40	1	0	0	2.5	0.0	0.0
072	40	2	0	5	5.0	0.0	12.5
073	40	1	0	2	2.5	0.0	5.0
074	40	0	0	0	0.0	0.0	0.0
075	40	10	0	21	25.0	0.0	52.5
076	40	25	0	10	62.5	0.0	25.0
077	40	26	4	25	65.0	10.0	62.5
078	42	4	1	13	9.5	2.4	31.0
079	39	2	0	0	5.1	0.0	0.0
080	40	4	0	6	10.0	0.0	15.0

Cluster code	Total examined	TF	TI	Dirty faces	% with TF	% with TI	% with dirty faces
081	40	5	1	0	12.5	2.5	0.0
082	40	0	0	0	0.0	0.0	0.0
083	40	20	8	25	50.0	20.0	62.5
084	40	37	8	29	92.5	20.0	72.5
085	40	34	8	39	85.0	20.0	97.5
086	40	38	7	39	95.0	17.5	97.5
087	40	31	5	33	77.5	12.5	82.5
088	40	4	0	6	10.0	0.0	15.0
089	40	18	2	32	45.0	5.0	80.0
090	40	5	0	27	12.5	0.0	67.5
091	40	7	1	19	17.5	2.5	47.5
092	40	2	1	4	5.0	2.5	10.0
093	39	25	5	32	64.1	12.8	82.1
094	40	14	2	21	35.0	5.0	52.5
095	40	11	0	28	27.5	0.0	70.0
096	40	14	2	20	35.0	5.0	50.0
097	38	4	0	15	10.5	0.0	39.5
098	40	12	0	39	30.0	0.0	97.5
099	40	20	1	23	50.0	2.5	57.5
100	40	26	6	20	65.0	15.0	50.0
Total	**3963**	**1507**	**341**	**2159**	**38.0**	**8.6**	**54.6**

* In a few clusters achieving the sample was difficult due to insecurity (revisits not possible).

Appendix 14: TF, TI and dirty faces in Narok survey segments

Cluster coded	Children 1-9 years old						
	Total examined	TF	TI	Dirty faces	% with TF	% with TI	% with dirty faces
001	40	0	0	3	0.0	0.0	7.5
002	40	0	0	11	0.0	0.0	27.5
003	40	1	0	0	2.5	0.0	0.0
004	40	2	0	3	5.0	0.0	7.5
005	40	3	0	17	7.5	0.0	47.2
006	40	3	0	20	7.5	0.0	50.0
007	40	1	0	15	2.5	0.0	37.5
08	40	0	0	12	0.0	0.0	30.0
009	40	1	0	4	2.5	0.0	10.0
010	40	4	0	18	10.0	0.0	45.0
011	40	0	0	14	0.0	0.0	35.0
012	40	0	0	8	0.0	0.0	20.0
013	40	6	0	20	15.0	0.0	50.0
014	40	1	0	22	2.5	0.0	55.0
015	40	8	1	25	20.0	2.5	62.5
016	40	5	0	2	12.5	0.0	5.0
017	40	1	0	0	2.5	0.0	0.0
018	40	8	0	29	20.0	0.0	72.5
019	40	10	0	33	25.0	0.0	82.5
020	40	0	0	23	0.0	0.0	57.5
021	40	0	0	7	0.0	0.0	17.5
022	40	0	0	28	0.0	0.0	70.0
023	40	0	0	34	0.0	0.0	85.0
024	40	0	0	12	0.0	0.0	30.0
025	40	0	0	0	0.0	0.0	0.0
026	40	0	0	6	0.0	0.0	15.0
027	40	0	0	0	0.0	0.0	0.0
028	40	0	0	32	0.0	0.0	80.0
029	40	7	2	28	17.5	5.0	70.0
030	40	19	0	26	47.5	0.0	65.0
031	40	3	1	28	7.5	2.5	70.0
032	40	2	0	11	5.0	0.0	27.5
033	40	0	0	25	0.0	0.0	62.5
034	40	3	3	21	7.5	7.5	52.5
035	40	0	0	18	0.0	0.0	45.0
036	40	0	0	24	0.0	0.0	60.0
037	40	0	0	29	0.0	0.0	72.5
038	40	0	0	15	0.0	0.0	37.5
039	40	0	0	0	0.0	0.0	0.0

Cluster code	Total examined	TF	TI	Dirty faces	% with TF	% with TI	% with dirty faces
040	40	0	0	0	0.0	0.0	0.0
041	40	0	0	2	0.0	0.0	5.0
042	40	0	0	15	0.0	0.0	37.5
043	40	0	0	0	0.0	0.0	0.0
044	40	0	0	9	0.0	0.0	22.5
045	40	0	0	22	0.0	0.0	55.0
046	40	0	0	9	0.0	0.0	22.5
047	40	10	0	27	25.0	0.0	67.5
048	40	16	3	35	40.0	7.5	87.5
049	40	17	2	22	42.5	5.0	55.0
050	40	12	0	26	30.0	0.0	65.0
051	40	6	0	14	15.0	0.0	35.0
052	40	8	1	39	20.0	2.5	97.5
053	40	11	0	18	27.5	0.0	45.0
054	40	12	0	18	30.0	0.0	45.0
055	40	14	1	26	35.0	2.5	65.0
056	40	7	1	29	17.5	2.5	72.5
057	40	16	0	13	40.0	0.0	32.5
058	40	13	0	25	32.5	0.0	62.5
059	39	10	0	29	25.6	0.0	74.4
060	40	14	0	22	35.0	0.0	55.0
061	40	20	0	37	50.0	0.0	92.5
062	40	18	2	34	45.0	5.0	85.0
063	40	24	4	40	60.0	10.0	100.0
064	40	18	5	37	45.0	12.5	92.5
065	40	11	1	23	27.5	2.5	57.5
066	40	10	0	21	25.0	0.0	52.5
067	40	16	8	14	40.0	20.0	35.0
068	40	13	2	33	32.5	5.0	82.5
069	40	0	0	18	0.0	0.0	45.0
070	40	2	0	11	5.0	0.0	27.5
071	40	0	0	16	0.0	0.0	40.0
072	40	18	0	30	45.0	0.0	75.0
073	40	5	0	7	12.5	0.0	17.5
074	40	11	0	10	27.5	0.0	25.0
075	40	0	0	4	0.0	0.0	10.0
076	40	1	0	1	2.5	0.0	2.5
077	40	1	0	11	2.5	0.0	27.5
078	40	0	0	20	0.0	0.0	50.0
079	40	1	0	29	2.5	0.0	72.5
080	40	1	0	17	2.5	0.0	42.5

Cluster code	Total examined	TF	TI	Dirty faces	% with TF	% with TI	% with dirty faces
081	40	2	0	30	5.0	0.0	75.0
082	40	5	1	29	12.5	2.5	72.5
083	40	0	0	14	0.0	0.0	35.0
084	40	6	0	2	15.0	0.0	5.0
085	40	0	0	12	0.0	0.0	30.0
086	40	0	0	5	0.0	0.0	12.5
087	40	0	0	12	0.0	0.0	30.0
088	39	0	0	5	0.0	0.0	12.8
089	40	2	0	21	5.0	0.0	52.5
090	40	0	0	9	0.0	0.0	22.5
091	40	0	0	20	0.0	0.0	50.0
092	40	0	0	1	0.0	0.0	2.5
093	40	0	0	0	0.0	0.0	0.0
094	40	0	0	1	0.0	0.0	2.5
095	40	0	0	18	0.0	0.0	45.0
096	40	0	0	23	0.0	0.0	57.5
097	40	0	0	31	0.0	0.0	77.5
098	40	1	0	17	2.5	0.0	42.5
099	40	0	0	12	0.0	0.0	30.0
100	40	0	0	10	0.0	0.0	25.0
Total	**3998**	**440**	**38**	**1708**	**11.0**	**1.0**	**42.8**

ABBREVIATIONS

CI	Confidence Interval
CO	Corneal Opacity
DOS	Division of Ophthalmic Services
GET 2020	Global Elimination of blinding Trachoma by the year 2020
TF	Trachomatous Inflammation: Follicular
TI	Trachomatous Inflammation: Intense
TT	Trachomatous Trichiasis
TT40	A TT survey conducted in people ≥40 years old
TS	Trachomatous Conjunctival Scarring
TSS	Trachoma Survey by Segment method
SAFE	Surgery, Antibiotics, Facial Cleanliness and Environmental sanitation
US$	USA Dollar
VISION 2020	Global Initiative for the Elimination of Avoidable Blindness by 2020
WHO	World Health Organization