EVALUATION OF TRICHIASIS SURGEONS' PERFORMANCE IN SELECTED TRACHOMA ENDEMIC AFRICAN COUNTRIES.

By

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DECLARATION

I, Olubukola Oyinade Ofoegbu, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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My heart-felt appreciation goes to my entire family for being my support system, my cheerleaders and giving me encouragement all through my time at University of Cape Town, pursuing this degree.

Saving the best for the last, I must give my utmost gratitude to the Almighty God, for giving me life, health, focus, direction and perseverance which all enabled me to pursue this degree.

SYNOPSIS

This thesis is a retrospective cohort study, with secondary data analysis of multi-centre data from 8 African countries which assesses the proportions of trichiasis surgeon audits conducted and factors predicting conduct of audits and performance at audits.

Part A of this thesis comprises the protocol which includes the study protocol section (which describes the methodology used and gives a brief background on the research subject) and a literature review section which gives more detail on the research subject based on the published literature. References are included at the end of this section.

Part B comprises the publication-ready manuscript composed in keeping with the stipulations of the chosen journal (Ophthalmic Epidemiology journal). It gives a summary of the background information on the subject, states the results, discusses the findings in relation to the published literature and states conclusions. References are given at the end of this section as well.

Part C comprises the appendices which include the ethical committee approval letter, copy of letter requesting permission to use data from the countries, instruction for authors from the ophthalmic epidemiology journal and other relevant information.

Abbreviations

Acronyms	**Meanings**
SAFE	**S**urgery **A**ntibiotics **F**acial Cleanliness **E**nvironmental improvement
WHO	World Health Organisation
GET2020	WHO Alliance for the Global Elimination of Trachoma by 2020 (GET2020 Alliance).
BLTR	Bilamellar tarsal rotation
PLTR	Posterior Lamellar Tarsal Rotation (also referred to as Trabut)
LQAS	Lot Quality Assurance Sampling
ICTC	International Coalition for Trachoma Control
HEADSTART	Human Eyelid Analogue Device for Surgical Training and skill Reinforcement in Trachoma

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Part A: Protocol

Section A: Study Protocol

1. Background

Blindness and visual impairment reduce the quality of life and life expectancy of people affected by it (Brézin, A. P., Lafuma, A., Fagnani, F. et al., 2004). It is vital to prevent loss of vision, especially from preventable causes like trachoma. Trachomatous trichiasis (trichiasis), the blinding consequence of trachoma, accounts for 2.8 million cases of morbidity, and a risk for blindness in trachoma-endemic countries (Flueckiger, R. M., Courtright P, Abdala M et al., 2019). It is the leading infectious cause of blindness worldwide (W.H.O., 2019c, Burton, M. J. and Mabey, D. C. W., 2009). Africa has a high trachoma burden (Burton, M. J. and Mabey, D. C. W., 2009) due to water scarcity, dusty environments, overcrowding, and a lack of proper sewage disposal systems, all of which increases trachoma transmission (Last A.R., Burr S.E., Weiss H.A. et al., 2014).

Children less than age 10 have a higher burden of active trachoma (Woldekidan E, Daka D and Legesse, D., 2019) and repeated infection may cause conjunctival scarring. This may lead, in adulthood, to in-turning of the eyelid and misdirection of the lashes towards the globe. Trichiasis is when the eyelashes touch the globe and potentially cause corneal abrasions (Burton M.J, Bowman R J. C. , Faal H et al., 2006). Constant rubbing of the lashes on the cornea and recurrent abrasions may cause corneal scarring and opacification and, in some cases, lead to blindness (Burton M.J, Bowman R J. C. , Faal H et al., 2006). Trichiasis often causes immense patient discomfort from corneal irritation due to constant lash contact with the cornea and corneal swelling (Woreta, T. A., Munoz, B. E. and Gower, E. W., 2009). It is therefore a disabling disease, even without visual impairment (Habtamu E, Wondie T, Aweke S et al., 2015).
Surgery plays an invaluable role in preventing vision loss from trichiasis. Because most trachoma-endemic regions have few ophthalmologists, most of these surgeries are conducted by non-ophthalmologists, including nurses, ophthalmic technicians and general health workers (Alemayehu, W., Melese,

M., Bejiga, A. et al., 2004). Bilamellar Tarsal Rotation (BLTR) (Reacher, M., Foster, A. and Huber, J., 1993) and Posterior Lamellar Tarsal Rotation (PLTR) (Halasa, A. and Jarudi, N., 1974) are two of the most effective surgical procedures for treatment of trichiasis and they are widely utilized. More recently, PLTR has been found to be more effective than BLTR (Habtamu, E., Wondie, T., Aweke, S. et al., 2016). The results of surgery can however be undermined by complications such as post-operative trichiasis which poses a continual threat to vision (West, E. S., Mkocha, H., Munoz, B. et al., 2005 , Zhang, H., Kandel, R. P., Sharma, B. et al., 2004). Patients who have undergone surgery require post-operative follow-up examination visits so the surgeon can check for good wound healing and recovery or to identify and manage complications. Post-operative care is patient-centred, to identify patient needs. Surgeon audits, on the other hand, are surgeon-centred, with the aim of identifying surgeons with sub-optimal surgical skills, in need of re-training. It is important to carry out regular reviews/audits on trichiasis surgeons and to implement modifications (if required) of surgical practices in order to maximize the chances of successful surgical outcomes with minimal complications.
A cross-sectional study involving 29 African countries revealed that only four had a national policy for conducting audits on trichiasis surgeons (Mwangi, G., Courtright, P. and Solomon, A. W., 2020a). Some reasons suggested by national coordinators for this were inadequate financial and human resources for all trichiasis-related activities, limited data for planning and poorly developed follow-up systems (Mwangi, G., Courtright, P. and Solomon, A. W., 2020a). This results in a situation whereby surgeons with excessive complications continue to operate. Surgeon audits are important to provide the vital connection to ensure policy is translated into individual practice and good outcomes.

2. *Rationale*

There have been very few publications (Mwangi, G., Courtright, P. and Solomon, A. W., 2020a, Djore, D., Djibrine, D., Ali, A. B. et al., 2020, Gebreselassie, G., Dawit, S., Alemayehu, S. et al., 2019) in the scientific literature on the outcomes of trichiasis surgeon audits. Even though there are standards that implementing partners are to follow, (e.g. every new surgeon should be audited at 6 months after certification, if they have performed a sufficient number of surgeries) there is a paucity of publications on how frequently audits are conducted or on what steps were undertaken after audits were completed.

This study will provide information on the proportion of surgeons getting an audit in eight countries and the possible reasons for surgeons to not pass their audit. Findings will assist national programmes, supervisors, and non-governmental partners to plan for improved quality of care in their trichiasis activities.

2.1 Primary research question

- What proportion of trichiasis surgeons pass or fail their surgeon audit in selected trachoma endemic countries?

2.2 Secondary research questions

- Are surgeons who utilize a particular surgical technique more or less likely to fail their surgeon audit?
- Are surgeons in a specific cadre more or less likely to fail their surgeon audit?
- Is duration since training a predictor for performance at an audit?

3. Methodology.

3.1. Study design: This was a multi-centre retrospective cohort study.

3.2. Study population: All individuals who were trained as trichiasis surgeons in eight trachoma-endemic countries (Tanzania, Kenya, Mozambique, Malawi, Zambia, Uganda, Nigeria and Ethiopia) which had support for trichiasis work from Sightsavers, a UK-based organization were included. Some of the countries (Kenya, Tanzania, Uganda, Malawi, Mozambique, Zambia) included all of the surgeons in the country while

Nigeria and Ethiopia only included those working in specific states or regions. The data set included information up to December 2019. The individuals trained in trichiasis surgery were ophthalmic nurses, general medical officers, general nurses, ophthalmic technicians, ophthalmic assistants and general health workers. The specific cadre of health workers that were trained as surgeons varied among the countries.

3.3. Methods: This was a secondary data analytic review using data previously collected and maintained by the ministries of health and Sightsavers. Both surgeons and countries were anonymised for analysis. Each country sets its own criteria for determining if a surgeon passes or fails an audit. In many cases however, any surgeon with an incidence of post-operative trichiasis greater than 10% were deemed to have an unacceptably high level of post-op trichiasis. These individuals were recommended for re-training to improve the quality of their surgeries. Surgeons with post-op trichiasis less than 10% were deemed to have passed the audit. The surgical audit capture tool used in the study is shown in Appendix 4.

3.4. Recruitment: The database, which lists the names of surgeons will be anonymised prior to analysis.

3.5. Data collection: A pre-existing data set will be used with data from Tanzania, Kenya, Mozambique, Malawi, Zambia, Uganda, Nigeria and Ethiopia. Individual countries will be contacted to obtain additional information for the analysis. No contact will be made with the surgeons or with patients. A codebook will be generated to define each variable in the database.

The database consists of the following:

Variable	Meaning
Country	Surgeon's country
Serial number	Unique identifier for each surgeon. No names included
State/region	Specific area/region in country
District	District in surgeon's country
Sex	Surgeon's sex
Cadre of surgeon	Surgeon's position in the medical profession e.g. ophthalmologist, ophthalmic nurse, medical officer etc. These will be combined into three groups: eye care surgical providers (ophthalmologists and cataract surgeons); dedicated eye care workers (ophthalmic nurses, ophthalmic medical officers, and ophthalmic technicians) and general health workers (general nurses or general medical officers).
Trained in BLTR or PLTR/Trabut or both	Specific surgical technique the surgeon was trained to practice.
Year first trained in trichiasis surgery	Specific year of first training
Year trained in HEADSTART	HEADSTART is an innovative method of training surgeons using mannequins before performing live

	surgeries (Tadesse, D., Montgomery, I. and Sankar, G., 2017).
Year certified to be trichiasis surgeon	Specific year that the surgeon was deemed competent following training and issued a certificate
Training funded by (donor/program)	Organisation which provided funding for surgeon training
Currently active - Yes/No	Surgeons who have performed one or more surgeries within the past 12 months are considered "active".
Reason for inactivity	Reason why an inactive surgeon has not performed surgery within the past 12 months
Year of first audit	Year when the surgeon audit was conducted for the first time
Audit recommended retraining Yes/No	Whether the surgeon was deemed in need of further training or not
Received re-training	Whether or not the recommended training was received
Year of subsequent audit	Year when another audit was conducted for surgeons who failed the first audit
Subsequent audit recommended re-training Yes/No	Whether the surgeon was deemed in need of further training or not
Year of supervisor training if applicable	Year when surgeon was selected to be trained as a supervisor (if applicable)
Currently active as a supervisor	Whether or not the surgeon supervisor is currently active as a supervisor

Cadre of trainer	Surgeon’s trainer’s position in the medical profession (ophthalmologist or cataract surgeon or other)

3.6. Data analysis: Microsoft Excel (Microsoft Office Excel 365) tables will be used for data cleaning. Stata statistical software (StataCorp. 2019. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC) will be used for analysis. Statistical significance related to continuous variables will be analysed using t-tests or Wilcoxon-Mann Whitney rank sum depending on the normality of the distribution of the data. Categorical variables will be analysed using the Chi-square test. P values and odds ratios (and their confidence intervals) will be reported and interpreted, as appropriate.

3.7. Risks and benefits: There will be no risks to the participants as this is a retrospective review of national records of surgeons. There will be no use of patient surgical data. Benefits obtainable would include measuring the outcome of the training and supervision of surgeons and identification of some associations with poor audit outcome. This study will also serve as a contribution to the current body of literature on the subject with the identification of any knowledge gaps. This study is part of a dissertation in fulfilment of requirements for of a Master of Public Health degree at UCT.

3.8. Ethics approval: Ethical approval for the study will be sought from the Human Research Ethics Committee (HREC) of the University of Cape Town and a HREC reference number will be obtained (Appendix 1).

3.9. Informed consent: This is not applicable in this instance and no consent will be obtained as this is a retrospective database review without any patient or surgeon contact. However, in each country, consent to use the Ministry of Health database will be obtained (Appendix 2)

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3.10. Privacy and confidentiality: Privacy and confidentiality of all data and results will be ensured by having all data stored on a password protected computer. Serial numbers will be used for identification and no names will be stored in the database. Reporting will not include any form of surgeon identification such as addresses for home or work.

3.11. Reporting of findings: The ultimate goal would be to publish our results in an ophthalmology peer-reviewed journal to add to the existing body of knowledge on trichiasis surgical quality. A further desire would be to present the findings of this research at both national and international ophthalmology conferences.

3.12. Departmental approval: Approval from the chairperson of the departmental research committee will be sought as required according to the stipulated tenets of the University of Cape Town.

3.13. Budget/ Funding : All costs in this research work are being borne by the researcher. These are minimal since this is a secondary data analysis.

3.14. Limitations of the study

There may be some minor differences in the way the audits were conducted in different centres and countries from where the data was obtained. Notably, the possibility of different criteria for success/failure at an audit in individual countries is a potential limitation. There was also some missing data in the database which was analysed.

3.15. Definitions

- Passing a surgeon audit: These individuals will not need surgery retraining.
- Failing a surgeon audit: These individuals require retraining or to discontinue surgery.
- Audit: This is the quality improvement process through which a sample of patients from a particular surgeon are examined post-

operatively (generally 3 to 6 months after surgery) to identify cases of post-operative trichiasis and other operative complications.

- Supervisor: individuals who oversee the smooth running of trichiasis surgery activities in trichiasis control programmes.
- Trainer: an ophthalmologist or cataract surgeon who has been trained as a surgeon, has performed numerous surgeries, and teaches a surgeon how to conduct trichiasis surgeries.
- Surgeon: An individual who carries out trichiasis surgeries.

Section B : Literature Review

1. *Objectives*

This literature review aims to present relevant information about trachomatous trichiasis (trichiasis), post-operative trichiasis and other complications following trachomatous trichiasis surgery, surgeon audits, and results obtained from audits which have been carried out in various settings.

2. *Literature search strategy*

Articles published in peer-reviewed journals, reliable online reports and manuals and dissertation reports on the subject of trichiasis and surgeon audits were selected for this literature review. No journal publications prior to 1970 were included.

2.1. Keywords: trichiasis, surgical audit, quality assurance, surgeon audit, post-operative trichiasis, surgical outcome

2.2. Inclusion criteria: Various articles and online reports in form of population-based cross-sectional and prospective studies or summaries giving information about trichiasis and surgical outcomes following trichiasis surgery.

2.3. Exclusion criteria: publications giving statistics which have been superceded by more current statistics (such as related to current prevalence of trichiasis or global burden of trachoma) were not included in this literature review. In addition, articles in languages other than English were excluded.

2.4. Databases: Google, PubMed, WHO website, Science Digest, Community Eye Health Journal, and the ICTC website were used to identify useful articles.

2.5. Results: 69 published articles specifically related to trichiasis, post-operative trichiasis and surgical audits were identified and included in the literature review.

3. Summary and interpretation of the literature

Trachoma is a disease of public health importance because it is the commonest infectious cause of blindness worldwide. The global trichiasis burden in 2016 was 2.8 million (Flueckiger, R. M., Courtright P, Abdala M et al., 2019). The blinding consequences of trachoma are of great concern because blindness results in significant reduction in quality of life (Masoud, K., Amin, S., Mohammad-Reza, A. et al., 2016) and imposes huge financial costs to the family, to society, and to the health care system (Pezzullo, L., Streatfeild, J. and Simkiss, P., 2018, Brézin, A. P., Lafuma, A., Fagnani, F. et al., 2004).

Blindness from trachoma occurs because of trichiasis, a complication of trachoma which affects the cornea. Trichiasis is the main risk factor leading to trachomatous corneal opacification, either directly from lash-induced corneal abrasions or indirectly from secondary bacterial infection of the damaged cornea (Burton, M. J., 2005). The cornea is the structure which accounts for the greatest refractive power in the eye and corneal disease is associated with significant visual morbidity (Chang, C. K., Lin, J. T. and Zhang, Y., 2017). Corneal opacification obstructs light or images from passing through the optical structures of the eye, preventing it from reaching the retina .

The cornea is also the most sensitive structure in the body (Dawson, C. R., Jones, B. R. and Tarizzo, M. L., 1981); irritation from in-turned lashes and abrasions results in a double burden of morbidity with pain, tearing and photophobia in addition to the visual impairment (Dawson, C. R., Jones, B. R. and Tarizzo, M. L., 1981).

Inward turning of the eyelid (entropion) from tarsal conjunctival scarring may occur from persistent inflammation due to *Chlamydia trachomatis* infection, generally in childhood. This may cause contact between eyelashes and the globe (trichiasis) and may eventually lead to corneal opacification (West, S. K., Munoz, B., Mkocha, H. et al., 2001). In most trachoma-endemic settings, women are the major caregivers to children, they have a higher likelihood of reinfection with *Chlamydia trachomatis* than men (Doyal, L. and Das-Bhaumik, R. G., 2018, Cromwell, E. A., Courtright, P., King, J. D. et al., 2009, Courtright, P. and West, S. K., 2004). Consequently, women have an almost two-fold higher age-adjusted prevalence of trichiasis compared to men (Cromwell, E. A., Courtright, P., King, J. D. et al., 2009).

The World Health Organisation (WHO) formed the Alliance for the Global Elimination of Trachoma by the Year 2020 (GET2020) in 1996 (W.H.O., 2019c), to eliminate trachoma as a public health problem. GET 2020 promotes the "SAFE strategy", initiated in 1993 (Tian, L. and Wang, N., 2018) as follows:

- **S**urgery (for repositioning of the in-turned eyelid)
- **A**ntibiotic (for antimicrobial control of *Chlamydia trachomatis* and to reduce the burden of infection)
- **F**acial cleanliness (to reduce frequent exchange of nasal and conjunctival discharge and transmission of infection) and
- **E**nvironmental improvement (to reduce fly population).

The SAFE strategy has been implemented by many countries over the years although trachoma is still endemic in 44 countries of the world but these countries are more concentrated in Africa with some clusters in Asia (W.H.O., 2019a).

While the other components of the SAFE strategy serve to prevent development of trichiasis, surgery serves the unique role of repositioning the eyelid to treat trichiasis and prevent the eye lashes from touching the cornea, therefore preventing corneal scarring and, ultimately, blindness. Not all trichiasis is due to an in-turned eyelid. (Rajak, S., Collin, R. and Burton, M., 2012). With no entropion, just a couple of eyelashes rubbing on the conjunctiva and none in the cornea, symptoms of photophobia and pain may be well-controlled with regular epilation (Reacher, M., Foster, A. and Huber, J., 1993). Until recently, the WHO recommended lid rotation surgery for everyone with trichiasis regardless of severity to avoid missing the opportunity to do surgery in an individual before the condition worsens (Rajak, S., Collin, R. and Burton, M., 2012).

3.1. Surgeons, trainers, supervisors and training

Due to the huge burden of unoperated trichiasis in endemic areas and other ophthalmic surgical priorities like cataract surgery, there are not enough ophthalmologists for all trichiasis cases to be operated solely by them. Therefore, surgeries are done by paramedical eye care workers or general health workers who undergo short, intensive training (usually 2 to 3 weeks) to be proficient at trichiasis surgery. The period of training includes theoretical classroom-based teaching, practice on mannequins (Tadesse, D., Montgomery, I. and Sankar, G., 2017) and then practice on human beings (live surgery) before certification. Since 2015-6 surgeons in selected countries have undergone training in HEADSTART and certification before being deployed to conduct surgery (Tadesse, D., Montgomery, I. and Sankar, G., 2017).

The ICTC recommends that supportive supervision is provided for all surgeons. This involves two main components (I.C.T.C., 2018). The first component is supervision of surgery and epilation, as well as instructions to the patient on how to self-epilate. The second component is supervision of trichiasis outreach and reporting. This involves maintaining proper patient management (e.g., team starts work on time, triage, has necessary supplies, does counselling, organizes team properly, ensures sterilization and instrument maintenance, and charts are completed)

3.2. Treatment options for trichiasis

Treatment options for trichiasis can be broadly divided into those which focus on removing the aberrant lashes without doing surgery on the eyelid and those which surgically evert the lid to keep the lashes from touching the globe (Rajak, S., Collin, R. and Burton, M., 2012). The lash treatments include epilation and lash follicle destruction procedures (such as electrolysis, cryotherapy, laser, removal of aberrant lash-bearing follicles and radiotherapy). The lid correcting procedures include Bilamellar Tarsal Rotation (BLTR), Posterior Lamellar Tarsal Rotation (PLTR), Tarsal advance procedures, posterior lamellar lengthening procedures, anterior lamellar and lid margin procedures and tarsectomy (Rajak, S. N., Habtamu, E., Weiss, H. A. et al., 2011). Among the surgical options for trichiasis, the procedures of choice are BLTR and PLTR. Initial research in Oman (Reacher, M., Huber, M., Canagaratnam, R. et al., 1990) led WHO to recommend the BLTR procedure because of the lower incidence of post-operative trichiasis compared to the other procedures tested. Studies have shown that both BLTR and PLTR may be used as alternatives to one another (W.H.O., 2005). The choice of which procedure is used is usually based on historical practices in the particular country or partner supporting training (I.C.T.C., 2012). The WHO 2nd Trichiasis Scientific Meeting, reviewing more recent evidence, led to the recommendation that all new surgeons are to be trained in PLTR (Solomon, A. W., 2016).

3.3. Bilamellar Tarsal Rotation

Bilamellar Tarsal Rotation (BLTR) was the preferred procedure for trichiasis correction for many years because of the short-term outcome results from a clinical trial in Oman (Reacher, M. H., Muñoz, B., Alghassany, A. et al., 1992).

It was shown that good results could be obtained by non-ophthalmologists (Alemayehu, W., Melese, M., Bejiga, A. et al., 2004). In BLTR surgery, a full thickness incision is made through the upper eyelid parallel to the eyelid margin. The distal part of the eyelid containing the eyelashes is rotated outwards so that the eyelashes are no longer in contact with the cornea, and this position is secured with sutures (W.H.O., 2015). Skin incision are placed at about 3 mm above the lid margin, because incision height has been known to have an impact on development of post-operative trichiasis (Merbs, S., Oktavec, K., Munoz, B. et al., 2015). The incision length should be about 20 mm (Reacher, M., Huber, M., Canagaratnam, R. et al., 1990). Complete success of the BLTR is achieved if there are no lashes rubbing against the globe and there are no complications (Reacher, M., Foster, A. and Huber, J., 1993).

3.4. Posterior lamellar tarsal rotation (Trabut procedure)

Collectively, procedures which combine tarsotomy (incision of the conjunctiva and the tarsal plate but not the skin or orbicularis muscle) with everting sutures are referred to as posterior lamellar tarsal rotation (PLTR) procedures (Halasa, A. and Jarudi, N., 1974). PLTR procedures are performed with the lid in an everted position, usually rotated over a lid plate. A horizontal incision about 3mm above the lid margin is made through the conjunctiva and tarsal plate. The anterior and posterior lamellae of the upper part of the lid are then separated between the orbicularis muscle and the tarsal plate. This separation between lamellae is also done in the lower part of the lid till the dark bulbs of the lash follicles are seen. Subsequently, three everting sutures are passed through the distal anterior lamella to emerge through the skin at 3mm above the lid margin. The sutures are tightened to exert traction which tucks the proximal portion of the posterior lamella behind distal portion of the posterior lamella and the lid everts (Merbs, S., Oktavec, K., Munoz, B. et al., 2015). The degree of eversion is determined by how superior in the upper portion and how close to the lid margin of the lower portion the sutures are placed (Rajak, S., Collin, R. and Burton, M., 2012).

3.5. *BLTR versus PLTR*

Both BLTR and PLTR are effective trichiasis correction surgical procedures and have been used in various settings. For many years, WHO recommended BLTR because it showed superiority over other trichiasis surgeries such as tarsal advance and rotation, eversion splinting, tarsal advance (lid split), tarsal advance and grafting, and tarsal grooving (Reacher, M., Huber, M., Canagaratnam, R. et al., 1990, Reacher, M. H., Muñoz, B., Alghassany, A. et al., 1992).

Recent research (Habtamu, E., Wondie, T., Aweke, S. et al., 2016, Habtamu, E., Wondieb, T., Tadesse, Z. et al., 2019) suggests that PLTR is more effective than BLTR (with lower post-op trichiasis rates - 13% versus 22%). Post-operative trichiasis is often minor (less than 5 lashes), significantly reducing the risk for corneal opacification and blindness.

3.6. *Post-operative trichiasis: incidence*

The term "post-operative trichiasis" refers to all trichiasis following surgery, irrespective of whether it was due to poor quality surgery or pre-existing clinical conditions. Early post-operative trichiasis (≤6 months after surgery) is usually due to surgical failure, while late post-operative trichiasis (greater than 6 months after surgery) is usually due to disease progression, generally continued conjunctival scarring and tarsal shortening. (I.C.T.C., 2012). Generally, there is little that can be done to prevent late-stage post-operative trichiasis.

Incidence of post-operative trichiasis varies widely with time post-surgery, ranging from 7.4% at 1 year to 62% at 3 years (Rajak, S., Collin, R. and Burton, M., 2012). A more recent systematic review (Mwangi, G., Courtright, P. and Solomon, A. W., 2020b) showed an incidence of post-operative trichiasis ranging from 2% (at 6 weeks after bilamellar tarsal rotation) to 69% (at 3 weeks after anterior lamellar repositioning).

Incidence of post-operative trichiasis among surgeons varies widely; in Gambia, post-operative trichiasis ranged from 24.3% at to 41.6% at 3.5 years (Burton, M., Bowman, R. and Faal, H., 2005). An Ethiopian study reported equal (low) incidence of post-operative trichiasis among two ophthalmologists and two trained, high volume general health workers at 3 to 6 months post-surgery (Alemayehu, W., Melese, M., Bejiga, A. et al., 2004). Regular surgeries of moderate to high volume may help to hone surgical skills. However some surgeons do not operate regularly (Habtamu, E., Rajak, S. and Gebre, T., 2011, Lewallen, S., Mahande, M., Tharaney, M. et al., 2007) as reported in studies in Ethiopia and Tanzania, and this negatively impacts surgical skills. A study in Ethiopia (Rajak, S., Habtamu, E., Weiss, H. et al., 2013) demonstrated a high incidence of post-operative trichiasis despite high volume surgery. This suggests that high volume and vast surgical experience alone may not be sufficient to prevent post-operative trichiasis.

The 3 to 6 months post-operative trichiasis incidence ranged from none at all in one study (Bouazza, M., Elbelhadji, M., Cherkaoui, S. et al., 2017) to 33.9% in an Egyptian study (Ahmed, R. A. and Abdelbaky, S. H., 2015). These variations may have been due to the presence of mostly major trichiasis in the Egyptian study.

One Ethiopian study (Alemayehu, W., Melese, M., Bejiga, A. et al., 2004) found an incidence of 14.3% at 6 months post-surgery, while another study demonstrated an incidence of 10.4% at 3 months post-surgery for patients who had BLTR done (Adamu, Y. and Alemayehu, W., 2002). A relatively low incidence of 4.6% (Woreta, T. A., Munoz, B. E. and Gower, E. W., 2009) was also obtained in a study in Ethiopia which was part of the STAR (Surgery for Trichiasis, Antibiotics to prevent Recurrence) trial. On average, the incidence of post-op trichiasis at 3 to 6 months post-op are 10% in an Egyptian study (Khafagy, A., M.M. Mostafa and Fooshan, F., 2012), 14.3% in an Ethiopian study (Alemayehu, W., Melese, M., Bejiga, A. et al., 2004) and 15.7% in a Moroccan study (Négrel, A. D., Chami-Khazraji, Y., Arrache, M. L. et al., 2000).

Post-operative trichiasis incidence at one year or after is usually due to non-surgical factors such as bacterial infection, severity of trichiasis, and severe baseline conjunctival inflammation (Burton, M. J., 2005). A Gambian study found a post-operative trichiasis incidence of 41.3% after a year of post-operative follow-up (Burton, M. J., 2005) at .A Tanzanian study (Merbs, S., Oktavec, K., Munoz, B. et al., 2015) found an incidence of 31% at 1 year post-surgery, while 5 different Ethiopian studies, found incidences at one year to be 19% (Burton, M. J., Rajak, S. N., Ramadhani, A. et al., 2012), 17.4% (Habtamu, E., Wondie, T. and Sewunet, S., 2017), 16.6% (Assefa, Y., Habte, D., Sendekie, T. et al., 2008), 12% (Habtamu, E., Wondie, T., Aweke, S. et al., 2018) and 7.6% (West, S., West, E. and Alemayehu, W., 2006). The incidence of post-operative trichiasis at greater than one year of follow-up was found to be generally high.

Guidelines promoted by the WHO have changed over time, as additional evidence became available. Before 2018 WHO recommended that the incidence of post-operative trichiasis should be less than 10% at 1 year post-operation (W.H.O., 2010). The 4th Global Scientific Meeting on Trachoma in 2018 (W.H.O., 2019b) revised the guideline as follows:

1. The incidence of post-operative trichiasis (at the 3-6 month follow up) among cases of minor trichiasis (≤5 eyelashes touching the globe) should be <10%.
2. The incidence of post-operative trichiasis (at the 3-6 month follow up) among cases of major trichiasis (5+ eyelashes touching the globe) should be <20%.

Surgeon audits are designed to address post-operative trichiasis at 3-6 months, to address factors that programmes have some ability to control (i.e. surgeon-related factors).

3.7. Other complications

The gains of having trichiasis surgery done can be undermined by other complications post-operatively. These can be diverse and can include:

- Granuloma formation usually appears as a red lump on an eyelid margin (Reacher, M., Foster, A. and Huber, J., 1993), and may impair vision if large enough (Alemayehu, W., Melese, M., Bejiga, A. et al., 2004). They occur with both absorbable and non-absorbable sutures. Large granulomas should be removed while smaller ones may be watched if not uncomfortable.

-Mild to moderate overcorrection may be left as it tends to settle into a normal position with time. But if severe, it may result in exposure keratopathy and corneal compromise especially if there is associated lagophthalmos (Rajak, S., Collin, R. and Burton, M., 2012).

-Eye lid contour abnormality (ECA) describes varying degrees of vertical deviation from the natural lid contour affecting horizontal lid length and it ranges from mild to severe (Gower, E., West, S., Cassard, S. et al., 2012).

-Non-absorbable silk sutures should normally be removed 7 to 10 days post-operative (Rajak, S., Collin, R. and Burton, M., 2012); f not, could be a nidus for infection.

3.8. Post-operative trichiasis: Factors which programmes have minimal capacity to change

The primary patient-related factor which predicts post-operative trichiasis is the presence of severe trichiasis pre-operatively. (Burton, M. J., 2005, Zhang, H., Kandel, R. P., Sharma, B. et al., 2004). This may be due to the persistent in-turning effect of the scarred posterior lamella on the lid and the fact that surgery on such lids is generally more difficult (Rajak, S. N., Habtamu, E., Weiss, H. A. et al., 2011). It has been suggested that the presence of *C. Trachomatis* infection at operation is associated with increased incidence of post-operative trichiasis (Burton, M. J., 2005). This has led to the administration of Azithromycin at time of surgery in settings where mass drug administration is being conducted. Azithromycin decreased incidence of post-operative trichiasis in hyper-endemic regions, like Ethiopia (West, S., West, E. and Alemayehu, W., 2006) but not in less endemic regions like Gambia (Burton, M. J., 2005) and Nepal (Zhang, H., Kandel, R. and Atakari, H., 2006).Other patient-related factors which may increase incidence of post-operative trichiasis include older age (Burton, M., Bowman, R. and Faal, H., 2005), female gender (Reacher, M. H., Muñoz, B., Alghassany, A. et al., 1992) and severe conjunctival inflammation (Burton, M. J., 2005).

3.9. *Post-operative trichiasis: Factors which programmes have a capacity to change*

Trachoma programmes do have control, however, over surgeon-related factors. Recent research has suggested that PLTR yields a lower likelihood of post-operative trichiasis compared to BLTR and, accordingly, WHO recommends that all new trichiasis surgeons are trained in PLTR. A critical factor in surgical outcome is the surgeon’s skill, ensured through proper training, supervision, and quality assurance in the form of audits. A study in Ethiopia showed that poor outcomes were associated with inadequate peripheral tissue dissection, poor suture positioning and tension, irregular incisions and inadequate correction (Habtamu, E., Wondie, T. and Sewunet, S., 2017), all related to the surgeon skills.

Surgical incisions with an internal scar of less than 4.5mm have been associated with increased incidence of postoperative trichiasis one year following BLTR surgery (Merbs, S., Oktavec, K., Munoz, B. et al., 2015). Similarly, eyelids with short incisions less than 22mm were four times more likely to have recurrent trichiasis compared to eyes with incisions between 22.1mm and 26mm (Gower, E., Merbs, S., Munoz, B. et al., 2011).

Surgeons are generally trained by ophthalmologists who have had experience with high volume trichiasis surgery and surgical training (W.H.O., 2015). The trainers use a trainer’s material provided by ICTC and supervision training is widely available (I.C.T.C., 2018). Nevertheless, poor training will lead to poor skill acquisition.

Surgeon supervisors, generally ophthalmologists or the most skilled trichiasis surgeons, oversee the efficient implementation of trichiasis surgery activities to help surgeons obtain good quality trichiasis management (I.C.T.C., 2018) This is important because mentoring and problem-solving are the main tenets of supportive supervision. Supervisors must have adequate clinical knowledge about trichiasis surgery and be equipped with the right tools e.g. checklists, training aids, referral guides etc. (I.C.T.C., 2018)

3.10. Quality assurance and surgeon audit for trichiasis

A surgeon audit is defined as the quality improvement process through which a sample of patients from a particular surgeon are examined post-operatively (generally by 6 months after surgery) to identify cases of post-operative trichiasis and other operative complications. Audit findings are used by the supervisors and the programme to decide if the surgeons should continue to do surgery or if retraining is needed. The retraining may be tailored to specific aspects depending on needs e.g. suturing, incision etc. In some cases, an audit may suggest that a surgeon should cease doing any surgery (Buchan, J. C., Limburg, H. and Burton, M. J., 2011). The audit compares actual surgical outcomes by individual surgeons with the predetermined quality standard (Myatt M, Limburg H, Minassian D et al., 2003).

Surgeon audits are recommended for all newly trained surgeons six to nine months after certification to ensure optimal surgical outcome and minimal complications. (W.H.O., 2016) For previously trained surgeons, an audit is recommended as some surgeons may have picked up some negative surgical habits (I.C.T.C., 2012). Surgeons who are recommended for retraining should have a follow up audit six to nine months after completing their retraining and certification.

Most programmes have established a pre-determined threshold for acceptable post-operative trichiasis--usually not more than 10% of operated cases, as recommended by WHO (W.H.O., 2019b). If an audit reveals post-operative trichiasis above the pre-determined threshold, the surgeon is recommended for retraining and/or intensive supervised surgical practice with a more experienced surgeon (Courtright, P., Burton, M. and Emerson, P., 2012). Ideally, audits should be performed by a supervisor and the surgeon should accompany in order to discuss specific cases (I.C.T.C., 2012).

The first step is to determine who to audit, and whether an audit is practical e.g. if the surgeon has done enough surgeries (usually at least 20-25 surgeries). The second step is to compile basic information (for each surgeon to be audited) about each operated patient that had surgery in the last six months (I.C.T.C., 2012): date of surgery, place of surgery, patient's name, and contact information (e.g. address, phone number of patient or patient's neighbour). This list will be used to select people for inclusion in the audit. The third step is to select a sample of patients for each surgeon—generally, an audit does not include all the surgeon's patients operated on over the last six months.

The Lot Quality Assurance Sampling (LQAS) method, a standardised method for monitoring the standard of outcomes (trichiasis surgeries), being delivered is commonly used (Myatt M, Limburg H, Minassian D et al., 2003, Buchan, J. C., Limburg, H. and Burton, M. J., 2011). The LQAS methodology was originally developed in the 1920s to control the quality of output in industrial production processes (Murthy, M. R. K., 2018) but has been widely adapted to various fields of healthcare. It was first applied to public health in the mid 1980s but has universal applicability (Murthy, M. R. K., 2018). It involves taking a random sample and testing the sample for quality; if the number of defective items in the sample exceeds a pre-determined criteria (decision rule), then the lot is rejected. The decision rule is based on the desired production standards to generate a statistically determined sample size. LQAS is a preferred methodology for many audits because it is statistically reliable and the number of cases required to classify a surgeon are small compared with other audit methods (Myatt M, Limburg H, Minassian D et al., 2003, Rath, R. S. and Solanki, H. K., 2019). It has been adopted by trachoma programmes for these reasons. (Gebreselassie, G., Dawit, S., Alemayehu, S. et al., 2019, Buchan, J. C., Limburg, H. and Burton, M. J., 2011).

A schematic diagram of the LQAS principles is in Appendix 3. An example of decision and stopping rules based on specific criteria is shown in the table in Appendix 5.

For trichiasis, the audit aims to identify surgeons with an unacceptably high proportion of cases of post-operative trichiasis. (Myatt M, Limburg H, Minassian D et al., 2003). It is not statistically meaningful to generate an incidence rate using LQAS; it is only possible to determine if a surgeon achieves the threshold or not. Between 20-40 cases are selected, generally with 5-10 cases selected as back-up.

LQAS was used by most of the countries in this study and surgeons with more than 10% post-operative trichiasis were classified as being above the acceptable threshold. (Buchan, J. C., Limburg, H. and Burton, M. J., 2011).

The fourth step is to compile relevant clinical data about each patient selected for the audit. Relevant clinical data includes type of surgery done, eye(s) having surgery, severity of trichiasis pre-operation (number of lashes and, entropion, location of trichiasis), any surgical complications during surgery, condition of eyelid at the post-operative visits (at one day, 7-14 days, and at 3-6 months).

The fifth step is the field visit to the selected cases. This is done at the specific outreach site or at patient houses. If a patient is not present, or has died, one of the back-up patients is selected. The clinical examination is done by the clinician, generally a supervisor or trainer, and all complications are documented. Outcomes can be discussed with the surgeon on-site or at a later date if the surgeon is absent at time of audit. A standard audit checklist is used. (I.C.T.C., 2012).

3.11. Findings from previously undertaken audits

Some research on surgeon audits in trichiasis has been conducted. In Ethiopia, the LQAS methodology was used to plan an audit for 80 surgeons in the East Badwacho and Yem districts (Gebreselassie, G., Dawit, S., Alemayehu, S. et al., 2019) but only two surgeons were audited. The post-operative trichiasis rates were found to be less than 10% for both and thus were considered acceptable. More recently, in a Chadian study (Djore, D., Djibrine, D., Ali, A. B. et al., 2020), a mobile data collection app was used for trichiasis surgical audits and found to be a cost-effective way of undertaking audit. All nine surgeons included in the audit had <25% post-operative trichiasis, the cut-off used to determine if retraining was needed.

A cross-sectional survey was conducted involving 29 trachoma endemic countries (Mwangi, G., Courtright, P. and Solomon, A. W., 2020a) in Africa. Among these, only four countries had a national policy for conducting trichiasis surgeon audits and only nine countries had a cut-off point at which poorly performing surgeons will have re-training conducted.

3.12. Identification of gaps or needs for further research

There is a relative paucity of published scientific research about surgeon audit in the field of trichiasis. More surgeon audits should also be carried out to refine the audit process and serve to develop strategies to improve training and supervision. The reasons for a low frequency of surgeon audits in trichiasis programs should be investigated. Further research into the use of mobile phone apps to make the audit process easier and more effective should be done. Every country should investigate reasons for poor surgical audit volumes and possible remedies for this . More detailed data collection to include number of lashes rubbing against the cornea, for example, may add value to research in the future.

References

Adamu, Y & Alemayehu, W 2002. A randomized clinical trial of the success rates of bilamellar tarsal rotation and tarsotomy for upper eyelid trachomatous trichiasis.*Ethiop Med J. ,* 40**,** 107-114.

Ahmed, R.A. & Abdelbaky, S.H. 2015. Short term outcome of anterior lamellar reposition in treating trachomatous trichiasis. *J Ophthalmol,* DOI: 10.1155/2015/568363.

Alemayehu, W, Melese, M, Bejiga, A, Worku, A, Kebede, W & Fantaye, D 2004. Surgery for trichiasis by ophthalmologists versus integrated eye care workers: a randomized trial. *Ophalmol,* 111 (3)**,** 578-84. DOI: 10.1016/j.ophtha.2003.06.030.

Assefa, Yared, Habte, Dereje, Sendekie, Tegbar & Mekonnen, Alemayehu 2008. Trichiasis recurrence in North Ethiopia: A one year prospective study of Trachomatous Trichiasis surgery done by integrated eye care workers. *Ethiop J Health Dev,* 22 (1)**,** 8-13 DOI: 10.4314/ejhd.v22i1.10048.

Bouazza, M, Elbelhadji, M, Cherkaoui, S, Mchachi, A & Benhmidoune, L 2017. Anterior lamellar resection with lid margin split of the upper eyelid in the treatment of trachomatous entropion. *J Fr Ophtalmol,* 40 (6)**,** 453-459 DOI: 10.1016/j.jfo.2016.12.020.

Brézin, A P, Lafuma, A, Fagnani, F, Mesbah, M & Berdeaux, G 2004. Blindness, low vision, and other handicaps as risk factors attached to institutional residence. *British Journal of Ophthalmology* 88 (10)**,** 1330-1337. DOI: 10.1136/bjo.2003.039180.

Buchan, J C, Limburg, H & Burton, M J 2011. Quality assurance in trichiasis surgery: a methodology. *Br J Ophthalmol.,* 95 (3)**,** 331-334 DOI: 10.1136/bjo.2003.039180.

Burton, M, Bowman, R & Faal, H 2005. Long term outcome of trichiasis surgery in the Gambia. *Br J Ophthalmol. ,* 89**,** 575–579. DOI: 10.1136/bjo.2004.055996.

Burton, M J 2005. A randomised controlled trial of azithromycin following surgery for trachomatous trichiasis in the Gambia. *Br J Ophthalmol,* 89 (10)**,** 1282–1288 DOI: 10.1136/bjo.2004.062489.

Burton, M J & Mabey, D C W 2009. The Global Burden of Trachoma: A Review. PLoS Negl Trop Dis 3(10): e460. DOI: 10.1371/journal.pntd.0000460.

Burton, M J, Rajak, S N, Ramadhani, A & Weiss, H A 2012. Post-operative recurrent trachomatous trichiasis is associated with increased conjunctival expression of S100A7 (psoriasin). *PLoS Negl Trop Dis,* 6 (12) DOI: 10.1371/journal.pntd.0001985.

Burton M.J, Bowman R J. C. , Faal H , E A. N. Aryee, Ikumapayi, U N., Alexander, N D. E. & Adegbola, R A. 2006. The Long-Term Natural History of Trachomatous Trichiasis in The Gambia. *Invest Ophthalmol Vis Sci.,* 47 (3) DOI: 10.1167/iovs.05-0714.

Chang, C K, Lin, J T & Zhang, Y 2017. Human eye ocular component analysis for refractive state and refractive surgery. *Int J Ophthalmol.,* 10 (7)**,** 1076-1080. DOI: 10.18240/ijo.2017.07.09.

Courtright, P, Burton, M & Emerson, P 2012. Eliminating trichiasis: the next steps forward. *Community eye health.,* 25 (78).

Courtright, P. & West, S K 2004. Contribution of sex-linked biology and gender roles to disparities with trachoma. *Emerging Infectious Diseases,* 10 (11) DOI: 10.3201/eid1011.040353.

Cromwell, E A, Courtright, P, King, J D., Rotondo, L A., Ngondi, J & Emerson, P. 2009. The excess burden of trachomatous trichiasis in women: A systematic review and meta-analysis. *Transactions of The Royal Society of Tropical Medicine and Hygiene,* 103 (10)**,** 985-992 DOI: 10.1016/j.trstmh.2009.03.012.

Dawson, C R, Jones, B R & Tarizzo, M L 1981. Guide to Trachoma Control. Geneva: World Health Organization.

Djore, D, Djibrine, D, Ali, A B, Tyau-Tyau, H & Hiron D2020. Pilot Audit of Trichiasis Surgery Outcomes Using a Mobile App in the Republic of Chad. *Middle East Afr J Ophthalmol.,* 27 (1)**,** 14-21 DOI: 10.4103/meajo.MEAJO_75_19.

Doyal, L & Das-Bhaumik, R G 2018. Sex, gender and blindness: a new framework for equity. *BMJ Open Ophthalmol. ,* 3 (1) DOI: 10.1136/bmjophth-2017-000135.

Flueckiger, R M, Courtright P, Abdala M & Abdou M 2019. The global burden of trichiasis in 2016. *BioRxiv : the preprint server for biology,* DOI: 10.1371/journal.pntd.0007835.

Gebreselassie, G, Dawit, S, Alemayehu, S & Temesgen, K 2019. Trachomatous Trichiasis (TT) Surgical Quality Outcome Audit in

Hadiya Zone and Yem Special District, Southern Ethiopia. *EC Gynaecology,* 8 (1)**,** 03-08.

Gower, E, Merbs, S, Munoz, B, Kello, A, Alemayehu, W, Imeru, A & West, S 2011. Rates and Risk Factors for Unfavorable Outcomes 6 Weeks after Trichiasis Surgery. *Investigative Ophthalmology & Visual Science* 52**,** 2704-2711 DOI: 10.1167/iovs.10-5161.

Gower, E, West, S, Cassard, S, Munoz, B & Harding, J 2012. Definitions and Standardization of a New Grading Scheme for Eyelid Contour Abnormalities after Trichiasis Surgery. *ploS ,* 6 (6) DOI: 10.1371/journal.pntd.0001713.

Habtamu E, Wondie T, Aweke S, Z Tadesse, M Zerihun & Zewudie, Z 2015. The Impact of Trachomatous Trichiasis on Quality of Life: A Case Control Study. *ploS - Negl trop dis,* 9 (11) DOI: 10.1371/journal.pntd.0004254.

Habtamu, E, Rajak, S & Gebre, T 2011. Clearing the backlog: trichiasis surgeon retention and productivity in Northern Ethiopia. *PLoS Negl Trop Dis. ,* 5 (4) DOI: 10.1371/journal.pntd.0001014.

Habtamu, E, Wondie, T, Aweke, S & Tadesse, Z 2018. Oral doxycycline for the prevention of postoperative trachomatous trichiasis in Ethiopia: a randomised, double-blind, placebo-controlled trial. *The Lancet.,* 6 (5)**,** 579-592 DOI: 10.1016/S2214-109X(18)30111-6.

Habtamu, E, Wondie, T, Aweke, S, Tadesse, Z, Zerihun, M & Zewudie, Z 2016. Posterior lamellar versus bilamellar tarsal rotation surgery for trachomatous trichiasis in Ethiopia: a randomised controlled trial. *The Lancet.,* 4 (3)**,** 175-184 DOI: 10.1016/S2214-109X(15)00299-5.

Habtamu, E, Wondie, T & Sewunet, S 2017. Predictors of Trachomatous Trichiasis Surgery Outcome. *Ophthalmology* 124 (8) DOI: 10.1016/j.ophtha.2017.03.016.

Habtamu, E, Wondieb, T, Tadesse, Z, Atinafu, B, Gashaw, B & Gebeyehu, A 2019. Posterior lamellar versus bilamellar tarsal rotation surgery for trachomatous trichiasis: Long-term outcomes from a randomised controlled trial. *Lancet,* 17 DOI: 10.1016/j.eclinm.2019.10.015.

Halasa, A & Jarudi, N 1974. Tarsotomy for the correction of cicatricial entropion. *Ann Ophthalmol. ,* 6**,** 837–840 DOI: 10.1001/archopht.1992.01080170136042.

I.C.T.C. 2012. Report of the Global Scientific Meeting on Trachomatous Trichiasis.

I.C.T.C. 2018. International coalition for trachoma control : Supportive Supervision for Trachomatous Trichiasis Programmes preferred practice manual.

Khafagy, A, M.M. Mostafa & Fooshan, F 2012. Management of trichiasis with lid margin split and cryotherapy. *Clin Ophthalmol,* 6**,** 1815–1817. DOI: 10.2147/OPTH.S35678.

Last A.R., Burr S.E., Weiss H.A. & Harding-Esch E.M. 2014. Risk Factors for Active Trachoma and Ocular Chlamydia trachomatis Infection in Treatment-Naïve Trachoma-Hyperendemic Communities of the Bijagós Archipelago, Guinea Bissau. *PLoS Negl Trop Dis. ,* 8 (6) DOI: 10.1371/journal.pntd.0002900.

Lewallen, S, Mahande, M, Tharaney, M, Katala, S & Courtright, P 2007. Surgery for trachomatous trichiasis: findings from a survey of trichiasis surgeons in Tanzania. *Br J Ophthalmol,* 91 (2)**,** 143-145 DOI: 10.1136/bjo.2006.102368.

Masoud, K, Amin, S, Mohammad-Reza, A & Farshad, A 2016. The Impact of Visual Impairment on Quality of Life. *Med Hypothesis Discov Innov Ophthalmol.,* 5 (3)**,** 96–103.

Merbs, S, Oktavec, K, Munoz, B, Perlini, E, West, S, Othman, M & Gower, E 2015. Lower Postoperative Scar Height is Associated with Increased Postoperative Trichiasis 1 Year after Bilamellar Tarsal Rotation Surgery. *Ophthalmic Epidemiol.,* 22 (3)**,** 200-7 DOI: 10.3109/09286586.2015.1036299.

Murthy, M R K 2018. Impact of Lot Quality Assurance Sampling (LQAS) For Better Monitoring & Evaluation (M&E) In Agriculture and Rural Development Projects. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS),* 11 (4) DOI: 10.9790/2380-1104011522.

Mwangi, G, Courtright, P & Solomon, A W 2020a. National approaches to trichiasis surgical follow-up, outcome assessment and surgeon audit in trachoma-endemic countries in Africa. *Br J Ophthalmol,* DOI: doi: 10.1136/bjophthalmol-2019-315777.

Mwangi, G, Courtright, P & Solomon, A W 2020b. Systematic review of the incidence of post-operative trichiasis in Africa. *BMC Ophthalmology.,* 20(1)**,** 451DOI: 10.1186/s12886-020-01564-0.

Myatt M, Limburg H, Minassian D & D, Kaytola 2003. Field trial of applicability of lot quality assurance sampling survey method for rapid assessment of prevalence of active trachoma. *Bull World Health Organ,* 81 (12)**,** 877-85.

Négrel, A D, Chami-Khazraji, Y, Arrache, M L, Ottmani, S & Mahjour, J 2000. The quality of trichiasis surgery in the kingdom of Morocco. *Sante,* 10 (2)**,** 81-92.

Pezzullo, L, Streatfeild, J & Simkiss, P 2018. The economic impact of sight loss and blindness in the UK adult population. *BMC Health Serv Res* 18 (63).

Rajak, S, Collin, R & Burton, M 2012. Trachomatous Trichiasis and its Management in Endemic Countries. *Survey of ophthalmology. ,* 57 (2)**,** 105–35. DOI: 10.1016/j.survophthal.2011.08.002.

Rajak, S, Habtamu, E, Weiss, H, Kello, A, Abera, B, Zerihun, M, Gebre, T, Gilbert, C, Khaw, P, Emerson, P & Burton, M 2013. The Outcome of Trachomatous Trichiasis Surgery in Ethiopia: Risk Factors for Recurrence. *PLoS Negl Trop Dis.,* 7 (8) DOI: 10.1371/journal.pntd.0002392.

Rajak, S N, Habtamu, E, Weiss, H A, Kello, A B, Gebre, T & Genet, A 2011. Surgery versus epilation for the treatment of minor trichiasis in Ethiopia: a randomised controlled noninferiority trial. *PLoS Medicine,* 8 (12) DOI: 10.1371/journal.pmed.1001136.

Rath, Rama Shankar & Solanki, Hariom Kumar 2019. Review of Lot Quality Assurance Sampling, Methodology and its Application in Public Health. *Nepal J Epidemiol. ,* 9 (3)**,** 781–787. DOI: 10.3126/nje.v9i3.24507.

Reacher, M, Foster, A & Huber, J 1993. Trichiasis surgery for trachoma : the bilamellar tarsal rotation procedure. *World Health Organisation. Geneva.*

Reacher, M H, Muñoz, B, Alghassany, A, Daar, S, Elbualy, M & Taylor, H R 1992. A controlled trial of surgery for trachomatous trichiasis of the upper lid. *Arch Ophthalmol. ,* 110 (5)**,** 667–674 DOI: 10.1001/archopht.1992.01080170089030.

Reacher, M, Huber, M, Canagaratnam, R & Alghassany, A 1990. A trial of surgery for trichiasis of the upper lid from trachoma. *Br J Ophthalmol. ,* 74**,** 109-113 DOI: 10.1136/bjo.74.2.109.

Solomon, A W 2016. Optimising the management of trachomatous trichiasis. *Lancet Global Health,* 4 (3)**,** 140-141. DOI: 10.1016/S2214-109X(16)00004-8.

Tadesse, D, Montgomery, I & Sankar, G 2017. HEAD START – an innovative training approach for life-long learning. *Community Eye Health,* 30 (97)**,** 14.

Tian, L & Wang, Nl 2018. Trachoma control: the SAFE strategy. *Int J Ophthalmol,* 11 (12)**,** 1887-1888 DOI: 10.18240/ijo.2018.12.01.

W.H.O. 2005. World Health Organization; Geneva: 2005. Final Assessment of Trichiasis Surgeons.

W.H.O. 2010. World Health Organization. 2010. Report of the third global scientific meeting on trachoma. Baltimore.
W.H.O. 2015. Trichiasis surgery for trachoma (2nd ed). Geneva: World Health Organization.

W.H.O. 2016. World Health Organization alliance for the global elimination of trachoma by 2020: second global scientific meeting on trachomatous trichiasis: Cape Town, 4–6 November 2015. World Health Organization. Available:
http://www.who.int/iris/handle/10665/250571.

W.H.O. 2019a. Eliminating trachoma: WHO announces sustained progress with hundreds of millions of people no longer at risk of infection.

W.H.O. 2019b. Report of the 4th Global Scientific Meeting on Trachoma, Geneva, 27–29 November 2018 World Health Organization, Geneva, Switzerland.

W.H.O. 2019c. The WHO Alliance for GET2020: Global partnership for trachoma elimination.

West, E S, Mkocha, H, Munoz, B, Mabey, D, Foster, A, Bailey, R & West, S K 2005 Risk factors for postsurgical trichiasis recurrence in a trachoma-endemic area. *Invest Ophthalmol Vis Sci. ,* 46 (2)**,** 447-53. DOI: 10.1167/iovs.04-0600.

West, S K, Munoz, B, Mkocha, H, Hsieh, Y H & Lynch, M C 2001. Progression of active trachoma to scarring in a cohort of Tanzanian children. *Ophthalmic Epidemiol.,* 8**,** 137-144 DOI: 10.1076/opep.8.2.137.4158.

West, S, West, E & Alemayehu, W 2006. Single-dose azithromycin prevents trichiasis recurrence following surgery: randomized trial in Ethiopia. *Arch Ophthalmol.,* 124**,** 309–314 DOI: 10.1001/archopht.124.3.309.

Woldekidan E, Daka D & Legesse, D 2019. Prevalence of active trachoma and associated factors among children aged 1 to 9 years in rural communities of Lemo district, southern Ethiopia: community based cross sectional study. *BMC Infect Dis* 19 (886) DOI: 10.1186/s12879-019-4495-0.

Woreta, T.A., Munoz, B.E. & Gower, E.W. 2009. Efffect of trichiasis surgery on visual acuity outcomes in Ethiopia. *Arch Ophthalmol.,* 127 (11)**,** 1505-10 DOI: 10.1001/archophthalmol.2009.278.

Zhang, H, Kandel, R & Atakari, H 2006. Impact of oral azithromycin on recurrence of trachomatous trichiasis in Nepal over 1 year. *Br J Ophthalmol. ,* 90**,** 943-948 DOI: 10.1136/bjo.2006.093104.

Zhang, H, Kandel, R P, Sharma, B & Dean, D 2004. Risk Factors for Recurrence of Postoperative Trichiasis: Implications for Trachoma Blindness Prevention. *Arch Ophthalmol.,* 122 (4)**,** 511-516 DOI: 10.1001/archopht.122.4.511.

Part B – Manuscript

Cover Page

a. Title : Evaluation of Trichiasis Surgeon Performance in Selected Trachoma Endemic Countries.
b. Running head title: Evaluation of Trichiasis Surgeons in Endemic Countries.
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This manuscript has been composed in compliance with the Ophthalmic Epidemiology journal's guidelines for authors. The choice of this journal was informed by its open access policy, broad scope and wide global reach (see instructions for authors in Appendix 6). Please note that the Harvard referencing style is being adhered to in the protocol section of this dissertation in keeping with the requirements of the University of Cape Town for dissertation submission in the MPH program. However, the Vancouver referencing style was recommended by this journal and the Vancouver style is used in the manuscript section.

Abstract

Purpose: Elimination of trachoma-related blindness requires addressing not only issues of trichiasis surgery availability and accessibility, but also quality. To improve surgeon performance, programmes undertake surgeon audits to identify surgeons needing re-training, reasons for poor outcomes, and actions to optimise surgical outcomes. This study aims to determine the frequency and associated factors of audits conducted in selected countries and factors associated with failed audits.

Methods: A multicentric study was conducted as a secondary data analysis of surgeon audit results for eight African countries. Stata® was used to generate results for chi-square tests for association, odds ratio and 95% confidence intervals between independent samples for categorical variables and one-way ANOVA tests for continuous variables.

Results: The study included 561 trichiasis surgeons and 193 (34.4%) had an audit. Dedicated eye care workers were more likely to have an audit ($p < 0.001$) compared to general health workers. Among audited surgeons, 29 (15%) failed and were recommended for re-training. Surgeons using posterior lamellar tarsal rotation (PLTR) surgery (59.8%) and those trained more recently (mean 4.2 years) were more likely to pass the audit.

Conclusion: Although surgeon audits are considered a routine part of programme activities in trachoma endemic countries, too few audits are being undertaken. Further research is needed to learn why surgeons practicing PLTR surgery and those trained more recently are more likely to pass their audit. To improve surgical outcomes, programmes must not only focus on surgical volume but carry out surgeon audits and use the audits to make programme decisions.

Introduction

Trachoma is caused by the intracellular bacterium *Chlamydia trachomatis* .[1] It is transmitted by personal contact and through flies which have contact with infected eye and nasal discharges [2]. Africa has a higher trachoma burden due to water scarcity, poor facial hygiene and poor sanitation leading to an increased risk of transmission [2]. Children under ten years old have a higher active trachoma burden [4] and repeated infection may cause conjunctival scarring. Conjunctival scarring sequelae may include in-turning of the lid margin, generally in people over the age of 40. This may lead to eye lashes touching the globe (trichiasis), which can cause corneal abrasions, ulceration, corneal scarring, with resultant blindness[5]. Trichiasis is the leading infectious cause of blindness worldwide[3, 6]. Recent estimates indicate that there are 2.8 million people with trichiasis[7].

The SAFE strategy was implemented by the World Health Organization (WHO) to eliminate trachoma as a public health problem. It comprises Surgery, Antibiotics, Facial cleanliness and Environmental improvement [8, 9]. Surgery is the only component which can reverse the in-turning of the eyelid and restore normal lid position to keep the lashes off the eyeball [10, 11]. WHO endorsed two surgical procedures, Bilamellar Tarsal Rotation (BLTR) and Posterior Lamellar Tarsal Rotation (PLTR) to correct trachomatous trichiasis [12]. There are inadequate numbers of ophthalmologists in trachoma endemic regions, therefore ophthalmic nurses or technicians and general health workers are trained as trichiasis surgeons [13].

Not all trichiasis surgery leads to a good outcome. In some studies, the incidence of post-operative trichiasis has been reported to be as high as 60% at 3 years [14-17]. Pre-existing conditions, such as severe trichiasis (>5 lashes touching the globe), presence of *C. Trachomatis* infection at operation time [18], older age [19], female gender [15] and past trichiasis surgery are risk factors for post-operative trichiasis. There are, however, surgeon-related factors which predict post-operative trichiasis. Poor surgical outcomes may result from inadequate training, supervision, equipment and instruments and surgical technique [12, 20]. Most post-operative trichiasis that is due to surgeon-related factors occur within 6 months post-surgery. A recent systematic review demonstrated that the incidence of post-operative trichiasis ranged from 6.2% to 15.8% six months after surgery [17].The most useful approach to assessing surgeon quality is to conduct surgeon audits [21]. Surgical cases that are relevant for inclusion in a surgeon audit are those that have occurred in the previous 3-6 months [22, 23]. Trichiasis programmes in Africa generally lack well established policies for conducting surgeon audits [24] and often too few surgeons are being audited [25]. There are two published reports of surgeon audits, one from Chad [25] and one from Ethiopia [22].

Surgeons are assessed by evaluation of a sample of their operated patients by a supervisor; surgeons whose poor outcomes are above a pre-determined threshold are recommended for re-training [26]. Recently, the target incidence of post-operative trichiasis was revised to < 10% at 6 months for cases with minor trichiasis (≤ 5 eyelashes touching the eyeball pre-operatively) and < 20% by 6 months for eyes with major trichiasis (> 5 eyelashes touching the eyeball) pre-operation[23].

The aim of this study was to determine the proportion of surgeons in trachoma programmes in eight countries which had audits done, factors which might predict whether an audit was done or not, to assess the proportion of surgeons who had successful/failed audits, and to highlight some factors associated with failed audits.

Materials and methods

This was a multicentric study that included all individuals trained as trichiasis surgeons in eight countries: Tanzania, Kenya, Mozambique, Malawi, Zambia, Uganda, Nigeria and Ethiopia. Individual countries were contacted to obtain their consent and no direct contact was made with the surgeons or their trainers.

This study was a secondary data analysis using a surgeon management list which included information on the surgeons, their training, whether they had a surgeon audit, and the outcome of the audit. Both surgeon and trainer identities were anonymised before analysis. The study was carried out in accordance with the guidelines in Declaration of Helsinki and ethical approval was obtained from the Human Research Ethics Committee (HREC) of the University of Cape Town.

Data included in the surgeon database included information about the surgeon (i.e. country, sex, cadre), information about training and their work (e.g., when trained, surgical technique, trainer) as well as about the audit (had audit or not, results of audit, retraining recommended or not). For the purpose of the analysis we created a variable, "surgeon cadre" and grouped them as eye care surgeons (ophthalmologists and non-physician cataract surgeons), dedicated eye care workers (ophthalmic nurses, ophthalmic medical officers), and general health workers.

In the first phase of the analysis, we sought to assess the proportion of audits done and associations with country, surgeon cadre, and type of surgery used. In the second phase of the analysis we sought to assess the proportion of surgeons who successfully completed the audit and to determine what factors may predict audit success or failure.

Data analysis was done using Microsoft Excel for data cleaning and Stata® (version 16) for statistical analysis[27]. Categorical variables were analysed using the chi-square test. Statistical significance was calculated. Odds ratios and 95% confidence intervals were calculated, where indicated. Kruskal-Wallis and Wilcoxon-Mann Whitney rank sum tests were used where indicated.

Results

From the eight countries there were 561 surgeons (Table 1), with more than 60% from Nigeria and Ethiopia, 171 surgeons (30.5%) each. Just over two-thirds of the surgeons were men, ranging from 55% (Tanzania) to 90% (Zambia). Only 8% of the trichiasis surgeons were eye care surgeons, ranging from 87.8% (Kenya) to 2.4% (Ethiopia). Most of the surgeons in Ethiopia were general health workers (74.2%) but this varied by region. The PLTR procedure was practiced by almost 60% of surgeons, with considerable variation between and within countries.

Surgeon audits were completed on 193 (34.4%) surgeons, ranging from 14.3% (Kenya and Zambia) to 81% (Malawi). Besides country of residence, the number of years since first trained was also predictive of having an audit. (Table 2) Dedicated eye care workers were more likely to be audited than other cadres and surgeons who practiced BLTR were about twice as likely to have an audit compared to surgeons trained in PLTR ($p < 0.001$). Among the 193 surgeons with completed audits, 29 (15%) failed their audit and were recommended for retraining. (Table 3). Surgeons with failed audits had a longer duration since receiving their training (4.9 years) than those who passed (4.2 years). Surgeons using PLTR were 5.79 times (95% CI 2.10-15.90) less likely to fail their audit compared to those using BLTR. Among the 29 surgeons recommended for re-training 19 (65.5%) have not been re-trained.

Not all surgeons have continued to practice surgery, 150 surgeons (32.5%) no longer conduct trichiasis surgery (Table 4).

Table 1: Country-based descriptive characteristics of study population N=561

Parameters	Ethiopia	Kenya	Malawi	Mozambique	Nigeria	Tanzania	Uganda	Zambia	Total (Mean & standard deviation)	P-values
	n=171 (%)	n=49 (%)	n=16 (%)	n=15 (%)	n=171 (%)	n=76 (%)	n=42 (%)	n=21 (%)	561	
Surgeon sex										<0.001
Male	128(74.9)	37(75.5)	15(93.8)	11(73.3)	147(86)	42(55.3)	28(66.7)	19(90.5)	427(53, 53.2)	
Female	43(25.1)	12(24.5)	1(6.2)	4(26.7)	24(14)	34(44.7)	14(33.3)	2(9.5)	134 (17, 15.6)	
Data missing	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	
Mean years since first trained (to 2019)	3.1	3.3	4.0	3.4	2.1	7.1	3.7	2.9	3.6 (1.5)	<0.001
Data missing	106(62.0)	9(8.2)	0(0.0)	0(0.0)	17(9.9)	1(1.3)	0(0.0)	0(0.0)	133(17)	
Mean years since HEADSTART* certified (to 2019)	5.8	NA	5.0	3.4	1.9	1.7	3.7	2.9	3.4 (1.9)	<0.001
Data missing	15(8.8)	49(100.0)	0(0.0)	0(0.0)	10(5.8)	8(10.5)	0(0.0)	4(19.1)	86(11)	
Surgeon cadre										<0.001
Eye care surgeons	3(1.8)	43(87.8)	4(25.0)	1(6.7)	0(0.0)	16(21.1)	0(0.0)	0(0.0)	67(8, 15.0)	
Dedicated eye care workers	29(17.0)	6(12.2)	12(75.0)	14(93.3)	171 (100.0)	58 76.3)	42(100.0)	14(66.7)	346(43, 54.5)	
General health workers	92(53.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.3)	0(0.0)	7(33.3)	100(12, 32.2)	
Data missing	47(27.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(1.3)	0(0.0)	0(0.0)	48(6)	
Surgical technique										<0.001
PLTR	116(67.8)	12(24.5)	0(0.0)	15(100.0)	133 (77.8)	0(0.0)	32(76.2)	21(100.0)	329 (41, 52.7)	

BLTR	44(25.7)	37(75.5)	16 (100.0)	0(0.0)	38(22.2)	76(100.0)	10(23.8)	0(0.0)	221 (28, 26.1)	
Data missing	11(6.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	11(1)	

NA = Not available
*HEADSTART is an innovative method of training surgeons using mannequins before performing live surgeries

Table 2: Audit-based comparisons of all surgeons

Parameters	Had audit n (%)	Did not have audit n (%)	Total n (%)	Odds ratio (95% CI) p value
Surgeon sex				1.33(0.89 -2.05) 0.19
Male	154(36.1)	273(63.9)	427 (100.0)	
Female	40(29.9)	94(70.1)	134 (100.0)	
Mean years (standard deviation) since first trained (to 2019)	4.2(3.9)	3.2(3.6)	3.6(3.7)	P = 0.004
Mean years (standard deviation) since HEADSTART certified (to 2019)	3.6(3.5)	3.3(3.2)	3.4(3.3)	P < 0.001
Surgeon cadre				P < 0.001
Eye care surgeons	16(23.9)	51(76.1)	67(100.0)	1.0 (Reference)
Dedicated eye care workers	141(40.8)	205 (59.2)	346 (100.0)	0.46(0.25 – 0.83) 0.009
General health workers	20(20.0)	80 (80.0)	100 (100.0)	1.25(0.61 – 2.7) 0.52
Surgical technique				0.51(0.36 – 0.73) <0.001
PLTR	94(28.6)	235(71.4)	329 (100.0)	
BLTR	97(43.9)	124(56.1)	221 (100.0)	
Country				<0.001
Ethiopia	54(31.6)	117(68.4)	171 (100.0)	
Kenya	7(14.3)	42(85.7)	49(100.0)	
Malawi	13(81.3)	3(18.7)	16(100.0)	
Mozambique	4(26.7)	11(73.3)	15(100.0)	
Nigeria	65(38.0)	106(62)	171 (100.0)	
Tanzania	36(47.4)	40(52.6)	76(100.0)	
Uganda	11(26.2)	31(73.8)	42(100.0)	
Zambia	3(14.3)	18(85.7)	21(100.0)	

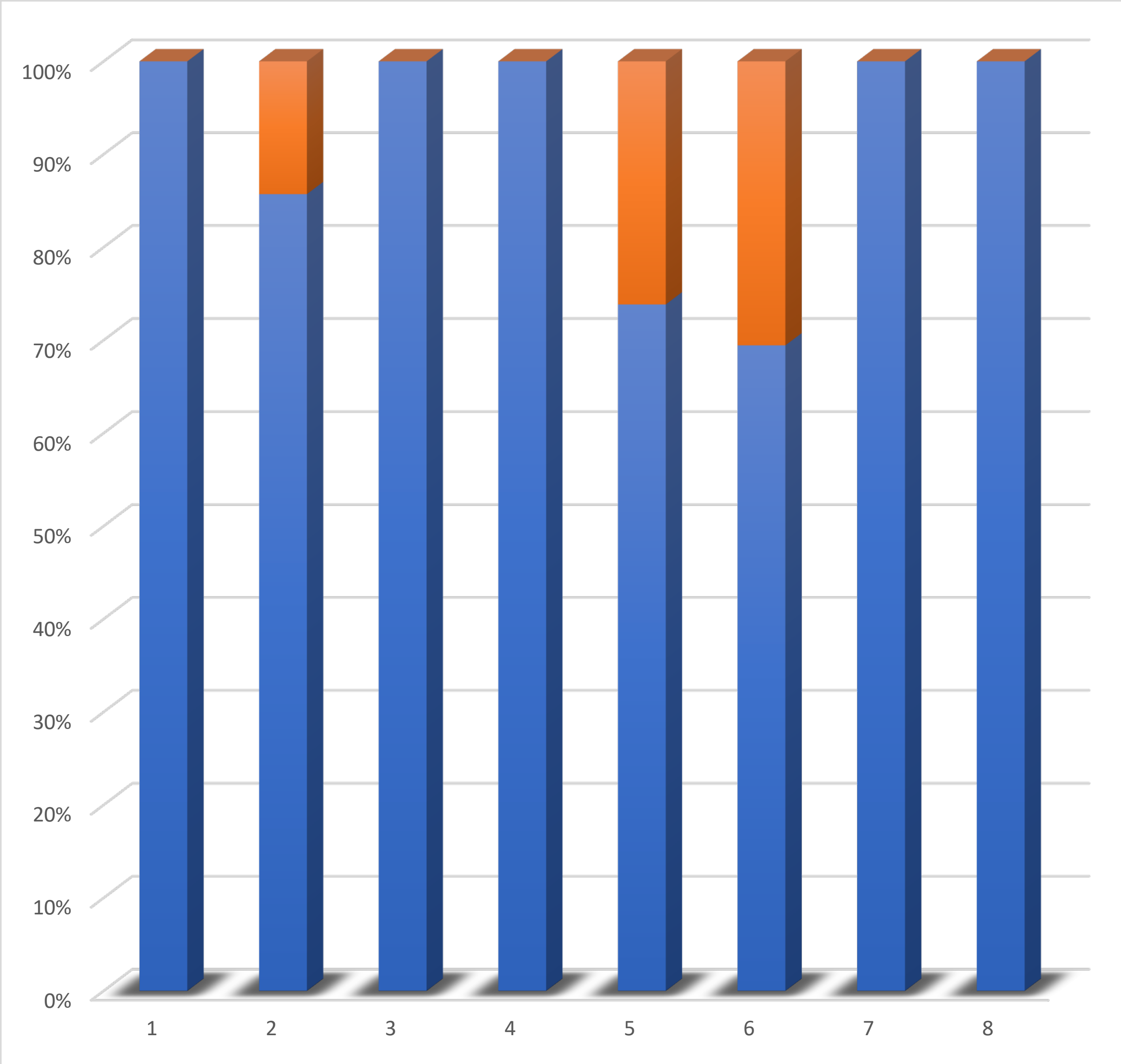

Figure 1: Bar chart showing the proportion of surgeons from different countries who passed or failed their audits respectively.

1 = Ethiopia
2 = Kenya
3 = Malawi
4 = Mozambique
5 = Nigeria
6 = Tanzania
7 = Uganda
8 = Zambia

Blue = Passed Audit

Orange = Failed Audit

Table 3: Summary statistics of audited surgeons based on performance at audits

Parameters	Passed audit	Did not pass audit	Total (%)	Odds ratio (95% CI) p value
	N (%)	N (%)		
Surgeon sex				0.99 (0.37 - 2.62) 0.98
Male	130(85.0)	23(15.0)	153(100.0)	
Female	34(85.0)	6(15.0)	40(100.0)	
Mean years (standard deviation) since first trained (to 2019)	4.2(3.8)	4.9(4.7)	4.5(4.3)	P = 0.009
Mean years (standard deviation) since HEADSTART certified (to 2019)	3.2(3.1))	3.7(3.9)	3.5(3.6)	P < 0.001
Year of audit				P = 0.07
2017	53(84.1)	10(15.9)	63(100.0)	1.0 (reference)
2018	63(91.3)	6(8.7)	69(100.0)	0.50 (0.125-1.17) 0.08
2019	47(78.3)	13(21.7)	60(100.0)	1.47 (0.55-3.26) 0.53
Surgeon cadre				0.05
Eye care surgeons	13(81.3)	3(18.7)	16(100.0)	1.0 (reference)
Dedicated eye care workers	114(81.4)	26(18.6)	140(100.0)	0.98 (0.26-3.69) 0.98
General health workers	20(100.0)	0(0.0)	20(100.0)	0.09 (0.01 – 1.97) 0.13
Surgical technique				5.79 (2.10-15.90) < 0.001
PLTR	88(94.6)	5(5.4)	93(100.0)	
BLTR	73(75.3)	24(24.7)	97(100.0)	
Country				0.007
Ethiopia	53(100.0)	0(0.0)	53(100.0)	
Kenya	6(85.7)	1(14.3)	7(100.0)	
Malawi	13(100.0)	0(0.0)	13(100.0)	
Mozambique	4(100.0)	0(0.0)	4(100.0)	
Nigeria	48(73.8)	17(26.2)	65(100.0)	
Tanzania	25(69.4)	11(30.6)	36(100.0)	
Uganda	11(100.0)	0(0.0)	11(100.0)	
Zambia	3(100.0)	0(0.0)	3(100.0)	

Table 4: Summary statistics of surgeons based on activity status (data available on 462 surgeons)

Parameters	Currently active	Not currently active	Total (%)	Odds ratio (95% CI) p value
Surgeon sex				0.8(0.51 – 1.24) 0.32
Male	238(68.8)	108(31.2)	346(100.0)	
Female	74 (63.8)	42(36.2)	116(100.0)	
Mean years (standard deviation) since first trained (to 2019)	3.4(3.7)	5.5(4.7)	4.0(4.1)	P < 0.001
Mean years (standard deviation) since HEADSTART certified (to 2019)	2.9(2.4)	3.1(2.7)	2.9(2.5)	P = 0.1
Year of audit				P < 0.001
2017	42(66.7)	21(33.3)	63(100.0)	1.0 (Reference)
2018	64(94.1)	4(5.9)	68(100.0)	0.13(0.04 – 0.39) <0.001
2019	50(94.3)	3(5.7)	53(100.0)	0.12(0.03 - 0.43) <0.001
Surgeon cadre				P < 0.001
Eye care surgeons	18(31.0)	40(69.0)	58(100.0)	1.0 (Reference)
Dedicated eye care workers	187(79.2)	49(20.8)	236(100.0)	0.12(0.06 – 0.22) < 0.001
General health workers	85(67.0)	42(33.0)	127(100.0)	0.22(0.11 – 0.43) < 0.001
Surgical technique				
PLTR	191(79.3)	50(20.7)	241(100.0)	3.11(2.06 – 4.70) < 0.001
BLTR	119(55.1)	97(44.9)	216(100.0)	
Surgeon audited				4.36(2.73 – 6.95) <0.001
Yes	156(84.8)	28(15.2)	184(100.0)	
No	156(56.1)	122(43.9)	278(100.0)	
Performance at audit				3.70(1.57 – 8.69) 0.002
Passed	131(84.0)	25(16.0)	156(100.0)	
Did not pass	17(58.6)	12(41.4)	29(100.0)	
Country				P <0.001
Ethiopia	75(56.4)	58(43.6)	133(100.0)	
Kenya	11(25.6)	32(74.4)	43(100.0)	
Malawi	16(100.0)	0(0.0)	16(100.0)	
Mozambique	15(100.0)	0(0.0)	15(100.0)	
Nigeria	97(80.8)	23(19.2)	120(100.0)	
Tanzania	45(62.5)	27(37.5)	72(100.0)	
Uganda	40(95.2)	2(4.8)	42(100.0)	
Zambia	11(52.4)	10(47.6)	21(100.0)	

Discussion

The conduct of surgeon audits, evaluation of surgical outcome and supportive supervision are important activities to ensure optimal surgical management of trichiasis (28). Despite encouragement by WHO and International Coalition for Trachoma Control (ICTC) on the need for surgeon audits, audits are not a regular practice by most trachoma elimination programs [(25)].

This research suggests that although audits are recommended for all surgeons, only about one-third of surgeons had an audit done. A study evaluating trichiasis management policies in Africa found that only 2 out of 27 countries had a national policy for conducting audits on trichiasis surgeons [(24)]. A recent study from Chad reported 9 out of 14 (64%) surgeons undergoing audit [(25)] while a study from Ethiopia included audit of two surgeons among a larger, but unreported, number of surgeons operating in the areas [(22)]. The variability in the proportions of surgeons audited in the eight countries cannot be fully explained by existing data, however, it is likely due to whether the Ministry of Health and partners have prioritized surgeon audits and the likelihood that some surgeons had an insufficient number of managed cases to justify an audit. It is also likely that the limited numbers of supervisors in some countries also impacted audit schedules. It should be noted that all eight countries had funding available to undertake the audits.

Among surgeons audited in the eight countries, 15% failed and were recommended for retraining. In a Chad study, none of the surgeons failed, [(25)] which may be because the trichiasis programme in Chad set a cut-off of 25% post-operative trichiasis as the benchmark for audit failure while the eight countries employed a more stringent cut-off of 10%. The Ethiopian study [(22)] only included two surgeons, one reporting 10% post-operative trichiasis and the other without any post-operative trichiasis. These studies only included a total of 11 surgeons compared to the 561 surgeons we report on.

Surgeons who have been practicing longer have a higher likelihood of not passing their audit. This may appear counter-intuitive however, it may indicate that surgeons newly trained on HEADSTART do not have previous practices to unlearn. This finding does suggest the importance of all surgeons, even if practicing for many years, to undergo a surgeon audit. Interestingly, surgeons practicing PLTR were 5.79 times more likely to have a successful audit compared to those practicing BLTR. Our data is insufficient to explain this finding but it does strengthen the WHO recommendation that all new trichiasis surgeons be trained in PLTR rather than BLTR (29).

Although retraining is recommended for surgeons with failed audits (26, 30, 31), our research results indicates that about two-thirds of them did not receive the recommended retraining. The reasons for failure to retrain cannot be determined from our data and further investigation is warranted.

Finally, trichiasis surgeon attrition is a recognised challenge within trachoma programs (32, 33). Our study revealed that about one-third of trained surgeons are no longer practicing. This is similar to previous work in Ethiopia and Tanzania (32, 34) and indicates the need for strategies to retain good-performing trichiasis surgeons in trachoma endemic countries.

The primary strength of this study was the large number of countries and surgeons included in the data set. That said, there was considerable missing data (including data on number of eyelashes touching the globe), limiting our ability to interpret the findings.

To improve surgical outcomes, all active trichiasis surgeons should undergo a surgeon audit. Findings from the audit should be used to decide and undertake, in a timely fashion, retraining of selected surgeons. Further investigation into factors predicting why audits are undertaken or not, why some surgeons pass their audit while others do not, and factors associated with a failed audit, is needed.

References

1. Thomson R.N., Holden M.T., Carder C., Lennard N. Chlamydia trachomatis: Genome sequence analysis of lymphogranuloma venereum isolates. Genome Res. 2008 18(1): 161–71.DOI: 10.1101/gr.7020108.

2. Last A.R., Burr S.E., Weiss H.A., Harding-Esch E.M.
Risk Factors for Active Trachoma and Ocular Chlamydia trachomatis Infection in Treatment-Naïve Trachoma-Hyperendemic Communities of the Bijagós Archipelago, Guinea Bissau. PLoS Negl Trop Dis 2014; 8(6). DOI: 10.1371/journal.pntd.0002900.

3. Burton M.J., Mabey D.C.W. The Global Burden of Trachoma: A Review. PLoS Negl Trop Dis 3(10): e460. 2009. DOI:10.1371/journal.pntd.0000460.

4. Woldekidan E., Daka D., Legesse D. Prevalence of active trachoma and associated factors among children aged 1 to 9 years in rural communities of Lemo district, southern Ethiopia: community based cross sectional study. BMC Infect Dis 2019;19(886). DOI: 10.1186/s12879-019-4495-0.

5. Burton M.J., Bowman R. J. C. , Faal H. , Aryee E. A. N., Ikumapayi U.N., Alexander N.D.E., et al. The Long-Term Natural History of Trachomatous Trichiasis in The Gambia. Invest Ophthalmol Vis Sci. 2006; 47(3). DOI: 10.1167/iovs.05-0714.

6. W.H.O. The WHO Alliance for GET2020: Global partnership for trachoma elimination. 2019.

7. Flueckiger R.M., Courtright P., Abdala M., Abdou M. The global burden of trichiasis in 2016. PLoS Negl Trop Dis 2019;13(11). DOI: 10.1371/journal.pntd.0007835.

8. Emerson P. The SAFE strategy for trachoma control: poised for rapid scale-up. Community Eye Health. 2014;27(86).

9. Tian L., Wang N. Trachoma control: the SAFE strategy. Int J Ophthalmol. 2018;11(12):1887-8. DOI: 10.18240/ijo.2018.12.01.

10. Reacher M, Foster A., Huber J. Trichiasis surgery for trachoma : the bilamellar tarsal rotation procedure. World Health Organisation Geneva. 1993.

11. Woreta T.A., Munoz B.E., Gower E.W. Efffect of trichiasis surgery on visual acuity outcomes in Ethiopia. Arch Ophthalmol. 2009;127(11):1505-10. DOI: 10.1001/archophthalmol.2009.278.

12. Merbs S., Oktavec K., Munoz B., Perlini E., West S., Othman M., et al. Lower Postoperative Scar Height is Associated with Increased Postoperative Trichiasis 1

Year after Bilamellar Tarsal Rotation Surgery. Ophthalmic Epidemiol. 2015;22(3):200-7. DOI: 10.3109/09286586.2015.1036299.

13. Rajak S.N., Habtamu E., Weiss H.A., Kello A.B., Gebre T., Genet A. Surgery versus epilation for the treatment of minor trichiasis in Ethiopia: a randomised controlled noninferiority trial. PLoS Medicine. 2011;8(12). DOI: 10.1371/journal.pmed.1001136.

14. Reacher M., Huber M., Canagaratnam R., Alghassany A. A trial of surgery for trichiasis of the upper lid from trachoma. Br J Ophthalmol 1990;74:109-13. DOI: 10.1136/bjo.74.2.109.

15. Reacher M.H., Muñoz B., Alghassany A., Daar S., Elbualy M., Taylor H.R. A controlled trial of surgery for trachomatous trichiasis of the upper lid. Arch Ophthalmol 1992;110(5):667–74. DOI:10.1001/archopht.1992.01080170089030.

16. Habtamu E., Wondie T., Aweke S., Tadesse Z., Zerihun M., Zewudie Z. Posterior lamellar versus bilamellar tarsal rotation surgery for trachomatous trichiasis in Ethiopia: a randomised controlled trial. The Lancet. 2016; 4(3):175-84 DOI: 10.1016/S2214-109X(15)00299-5.

17. Mwangi G., Courtright P., Solomon A.W. Systematic review of the incidence of post-operative trichiasis in Africa. BMC Ophthalmology. 2020;20(1):451. DOI: 10.1186/s12886-020-01564-0.

18. West S., West E., Alemayehu W. Single-dose azithromycin prevents trichiasis recurrence following surgery: randomized trial in Ethiopia. Arch Ophthalmol 2006;124:309–14. DOI: 10.1001/archopht.124.3.309.

19. Burton M.J. A randomised controlled trial of azithromycin following surgery for trachomatous trichiasis in the Gambia. Br J Ophthalmol. 2005;89(10):1282–8. DOI: 10.1136/bjo.2004.062489.

20. Habtamu E., Wondie T., Sewunet S. Predictors of Trachomatous Trichiasis Surgery Outcome. Ophthalmology 2017;124(8). DOI: 10.1016/j.ophtha.2017.03.016.

21. Négrel A.D., Chami-Khazraji Y., Arrache M.L., Ottmani S., Mahjour J. The quality of trichiasis surgery in the kingdom of Morocco. Sante. 2000;10(2):81-92.

22. Gebreselassie G., Dawit S., Alemayehu S., Temesgen K. Trachomatous Trichiasis (TT) Surgical Quality Outcome Audit in Hadiya Zone and Yem Special District, Southern Ethiopia. EC Gynaecology. 2019;8(1):03-8.

23. W.H.O. Report of the 4th Global Scientific Meeting on Trachoma, Geneva, 27–29 November 2018. World Health Organization, Geneva, Switzerland. 2019.

24. Mwangi G., Courtright P., Solomon A. National approaches to trichiasis surgical follow-up, outcome assessment and surgeon audit in trachoma-endemic countries in Africa. Br J Ophthalmol. 2020.

25. Djore D., Djibrine D., Ali A.B., Tyau-Tyau H., Hiron D. Pilot Audit of Trichiasis Surgery Outcomes Using a Mobile App in the Republic of Chad. Middle East Afr J Ophthalmol. 2020;27(1):14-21. DOI: 10.4103/meajo.MEAJO_75_19.

26. Buchan J.C., Limburg H., Burton M.J. Quality assurance in trichiasis surgery: a methodology. Br J Ophthalmol. 2011;95(3):331-4. DOI: 10.1136/bjo.2003.039180.

27. StataCorp. 2019. Stata Statistical Software: Release 16. College Station TSL.

28. W.H.O. World Health Organization alliance for the global elimination of trachoma by 2020: second global scientific meeting on trachomatous trichiasis: Cape Town, 4–6 November 2015. World Health Organization. Available:http://www.who.int/iris/handle/10665/250571. 2016.

29. Habtamu E., Wondieb T., Tadesse Z., Atinafu B., Gashaw B., Gebeyehu A. Posterior lamellar versus bilamellar tarsal rotation surgery for trachomatous trichiasis: Long-term outcomes from a randomised controlled trial. Lancet. 2019;17. DOI: 10.1016/j.eclinm.2019.10.015.

30. Gower E.W., Kello A.B., Kollmann K.M. Training trichiasis surgeons: Ensuring quality. Community Eye Health. 2014;27(87):58.

31. Courtright P., Burton M., Emerson P. Eliminating trichiasis: the next steps forward. Community eye health. 2012; 25(78).

32. Habtamu E., Rajak S., Gebre T. Clearing the backlog: trichiasis surgeon retention and productivity in Northern Ethiopia. PLoS Negl Trop Dis 2011;5(4). DOI: 10.1371/journal.pntd.0001014.

33. Rowe A.K., Savigny D.D., Lanata C.F. How can we achieve and maintain high-quality performance of health workers in low-resource settings? Lancet. 2005;366:1026 - 35. DOI: 10.1016/S0140-6736(05)67028-6.

34. Lewallen S., Mahande M., Tharaney M., Katala S., Courtright P. Surgery for trachomatous trichiasis: findings from a survey of trichiasis surgeons in Tanzania. Br J Ophthalmol. 2007;91(2):143-5. DOI: 10.1136/bjo.2006.102368.

35. Murthy M.R.K. Impact of Lot Quality Assurance Sampling (LQAS) For Better Monitoring & Evaluation (M&E) In Agriculture and Rural Development Projects. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2018;11(4). DOI: 10.9790/2380-1104011522.

Part C: Appendices

Appendix 1: Human Research Ethics Committee Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

20 October 2020

HREC REF: 229/2020

Prof R Geneau
Division of Ophthalmology
H-53, OMB
Email: - robert.geneau@uct.ac.za
Student: bukolaofoegbu@yahoo.com

Dear Prof Geneau

PROJECT TITLE: EVALUATION OF TRICHIASIS SURGEONS' PERFORMANCE IN SELECTED TRACHOMA ENDEMIC COUNTRIES-MASTERS CANDIDATE-DR. OLUBUKOLA OFOEGBU

Thank you for your response, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020 & 06 July 2020.

Approval is granted for one year until the 30 October 2021.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student: Dr Olubukola Ofoegbu will also be involved in this study.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

HREC/REF:229/2020sa

Appendix 2: Letter of Request for Data Use Sent to Countries.

Request for permission to use data from the National Trachoma program

Most trachoma endemic countries in Africa continue to require interventions in order to reach the goal of a prevalence of trichiasis unknown to the health system of <0.2% in adults age 15 years and above. Training, supervising, and auditing of trichiasis surgeons is a key part of this work. That said, there is little information on the progress to achieve routine auditing and supervision of surgeons. To this end, we are proposing to undertake a study using existing data from the trichiasis programmes supported by the Trust and DFID programmes.

We request permission to use some data on each trichiasis surgeon (variables listed below) from the last 3 years of trichiasis surgery in **. The research will be for my Masters dissertation at the University of Cape Town. My research work will be supervised by Prof Paul Courtright, Dr Robert Geneau, and Mr. Deon Minnies. This research will explore the contribution of surgeon audits to improved trichiasis services. All data to be used without identifiers—thus, no individual surgeon will be identifiable in the data base.

After completion of my dissertation, I would be keen to draft up the work for publication. If there is interest in a publication, we would be keen to have you or someone whom you appoint to be a co-author on this work.

I request for authorisation to use the data for this analysis. Sight-savers has informed that this data has already been compiled as part of Trust and DFID supported work. I look forward to hearing from you. Thank you.

Best regards

Dr. Olubukola Ofoegbu.

Cc: Moses Chege
Paul Courtright
Robert Geneau
Deon Minnies

Data for analysis

- Surgeon # (name not included)
- Whether surgeon audit was done or not
- Whether surgeon passed or failed the surgeon audit,
- Surgeon's cadre (i.e. nurse, doctor, ophthalmologist etc.),
- Surgeon's trainer's cadre,
- Surgeon's country,
- Surgical technique(s),
- Any complications experienced,
- Whether retraining was recommended,
- Reason for recommendation of retraining,
- Cadre of trainer.

Appendix 3 : Table illustrating LQAS methodology. Courtesy (Murthy, M. R. K., 2018)[35]

Actions for good results	**Actions for Under-performance**
Maintain the program at current level	Identify the reasons for program problem
Identify “best practices” that can help other programs improve their performance	Develop targeted solution

Appendix 4. Surgical audit data capture tool used in this study.

SURGEON NAME:							**AUDIT DATE:**			
NAME	AGE	SEX	HOSP.	DATE	NO. OF trichiasis LASHES PRE-OP		POST-OP EPILATION DONE? Y/N		NO OF LASHES TOUCHING GLOBE	
					RE	**LE**	**RE**	**LE**	**RE**	**LE**

Appendix 5: LQAS "stopping rules" for a range of acceptable POT rates

	Classification		**Errors**		**Stopping rules**	
Maximum acceptable post-operative trichiasis	Low rate of post-operative trichiasis (%)	High rate of post-operative trichiasis (%)	False positive rate (%)	False negative rate (%)	N	D
10	5	15	8	10	60	5
10	5	20	5	8	40	4
15	10	20	10	10	80	11
15	5	25	8	9	20	2
20	10	30	7	8	30	5
30	20	40	9	7	40	11

N = Maximum number of eyes to be examined
D = Maximum allowable number of post-operative trichiasis above which a surgeon is classified as high post-operative trichiasis (when this number is reached, the audit of the surgeon stops : no need to assess additional eyes as this surgeon is classified as "high post-operative trichiasis"

Using the recommended high post-operative trichiasis and low post-operative trichiasis, 30 eyes (maximum) would be assessed per surgeon. The audit of a particular surgeon would stop if 5 eyes were found with post-operative trichiasis

Appendix 6 : Ophthalmic Epidemiology Journal Instruction for Authors

Structure

Your paper should be compiled in the following order: title page; abstract; keywords; main text introduction, materials and methods, results, discussion; acknowledgments; declaration of interest statement; references; appendices (as appropriate); table(s) with caption(s) (on individual pages); figures; figure captions (as a list).

Word Limits

Please include a word count for your paper. Word counts vary depending on the paper type.
Editorial – Not more than 800 words (including author details and title)
Review Article – Not more than 4000 words with <=6 Tables/Figures (excluding title, author details, and references)
Original Article – Not more than 3000 words with <=6 Tables/Figures (excluding title, author details, and references)
Brief correspondence – Not more than 1000 with <=2 Tables/Figures (excluding title, author details, and references)

Style Guidelines

Please refer to these quick style guidelines when preparing your paper, rather than any published articles or a sample copy.

Please use British (-ize) spelling style consistently throughout your manuscript.

Any form of consistent quotation style is acceptable. Please note that long quotations should be indented without quotation marks.

All submissions should be double spaced, with consecutively numbered pages. All abbreviations/acronyms must be defined at first use in the abstract, again at first use in the text and in each and every table or figure, regardless of seeming redundancy. The following are the files need to make your online submission complete:

I. MANUSCRIPT FILE 1. Cover page – a) list the title of your submission – no abbreviations or acronyms (acronyms may be considered if important for recognition of a prominent study, and in that case they should be used only after defining the acronym in the title) b) supply a running head - a shortened version of title, not to exceed 50 characters. If the full title is 50 characters or less, they can be the same. c) All authors of a manuscript should include their full name and affiliation on the cover page of the manuscript. d) indicate who is the corresponding author and the corresponding contact information (especially email), e) financial support – list all financial support f) list any proprietary interests or conflicts of interest for any and all authors related to this submission. “If none, please state: None of the following authors have any proprietary interests or conflicts of interest related to this submission:”; then list all the authors with no such interests. “None of the authors” suffices if no one has any such interests. Please err on the side of disclosure if it is unclear whether something is an interest or not, and please include relationships that may be perceived by others as a conflict of interest. g) statement that this submission has not been published anywhere previously and that it is not simultaneously being considered for any other publication. Note: if the paper previously has been reviewed and rejected by another journal, please indicate so, and please indicate what criticisms were given and what changes have been made in response (as if you were revising and resubmitting to the original journal). We are open to accepting such papers if they have merit, and there is no need to hide this information.

2. Abstract – start on new page – not to exceed 250 words, define all abbreviations or acronyms used at first use, formatted into the following four sections: a) Purpose b) Methods c) Results d) Conclusion

3. Manuscript text – start on a new page. The text should not exceed 4,000 words. Define all abbreviations and acronyms at first use (even if previously defined in abstract). The text should be divided into the following 5 sections: a) Introduction—give the rationale for why this manuscript is important b) Materials and Methods – should include a statement regarding adherence to the guidelines of the Declaration of Helsinki as well as giving the name of the Institutional Review Board which granted approval or which indicated approval was not needed. Any waivers granted, such as HIPAA waivers or waiver of consent, should be mentioned. Whether patients consented to participate in the study should be mentioned; if not, the reason why not should be mentioned (e.g., Institutional Review Board waiver of consent) c) Results—summarize the key and supportive results in a clear, crisp, straightforward manner. d) Discussion—discuss what the key findings are, how it fits in with existing knowledge on the subject, and if there alternative explanations of the observations such as bias or random error. Please include a strengths and limitations paragraph, as well as a concluding paragraph summarizing the main items of knowledge that the paper has provided and relevant applications. e) References – Please follow the directions in Section 4 below.

4. References - cite in the text as superscript by reference number, consecutively as they appear in the text, starting with 1. Prepare a numbered reference list. Only published and accepted (in press) articles can be cited. Abstracts should be cited parenthetically within the text as should any personal communication or unpublished data. Submitted articles are not citable, and should be referenced as unpublished data.