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Research Article

Prevalence and Characteristics of Eye Problems Reported in an East African Refugee Camp: A Cross-Sectional Survey

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Abstract

Despite efforts to improve global access to basic ophthalmologic services, there remains a paucity of data regarding the prevalence of untreated ocular disease among forced migrants and refugees, particularly in east Africa. We aimed to estimate the prevalence of untreated and surgically amenable eye conditions among refugees in Nyarugusu Refugee Camp, Tanzania, and to identify factors associated with untreated eye problems. We conducted cluster-randomized sampling using the cross-sectional Surgeons OverSeas Assessment of Surgical Needs (SOSAS) survey tool to assess prevalence of surgical eye disease and access to health services among refugees in Nyarugusu from August-September 2021. Descriptive analysis and multivariable logistic regression were performed to explore associations between covariates and the presence of unresolved eye problem(s). Among 3574 refugees, 12% (n=430; mean age 36 ±20 yrs.) reported eye issues. Of these, 296 (69%) further characterized their problems, with 44% reporting acquired disability and 42% non-injury-related wounds. Of the 368 (86.4%) who described their issues as disabling, 78.8% endorsed a negative impact on ability to work and 27.7% required help with daily living. Most were currently (84.6%; 357/427) and chronically affected (>12 months; 88.3%; 378/428). Farming and housewife occupations were positively associated with unresolved eye problem(s). Among 312 (72.7%) who sought care, only 13 (4.2%) underwent surgery. Nearly half (136) of 279 surveyed individuals self-reported potential surgical needs, citing barriers to surgical care such as lack of available services, financial and time constraints, and limited knowledge about accessing treatment. In conclusion, nearly 1 in 8 refugees endorsed chronic and disabling eye problems, negatively impacting their work and daily life. Most who may benefit from surgery have not received care due to significant barriers and gaps in ophthalmologic services. Further investigation to better characterize specific ocular etiologies in under-resourced protracted refugee settings can inform resource allocation strategies to address unmet eye care needs.

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1. Introduction

In 2020, global estimates revealed that around 596 million people experienced distance vision impairment (VI), including 43.3 million who were blind. Additionally, 510 million individuals had uncorrected presbyopia, a type of near VI that can be corrected with reading glasses [1, 2]. VI has widespread implications for health and quality of life and has been linked to worsened status in many aspects of life, including mental health, cognition, social function, employment, and educational attainment. Furthermore, VI results in significant economic burden, with the annual global cost of productivity estimated to be US$411 billion [3, 4]. Many of these consequences can be reduced by timely access to quality eye care. While there are many causes of vision loss, over 90% of global VI is preventable or treatable through highly effective self-limited interventions such as eyeglasses, surgery, mass antibiotics, Vitamin A distribution, and improved sanitation. However, limited access to high-quality affordable eye care in low- and middle-income countries (LMICs) leads to high prevalence of VI in these regions, with an estimated 90% of those affected by VI living in LMICs [1].

In Tanzania, the International Agency for the Prevention of Blindness reported that approximately 290,000 individuals were affected by vision loss in 2020, highlighting the significant burden of eye disease in this region [5]. Importantly, the global burden of untreated VI tends to fall disproportionately on marginalized communities, including women, ethnic minorities, rural populations, and refugees, with the latter consistently facing a greater burden of untreated eye disease across all age groups and settings of displacement [1, 6-11]. The number of refugees and displaced persons worldwide continues to grow rapidly, with current estimates of 36.5 million refugees among 110 million forcibly displaced people and 75% of refugees residing in LMICs [12]. There is a paucity of research on eye health and eye care resources among current refugee populations, with prior studies in Africa focusing largely on nutritional or infectious etiologies of VI such as trachoma and onchocerciasis [1, 13]. Notably absent from this body of literature is a household-based study of eye disease burden within a protracted refugee setting.

Established in 1996 to shelter Congolese refugees, Nyarugusu Refugee Camp in Kigoma, Tanzania is one of Africa's largest and oldest refugee camps. It remains operational today and is considered a protracted refugee setting [14]. Many Congolese refugees have resided in the camp since its inception; in 2015, the camp underwent significant expansion to accommodate an influx of Burundian refugees fleeing political instability and civil unrest. Recent population estimates from 2024 indicate approximately 135,000 individuals, equating to around 36,000 households, presently reside within the camp. These figures suggest that refugees living in Nyarugusu constitute nearly 60% of Tanzania's total refugee population [15]. Our group previously outlined the prevalence of potentially surgically treatable conditions among refugees in Nyarugusu Refugee Camp using the validated Surgeons Overseas Assessment of Surgical Needs (SOSAS) tool and found that over 46% of refugees reported at least one existing or prior condition that may be amenable to surgery, including eye-related problems [16]. Stemming from this parent study, we aimed to elucidate the prevalence of preventable but untreated eye problems among refugees in Nyarugusu Camp and to explore associated factors that may be contributory.

2. Materials and Methods

The methods for administration of our cluster-randomized, cross-sectional survey have been described in detail previously [16]. The SOSAS tool is an established survey instrument that has been utilized to measure the burden of surgical disease in multiple LMIC settings, including a refugee camp in Syria [17, 18]. Between August 4, 2021 and September 10, 2021, the SOSAS survey was administered at households in 126 randomly selected housing clusters in Nyarugusu Refugee Camp. All survey participants were refugees; no local Tanzanians were included in this study. Within each household, two individuals were randomly selected to undergo a head-to-toe verbal examination to elicit active or resolved problems across multiple anatomical regions that could potentially require surgical care. In this manuscript, we specifically outline the burden of reported eye problems, which are defined as issues affecting one or both eyes.

Our descriptive analysis included demographic factors, baseline health characteristics, characteristics specific to the eye conditions, and reported reasons for not having surgery among all patients who endorsed an eye problem. We presented categorical variables as a total number with a corresponding percentage and continuous variables as a mean with a standard deviation or a median with an interquartile range. Participants with missing data for one or more variables were still included in the analysis, resulting in variations in the denominator across different results.

To explore predictors of presence of an active eye problem,

we used a multivariable logistic regression model. Reference groups included age under 18, male sex, Burundian nationality, secondary school education, no employment, married marital status, Christian religion, illiteracy, poor health status, no primary health center utilization, no illness within the past year, and time course of over twelve months or more. The reference group for time course was selected based on highest total number. We presented findings from the multivariable analysis as odds ratios with 95% confidence intervals. All patients with missing input(s) for any variable were excluded from the model. All analyses were performed using Stata 16 (Stata 16, College Station, TX).

The Tanzanian Commission on Science and Technology (2020-391-NA-2011-143) and the Johns Hopkins Medicine Institutional Review Board (IRB00258009) both granted approval for this study. The Tanzanian Ministry of Home Affairs provided permission to enter Nyarugusu refugee camp. Informed consent was verbally obtained from all adult participants. Parent/guardian consent or assent was obtained for subjects under the age of 18.

3. Results

3.1. Proportion and Demographic Characteristics of Individuals Reporting Eye Problems

Among all interviewed refugees, 12% (430 of 3574) of refugees endorsed a history of eye issues, with 83% of those individuals (357 of 427) reporting active eye problems at the time of the survey. Of those who endorsed eye problems, 31.4% (135 of 430) were Congolese refugees and 68.4% (294 of 430) were Burundian refugees.

The mean age (SD) among those who endorsed eye problems was 36 (±20) years. Individuals aged 18 to 29 years were the most common age group in our study population (26%; 111 of 430), followed by individuals aged 30 to 44 years (22%; 93 of 430). More females (69%; 298 of 430) than males reported eye problems. Most individuals who reported an eye problem were unemployed (56%; 242 of 429), and the most common occupation thereafter was farmer (19%; 80 of 429). Most individuals were literate (70%; 303 of 430). See Table 1.

3.2. Baseline Health Status and Health Care Seeking Behavior of Individuals Reporting Eye Problems

Most respondents who reported eye problems had previously sought medical care at a primary health center in Nyarugusu (96%; 414 of 430), and 51% (219 of 427) considered themselves to be generally healthy. Most endorsed experiencing illness (of any kind) in the 12 months leading up to survey administration (84%; 359 of 429). The median (IQR) duration of self-reported sickness was 4 (2 to 7) weeks. The median number (IQR) of visits to a health center within the last year was 3 (2 to 6) visits. Among those who reported illness (of any kind) in the 12 months leading up to survey administration, over half (55%; 197 of 358) reported recovery while the remainder (45%; 161 of 358) endorsed ongoing symptoms at the time of survey. See Table 1.

Table 1. *Demographics and baseline characteristics of individuals reporting eye problems vs. parent study population. Data presented as mean (SD), median (IQR), or% (n). Sum of values in each category may not add up to the total number of patients interviewed due to missing data.*

Parameter	Parent Study Population	Individuals Reporting Eye Problems		
N	**3574**	**Total: 430**	**DRC: 135**	**Burundi: 294**
Average age ±SD	23 (18)	36 (20)	41 (21)	33 (19)
Age Categories				
Under 18 Years	44 (1563 of 3544)	19 (83 of 426)	17 (22 of 133)	21 (61 of 292)
Age 18 to 29	26 (920 of 3544)	26 (111 of 426)	16 (21 of 133)	30 (89 of 292)
Age 30 to 44	17 (593 of 3544)	22 (93 of 426)	17 (23 of 133)	24 (70 of 292)
Age 45 to 59	8 (277 of 3544)	16 (70 of 426)	26 (34 of 133)	12 (36 of 292)
Age 60 or Older	5 (191 of 3544)	16 (69 of 426)	25 (33 of 133)	12 (36 of 292)
Sex				
Male	43 (1547 of 3573)	31 (132 of 430)	39 (52 of 135)	27 (79 of 294)
Female	57 (2026 of 3573)	69 (298 of 430)	61 (83 of 135)	73 (215 of 294)
Country of origin				

Parameter	Parent Study Population	Individuals Reporting Eye Problems		
N	**3574**	**Total: 430**	**DRC: 135**	**Burundi: 294**
DRC	52 (1863 of 3568)	31 (135 of 430)	100 (135 of 135)	--
Burundi	48 (1697 of 3568)	68 (294 of 430)	--	100 (294 of 294)
Other	0.2 (8 of 3568)	0 (1 of 430)	--	--
Education				
None	34 (1224 of 3571)	27 (118 of 430)	28 (38 of 135)	27 (80 of 294)
Primary school	36 (1285 of 3571)	42 (179 of 430)	33 (44 of 135)	46 (135 of 294)
Secondary school	28 (1006 of 3571)	30 (127 of 430)	36 (48 of 135)	27 (78 of 294)
Higher education	2 (56 of 3571)	1 (6 of 430)	4 (4 of 135)	<1 (1 of 294)
Occupation				
Unemployed	63 (2256 of 3570)	56 (242 of 429)	57 (77 of 135)	56 (164 of 293)
Farmer	13 (468 of 3570)	19 (80 of 429)	17 (23 of 135)	19 (57 of 293)
Small business	5 (167 of 3570)	6 (25 of 429)	3 (4 of 135)	7 (21 of 293)
Domestic helper	0.3 (11 of 3570)	0 (1 of 429)	<1 (1 of 135)	--
Self-employed	4 (153 of 3570)	4 (17 of 429)	3 (4 of 135)	4 (13 of 293)
Housewife	5 (167 of 3570)	7 (30 of 429)	12 (16 of 135)	5 (14 of 293)
Other	10 (348 of 3570)	8 (34 of 429)	7 (10 of 135)	8 (24 of 293)
Marital status				
Married	35 (1244 of 3561)	50 (216 of 430)	45 (61 of 135)	52 (154 of 294)
Single	47 (1681 of 3561)	27 (117 of 430)	31 (42 of 135)	26 (75 of 294)
Divorced	5 (167 of 3561)	5 (22 of 430)	6 (8 of 135)	5 (14 of 294)
Other	13 (469 of 3561)	17 (75 of 430)	18 (24 of 135)	17 (51 of 294)
Religion				
Christian	93 (3326 of 3565)	97 (416 of 430)	94 (127 of 135)	98 (288 of 294)
Muslim	5 (173 of 3565)	2 (8 of 430)	4 (5 of 135)	1 (3 of 294)
Other	2 (66 of 3565)	1 (6 of 430)	2 (3 of 135)	1 (3 of 294)
Health indicators**				
Literate	59 (2108 of 3571)	70 (303 of 430)	64 (86 of 135)	73 (216 of 294)
Generally healthy	79 (2802 of 3536)	51 (219 of 427)	56 (74 of 132)	49 (144 of 294)
Have ever been to a camp clinic or hospital	92 (3297 of 3570)	96 (414 of 430)	97 (131 of 135)	96 (282 of 294)
Ill within past year	60 (2145 of 3562)	84 (359 of 429)	78 (105 of 135)	86 (253 of 293)
Time ill in weeks*	2 (IQR 1-4)	4 (IQR 2-7)	3.5 (IQR 2-8)	4 (IQR 2-6)
Number of visits to health center*	2 (IQR 1-4)	3 (IQR 2-6)	2.5 (IQR 2-4.5)	2 (IQR 2-6)
Recovered from illness*	76 (1618 of 2142)	55 (197 of 358)	47 (49 of 105)	59 (148 of 252)

Abbreviations: *DRC* Democratic Republic of the Congo; *SD* Standard deviation; *IQR* Interquartile range.
*Among those who reported illness in the past year.
**Reported as% "yes" responses or median (IQR).

3.3. Characteristics of Eye Problems in Nyarugusu Refugee Camp

Among the 430 participants who reported a prior or active eye problem, 84% (357 of 427) indicated that the issue was ongoing at the time of the survey. Most reported that their eye problems began more than one year before the survey (88%; 378 of 428).

Of the 430 refugees reporting eye problems, 296 individuals were able to subcategorize their eye pathology. The survey tool allowed participants to distinguish among the following six categories: injury-related wounds, non-injury-related wounds, congenital deformities, acquired deformities, and burns, masses, or growths. The most commonly endorsed subcategory was acquired deformity (44%; 129 of 296) followed by non-injury-related wounds (42%; 125 of 296). See Figure 1 for a graphical representation of reported eye pathology types.

Eighty-six percent (368 of 426) of individuals who endorsed eye problems characterized their problem as disabling. Among these individuals, 79% (290 of 368) reported that their eye problem negatively impacted their ability to work; 28% (102 of 368) reported requiring help with activities of daily living (ADLs); 15% (55 of 426) reported requiring help with transportation, and 10% (38 of 426) endorsed feeling shame because of their eye problems.

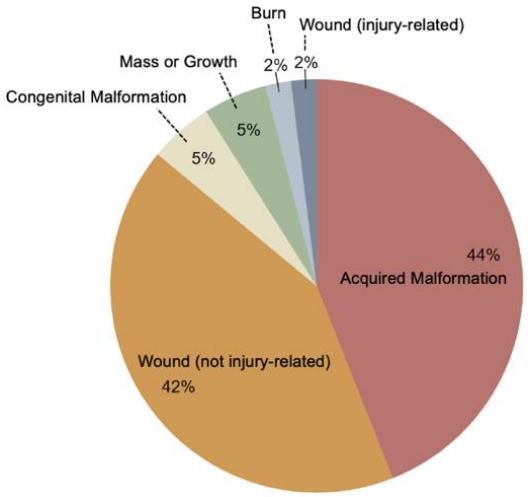

Figure 1. *Proportions of eye problems by reported type of problem. Of the 430 individuals who reported eye issues, 296 provided responses to the survey question regarding pathology categorization. The most common issues were acquired malformations and non-injury-related wounds, followed by congenital malformations, masses or growths, burns, and injury-related wounds.*

3.4. Care Sought for Eye Problems

Most individuals with reported eye problems sought care (73%; 312 of 429). Among those who sought treatment, the majority received some form of medication (78%; 242 of 312). However, 20% (62 of 312) of those who sought healthcare received no treatment, and only 5% (13 of 312) underwent surgical treatment. Among the patients who received surgery, 62% (8 of 13) underwent major procedures, while 38% (5 of 13) had minor procedures. Given the limited eye care infrastructure within the camp itself, we assume that these procedures were performed outside the camp as referral cases. Additionally, 6% (26 of 427) of surveyed individuals visited traditional healers for their eye problems, and 4% (12 of 312) reported receiving herbal medicine. Notably, 2% (7 of 427) exclusively sought care from traditional healers.

3.5. Reasons for Not Receiving Surgery

As part of the SOSAS survey, participants were asked about the primary reason(s) they did not receive surgery to address their eye problem, resulting in 279 total responses. Among these, five individuals reported having already undergone surgery; therefore, their responses were excluded from further descriptive analysis. Notably, of the five who had received surgery, three reported experiencing ongoing eye issues at the time of survey. Among the remaining respondents, half (50%; 136 of 274) identified what they considered to be the most significant barrier(s) to receiving surgical care, while the other half (50%; 138 of 274) reported no perceived need for surgical intervention.

Among those who reported barriers to surgical care, the most commonly cited issue was a lack of services (including facilities, staff, and medical equipment), identified by 62% (84 of 136) of respondents. Following this, 23% (31 of 136) cited financial constraints related to treatment, and 8% (11 of 136) indicated a lack of knowledge about how to access treatment. Other reported challenges included lack of time to receive treatment (4%; 5 of 136), fear and/or mistrust (2%; 3 of 136), and lack of money for travel (1%; 2 of 136). See Table 2.

Table 2. *Characteristics of eye disease in Nyarugusu refugee camp. Data presented as% (n). Individual surveys with missing data for certain variables were excluded for those variables, resulting in denominator variation.*

Parameter	Total (N=430)
Time Course (i.e., duration of symptoms)	
0-1 months	6 (25 of 428)
1-12 months	6 (25 of 428)
>12 months (Chronic)	88 (378 of 428)
Details of Eye Problem	
Wound (Injury or Trauma-Related)	2 (7 of 296)
Wound (Not Injury or Trauma-Related)	42 (125 of 296)
Burn	2 (5 of 296)

Parameter	Total (N=430)
Mass or Growth	5 (14 of 296)
Congenital Malformation	5 (16 of 296)
Acquired Disability	44 (129 of 296)
Is the problem currently affecting you?	
No	16 (70 of 427)
Yes	84 (357 of 427)
Is the problem debilitating? If so, in what way(s)?	
No	14 (58 of 426)
Yes	86 (368 of 426)
I feel ashamed	10 (38 of 368)
I am not able to work like I used to	79 (290 of 368)
I need help with transportation	15 (55 of 368)
I need help with daily living	28 (102 of 368)
Did you seek healthcare for this problem? If so, what treatment(s) did you receive?	
No	27 (117 of 429)
Yes	73 (312 of 429)
No Treatment Received	20 (62 of 312)
Major Procedure	3 (8 of 312)
Minor Procedure	2 (5 of 312)
Medication	78 (242 of 312)
Herbal Medicine	4 (12 of 312)
Did you see a traditional healer?	
No	94 (401 of 427)
Yes	6 (26 of 427)
Traditional healer only	2 (7 of 427)
What is the primary reason you have not received eye surgery for your problem?*	
No perceived need	50 (138 of 274)
No services (facilities, staff, medical equipment)	31 (84 of 274)
No money for treatment	11 (31 of 274)
Did not know about access to treatment	4 (11 of 274)
No time to receive treatment	2 (5 of 274)
Fear/mistrust	1 (3 of 274)
No money for travel	<1 (2 of 274)

*Of the 279 total responses for this survey question, 5 individuals reported that they had already received surgery for their eye problem. These 5 individuals were excluded from further analysis.

3.6. Multivariable Analysis

The results of our multivariable logistic regression model are displayed in Table 3. With respect to occupation, housewives (mother of the home) and farmers were 5.26 times (95% CI 1.08-25.53) and 2.88 times (95% CI 1.17-7.09) more likely to report unresolved eye problem(s) compared to the reference group of unemployed participants, respectively. No significant odds differences as defined by the conventional threshold of $p<0.05$ were noted on the basis of age, sex, country of origin, education, marital status, religion, literacy, use of primary health care services, health status, or time course of eye problem. See Table 3.

Table 3. *Multivariable analysis of factors associated with having a current unresolved (active) eye problem among refugees.*

Covariates	OR	95% CI	P-value
Age Category			
Under 18	REF	-	-
18 to 29	0.39	0.13 - 1.16	0.089
30 to 44	0.50	0.15 - 1.73	0.275
45 to 59	0.94	0.24 - 3.66	0.932
60 or Older	1.94	0.44 - 8.58	0.380
Sex			
Male	REF	-	-
Female	0.88	0.45 - 1.74	0.716
Country of origin			
Burundi	REF	-	-
DRC	0.69	0.33 - 1.43	0.317
Education			
None	0.22	0.04 - 1.30	0.094
Primary school	0.72	0.34 - 1.51	0.378
Secondary school	REF	-	-
Higher education (college diploma)	0.38	0.03 - 5.28	0.468
Occupation			
Unemployed	REF	-	-
Farmer	2.88*	1.17 - 7.09	0.022
Small Business Owner	1.78	0.54 - 5.91	0.347
Self-Employed	0.45	0.13 - 1.50	0.192
Domestic Helper [a]	-	-	-
Housewife (mother of the home)	5.26*	1.08 - 25.53	0.039
Other	2.08	0.65 - 6.68	0.219

Covariates	OR	95% CI	P-value
Marital status			
Married	REF	-	-
Single	1.23	0.47 - 3.26	0.671
Divorced	5.97	0.68 - 52.20	0.106
Other	0.93	0.38 - 2.28	0.872
Religion			
Christian	REF	-	-
Muslim	0.61	0.06 - 6.07	0.675
Other [b]	-	-	-
Literate			
No	REF	-	-
Yes	0.22	0.04 - 1.17	0.077
Generally Healthy?			
No	REF	-	-
Yes	1.51	0.80 - 2.84	0.206
Use PHC?			
No	REF	-	-
Yes	0.11	0.01 - 1.04	0.054
Illness Past Year			
No	REF	-	-
Yes	1.91	0.84 - 4.33	0.121
Timing of Eye Problem			
Last Month	0.89	0.25 - 3.20	0.857
Between 1-12 Months Back	0.41	0.13 - 1.24	0.113
Over 12 Months Back	REF	-	-

Note: Multivariable model includes 409 observations, as all patients with missing input(s) for any variable were excluded from the model. Null value = 1 for OR confidence intervals.

Abbreviations: *PHC* Primary health care; *REF* Reference group; *DRC* Democratic Republic of the Congo; *OR* Odds ratio; *CI* Confidence interval.

*Statistically significant OR, defined as having a p-value <0.05.

[a]Only one individual reported occupation of domestic helper.

[b]Only 6 individuals reported "Other" as their religion.

4. Discussion

4.1. Burden of Eye Conditions Among Refugee Populations

To our knowledge, this study represents the first community-based study on eye conditions in a protracted refugee setting in Tanzania and sub-Saharan Africa. Nearly one-eighth (12%) of Nyarugusu refugees endorsed a current or prior history of eye conditions. While the prevalence of self-reported eye conditions among the local Tanzanian population remains largely unexplored in recent studies, a 1990 population-based survey in three central Tanzanian villages provides a comparative context, with a reported bilateral VI prevalence of 1.04% and 1.75% in one eye [19]. Additionally, a 2020 study in the Singida region of Tanzania found a prevalence of blindness and severe VI of 7.1% among individuals aged 50 and older, determined through rapid ocular examinations [20]. Although we did not have a trained eye care provider available to corroborate the VI prevalence in our study population, it is reasonable to infer that the burden of untreated eye disease may be equal to or even exceed that of the local Tanzanian population in protracted refugee contexts like Nyarugusu Camp.

This inference is supported by studies in refugee settlement camps in Uganda and Bangladesh, which reveal an increased prevalence of eye diseases among refugees compared to local populations. Common pathologies in these settings include refractive error, cataracts, xerophthalmia, trachoma, and glaucoma [6, 8]. Furthermore, even in non-resource-constrained settings, refugees and migrants exhibit significantly higher rates of VI and ocular morbidities. For instance, research on Syrian refugees in Canada and Turkey shows a higher prevalence of preventable or treatable causes of VI among refugees, despite access to free public health services [21-23].

While health care delivery plays a critical role in perpetuating ocular health inequities among refugee populations, evidence also suggests that poor visual outcomes are linked to the experience of displacement itself. Factors such as disproportionate risk exposure, trauma, social unrest, poor sanitation, and the location of displacement contribute to these outcomes [13]. Given the protracted nature of Nyarugusu Camp, it is also plausible that the burden of eye disease among refugees is comparable to that of the local Tanzanian population.

However, the complexity of accessing eye care in these settings must be acknowledged when comparing estimates, as it highlights the challenges in fully understanding the eye disease burden. Despite international support, access to eye care for refugees remains challenging, as treatment often relies on referrals to external hospitals. This dependence on external referrals complicates timely diagnosis and treatment, with budgetary constraints and other external factors frequently hindering care.

4.2. Demographic and Occupational Risk Factors for Eye Conditions

Among refugees living in Nyarugusu, we observed that individuals reporting eye problems were more likely to be older (mean age 36 yrs.), female (69%), and to have lower baseline health status (51% reported being generally healthy)

compared to the parent study population (mean age 23 yrs.; 57% female; 79% reported being generally healthy). Age is a recognized risk factor for numerous eye pathologies, and research indicates that women bear a disproportionate burden of global blindness, constituting approximately 64% of total cases with an age-adjusted prevalence 39% higher than in men [24, 25]. Additionally, studies in sub-Saharan Africa highlight an excess risk of cataract and trachoma among women [26, 27]. Although our study did not delve into the etiologies of reported eye problems in Nyarugusu Camp, the demographic variations observed align with established findings in existing literature.

Building on these findings, our multivariable model identified statistically significant associations between the occupations of farmer and housewife and the presence of active eye problem(s), defined as unresolved eye problem(s) at the time of survey administration. Although we cannot conclusively infer causality, it is plausible that farmers' increased exposure to environmental hazards and UV radiation, along with housewives' increased exposure to indoor cooking environments and child caretaking responsibilities, may contribute to heightened disparities in eye health in the LMIC context [28, 29]. For housewives, several well-documented risk factors have been linked to the high prevalence of trachoma, the leading infectious cause of blindness worldwide. These include frequent exposure to indoor smoke, sharing living spaces with animals, and close contact with young children, who often act as reservoirs for the infectious form of the disease [28, 30-32]. A study by Alene et al. in rural Ethiopia reported that the prevalence of active trachoma was significantly higher among women for children under 7 years old (67.6%) compared to non-caretakers (41.1%), underscoring the heightened risk for caretakers [28].

Other covariates in the model, including literacy (OR 0.22, CI 0.04-1.17, p=0.077) and the use of primary health care services within the camp (OR 0.11, CI 0.01-1.04, p=0.054), showed trends toward statistical significance, suggesting a possible negative association with the presence of a current unresolved eye problem, though these did not reach conventional levels of significance. The wide confidence intervals for both significant and non-significant covariates suggest that our study may be underpowered, and increased statistical power may reveal further associations.

Finally, the association between VI, eye disease, and reduced quality of life is well-established [33-36]. In our study, 86% of respondents reported debilitating eye issues that impacted their ability to work, required assistance with transportation and daily activities, and resulted in feelings of shame. Encouragingly, research supports that ophthalmic interventions can significantly improve quality of life in individuals with VI compared to baseline measurements or no intervention [36]. The profound influence of VI on quality of life, coupled with associated economic productivity losses, underscores the compelling need for increased investments in eye health, particularly for vulnerable populations such as refugees.

4.3. Types of Eye Pathologies Found in a Protracted/Chronic Refugee Setting

Among individuals who were able to subcategorize their eye problem(s), 86% reported acquired disabilities or non-injury-related wounds, with only 2% citing injury-related wounds. The majority (88%) of eye problems were chronic, with symptoms persisting for over a year.

In our previous investigation of referrals from Nyarugusu Refugee Camp to Kabanga Hospital (January 2016-May 2017), ophthalmology was the most common specialty referred to, comprising 48.6% of referrals. The primary reasons for referral were vision problems (43.3% of cases), which included refractive errors, hyperopia, metropia, and low vision, followed by cataracts at 21.2% [37]. Although this study predates our current investigation by several years, we anticipate similar referral patterns and prevalent eye pathologies in Nyarugusu Camp. Supporting this, a study in Thailand's Mae La Refugee Camp, another protracted refugee setting, found that while acute ophthalmic surgical needs were present, the primary burden of surgically treatable eye disease was chronic, with few acute surgical referrals but numerous cataract surgeries performed by visiting ophthalmologists along the Thai-Burma (Myanmar) border [38]. Collectively, these findings highlight the predominance of non-traumatic and elective eye care needs in chronic refugee settings, emphasizing the substantial demand for ongoing management of chronic eye conditions among marginalized refugee populations.

4.4. Building Eye Care Services for Refugees

In our study, 62% of patients identified lack of available services (including facilities, staff, and medical equipment) as the primary barrier to receiving surgical treatment for their eye condition(s). This finding highlights an urgent need to strengthen the infrastructure and capacity to treat ophthalmological conditions in Nyarugusu Refugee Camp. Importantly, our findings regarding the prevalence of eye diseases in Nyarugusu Refugee Camp are consistent with research conducted among vulnerable refugee populations globally, including Rohingya in Bangladesh, Sudanese in Uganda, and Afghanis in Pakistan [8, 9, 37, 39]. As in Nyarugusu, the etiologies of blindness in these other refugee camp settings are largely reversible or avoidable altogether and include refractive errors, cataracts, vitamin A deficiency, amblyopia, and corneal scarring [7, 10, 40]. Refugees often encounter referral delays and resettlement postponement as they move within their host nations. For eye conditions specifically, delays in care can lead to poor outcomes, exacerbated complications, and irreversible blindness. Here, we advocate for increasing access to essential ophthalmological subspecialty care for individuals living in refugee camps.

While camp-level solutions are possible, such solutions can lead to isolation of refugees from local economies and lack of

health equity between refugee and host populations. Refugee settings like Nyarugusu often face severe staffing challenges, making it unlikely to recruit and retain full-time ophthalmology staff within the camp itself. Alternatively, district-level solutions offer a more sustainable approach by integrating refugees into local communities and improving access to care. These solutions include establishing streamlined referral pathways to ensure timely access to ophthalmological care within nearby cities, collecting data on eye disease and treatment within refugee camps to monitor the effectiveness of interventions, and launching educational campaigns to bring awareness to the most common eye diseases and preventative measures that can be taken. We also recognize that many host communities in refugee camp settings are comparably impoverished to refugees themselves and we advocate for ensuring that they too benefit from strengthened district-level ophthalmological care.

The United Nations' "Vision for Everyone" resolution found that the burden of eye disease disproportionately impacts refugees and displaced persons, with one reason being that refugee camp settings often lead to delayed diagnoses and increased risk of VI [41]. Thus, improving referral systems would be a key way to address this lack of available services, which was identified as a barrier for refugees in our study. After such solutions are implemented, systematic data collection and monitoring can help to identify remaining needs and to adjust public health strategies accordingly. Finally, community health workers and educational campaigns can foster a proactive approach to preventing eye disease within refugee populations. A trachoma campaign in a Somali refugee camp significantly reduced cases of active trachoma, highlighting the effectiveness of such initiatives [42].

There are only 2.5 ophthalmologists per million people in sub-Saharan Africa [43]. However, there are significant training pipeline issues: one model predicted that over half of Tanzanian medical graduates enrolled between 2011 and 2020 will not be practicing clinical medicine in 2025 [44]. Further, a 2012 census found that 39.6% of tracked medical graduates were not practicing clinical medicine at all [45]. In light of this underutilized talent, increasing access to subspecialty care at the district hospital level will require a multi-faceted approach that could include: incentivizing completion of subspecialty training with guaranteed employment, increasing training and employment of specialty nurses and optometrists, cross-training general surgeons in specialty procedures, utilizing visiting surgeons to teach hands-on skills in low-resource settings, incorporating tele-ophthalmology platforms for remote access to consultation and ongoing support, and using nongovermental organizations (NGOs) and global partnerships for surgical equipment and funding needs. Together, the focus of these solutions should be on ensuring scalability, sustainability, and operational efficacy of high-quality ophthalmological care in low-resource settings.

4.5. Pathology-Specific Considerations for Eye Care Capacity Building in Low-Resource Settings

As part of a Delphi exercise in 2020 by the Lancet Global Health Commission on Global Eye Health, 16 Grand Challenges were identified to serve as a starting point for immediate action by stakeholders, with one Grand Challenge being to "develop and implement services that prioritize and, by design, reach marginalized or vulnerable groups (women, poor communities… and refugee camps)... with quality affordable eye services" [1, 46]. In order to achieve this, there are several arms of capacity building that require attention, including surgical services, optometric services for refractions and eye disease screening, spectacle distribution, medication administration, and public health and infrastructure needs. Furthermore, specific approaches to improving access to eye care services may vary in a region-dependent manner based on the most prevalent pathologies.

For example, community-level interventions have been effective in low-resource settings, especially when implemented through community-directed approaches. Specific examples include rubella vaccination to prevent ophthalmic complications of congenital rubella, Vitamin A supplementation and measles vaccination to reduce childhood corneal ulceration, and mass drug administration of azithromycin for trachoma and ivermectin for onchocerciasis [47-51]. However, community-level interventions are particularly suited for infectious and nutritional etiologies of eye disease, and it is unlikely that the VI burden in refugee settings can be sufficiently addressed through such interventions alone.

In tackling uncorrected refractive error, which is a major contributor to global VI and is prevalent among refugee populations, spectacle distribution programs have been cost-effective and widely successful in boosting functional baseline and workplace productivity [7, 10, 52, 53]. School-based spectacle distribution programs have also been effective in enhancing educational performance in schoolchildren and present a potentially beneficial approach in chronic refugee settings like Nyarugusu, where children constitute a substantial portion of the population [54, 55]. However, a critical concern lies in reaching children who do not attend school as well as adults who experience disability and productivity loss due to uncorrected refractive error [56]. Additionally, though individual assessment and distribution of glasses represents a seemingly simple solution, ensuring sustained effectiveness and durability poses challenges. A study in refugee camps on the Thailand-Burma (Myanmar) border found reduced wearing compliance among spectacle recipients at 12 months, attributed to issues such as broken frames and lenses, vision-related complaints, lost spectacles, and appearance [57, 58]. Overall, there is a substantial need for health services to cultivate a skilled workforce capable of providing spectacles, whether through the deployment of optometrists, ophthalmologists, refraction technicians, or the

training of community health workers (CHWs). Additional considerations involve ensuring equitable spectacle delivery and implementing contextual interventions to promote compliance [57, 59].

Cataracts present a distinct eye pathology particularly in low-resource settings, as cataract surgery offers a singular and effective solution for reversing associated vision loss. In refugee settings, cataracts are often the leading cause of blindness, accounting for up to 75% of total blindness [8, 10, 23, 39]. The utilization of visiting cataract surgeons has been effective in some refugee settings; however, this strategy requires extensive local support for preoperative identification and preparation of patients, and would be difficult to implement for other eye conditions that are also surgical in nature but are lower in prevalence [38]. Moreover, this approach fosters a dependence on visiting teams for consistent eye health services and may hinder the development of local eye care capacity. The use of mid-level ophthalmic personnel has also been explored, as mid-level providers are more likely to establish their practice in rural and underserved areas when compared to ophthalmologists. A community-level study in Tanzania, examining cataract surgery outcomes led by non-physician assistant medical officer ophthalmologists (AMO-O) in their final stages of training, demonstrated noteworthy improvements in post-operative visual acuity. However, continued outcome monitoring and adjustments in training protocols may be necessary for effective large-scale implementation [60].

In contrast, glaucoma is a chronic eye disease that requires early detection and treatment to avoid irreversible vision loss, and surgical interventions seldom offer lifelong control. The World Health Organization's Model List of Essential Medicines (23rd list, published July 2023) includes several key glaucoma medications, such as topical latanoprost, pilocarpine, and timolol, as well as acetazolamide tablets [61]. Since long-term use of topical ocular hypotensive drops is the primary initial treatment for glaucoma, ensuring medication adherence and consistent access to eye drops in protracted refugee settings remains a significant challenge, potentially exacerbating ocular morbidity [1, 62]. Moreover, even after treatment initiation, ongoing monitoring is essential for glaucoma patients to evaluate disease progression, which poses yet another challenge in refugee settings. Potential solutions to bridge this gap involve implementing home-based monitoring or training CHWs to deliver ongoing surveillance [63].

In protracted refugee settings such as Nyarugusu Camp, where access to referral care is complex and ophthalmologic services are even scarcer, investing in the training of CHWs and mid-level ophthalmic providers for early detection, referral, and treatment of specific eye diseases may enhance outcomes [60, 64-66]. As prevalent eye pathologies within a population should guide the selection of appropriate interventions and areas of critical capacity building, it is essential to conduct further needs assessments in chronic refugee settings. A limitation of our study, and an important area for future research in Nyarugusu Camp, would be conducting a prospective study that includes pathology-specific survey questions and basic eye exams by trained eye care providers to better assess the need for surgical, optical, or medical interventions based on the specific needs identified.

4.6. Inclusion of Ophthalmic Surgical Care in Tanzanian Capacity Building Policies

Among the 12% of refugees in Nyarugusu Refugee Camp who endorsed eye problems, 84% reported unresolved issues at the time of our survey. Additionally, among respondents addressing barriers to surgical care, 51% self-reported possible need for surgical intervention for their eye condition. Given that the total Tanzanian refugee population exceeds 246,000 people, we project that approximately 13,000 to 25,000 refugees in Tanzania may have unresolved eye conditions amenable to surgery [67].

As it pertains to the advancement of eye care, the Tanzanian Health Sector Strategic Plan for 2021-2026 (HSSP V) outlines nine interventions in ophthalmology, primarily focusing on strengthening eye health services at the primary healthcare level and preventing diabetes-related VI [68, 69]. Costing analysis revealed that total ophthalmology healthcare expenses under the HSSP V for the period 2021-2025 are projected to reach TZS 676 billion (USD 294 million), representing just one percent of total HSSP V costs. This includes expenditures for drugs, commodities, and supplies, with costs projected to increase from TZS 96 billion (USD 41 million) in 2021 to TZS 176 billion (USD 76 million) in 2025 [68]. Primary cost drivers include newborn eye infection prophylaxis (35 percent), cataract surgery (20 percent), and treatment for glaucoma (16 percent), whereas top unit costs include ocular oncology, oculoplastic surgery, and retinopathy screening and photocoagulation [70]. While the HSSP V also emphasizes sustaining advancements in secondary and tertiary eye health services in Tanzania, including improvements in infrastructure, workforce development, and service delivery, it lacks clear strategies for scaling up specialized ophthalmic surgical services [68]. Significant gaps in eye care coverage continue to exist, likely due to the prioritization of other health sectors [71].

The Tanzanian National Surgical, Obstetric, and Anesthesia Plans (NSOAP) is another established healthcare policy framework, focused on improving surgical, obstetric, and anesthesia (SOA) care across six domains: service delivery, infrastructure and supplies, SOA workforce, information management and technology, finance, and governance [45, 72]. While the 2018-2025 plan systematically addresses these areas, it notably lacks emphasis on developing SOA capacity for ophthalmic care [45]. Progress has been slow, with significant challenges such as limited awareness of the plan among regional health officials [73]. By 2024, the number of SOA specialists increased from 0.46 to 1.96 per 100,000

population, nearing the 2025 target of 2.27. A study by Hellar et al. reported 297 SOA specialists at the regional level, most of whom were obstetricians (43%) and general surgeons (21.3%). However, the absence of ophthalmic specialists in this data highlights the lack of prioritization for eye care within the NSOAP [73].

To establish comprehensive surgical eye care services for all Tanzanian refugees and the broader population, we strongly advocate for the integration of eye care into upcoming policies and plans aimed at enhancing surgical capacity and accessibility in Tanzania.

4.7. Limitations and Recommendations for Future Research

Our study is subject to several limitations. First, it relied on trained CHWs conducting verbal head-to-toe examinations and participant self-reporting rather than eye exams by licensed physicians. This could lead to participant misinterpretation, problem mischaracterization, and recall bias. While a physical examination by an ophthalmologist or optometrist would provide a more accurate assessment of eye disease prevalence, it was not feasible in this resource-limited setting with minimal eye care capacity at baseline. Additionally, the study's translation into Kiswahili may have led to informal translations for Kirundi-speaking participants, introducing potential misinterpretation or language barriers. The nature of the reporting itself through a survey tool administered by multiple individuals is also subject to interobserver variability in the reported results. Furthermore, there was some missing data for some participants, which may have impacted the accuracy of the overall findings. Finally, the categorization of eye conditions was subject to the general categories listed in the SOSAS tool (e.g. acquired malformations, wounds, burns, etc.) rather than specific causes of VI (e.g. refractive errors, cataracts, diabetic retinopathy, trachoma). This broad categorization limited our ability to identify specific pathologies for each condition and estimate workforce and equipment needs accurately.

Future research should incorporate direct ophthalmic examinations by trained eye care providers to more precisely categorize ocular conditions in refugee populations. A comprehensive assessment of specific pathologies—such as cataracts, refractive errors, glaucoma, and trachoma—would refine estimates of pathology-specific surgical and medical needs, thereby guiding resource allocation strategies.

In addition to understanding pathology-specific needs in Nyarugusu refugee camp and similar populations, several other research efforts are essential for reducing the burden of untreated VI and improving access to quality ophthalmic care. Future studies should explore the long-term socioeconomic and health impacts of untreated eye conditions in refugee settings, furthering our understanding of the broader consequences of vision loss on marginalized populations and strengthening advocacy for eye care integration into refugee health policies at all levels. Given that limited access to services was a major barrier to surgical care, studies could also assess various referral models for ophthalmic care in refugee settings, including streamlined district hospital referrals, mobile surgical outreach programs, and telemedicine consultations. Additionally, evaluating the cost-effectiveness and impact of scalable interventions—such as community-based eye screening programs, CHW-led health campaigns, and subsidized spectacles for refractive errors—could inform practical and sustainable approaches to improving eye care access in resource-limited settings.

Finally, future research should address strategies to expand the ophthalmic surgical workforce, particularly at the district hospital level. Studies could assess the feasibility of various training models such as task-shifting or the use of non-physician surgical providers to address workforce shortages. The integration of telemedicine and remote surgical mentorship could further extend the reach of ophthalmic surgeons to underserved areas.

5. Conclusions

To our knowledge, this is the first household-based study of eye disease burden in a protracted refugee setting in East Africa. Nearly one in eight refugees surveyed in Nyarugusu Refugee Camp endorsed eye problems, with most individuals reporting eye problems that were chronic and disabling in nature. Although nearly three-fourths of Nyarugusu refugees affected by eye problems have actively sought care for their condition, only a select minority had received surgical intervention, while many other participants cited lack of available services as a primary barrier to receiving surgical eye care. Previous work has shown ophthalmologic concerns are one of the leading reasons for referral from Nyarugusu to outside hospitals, further emphasizing the critical shortage of eye care services within the camp. Conducting thorough needs assessments with trained eye care providers would be useful in guiding targeted resource allocation and capacity-building initiatives tailored to prevalent pathologies. Above all, however, urgent action is required to expand the ophthalmic surgical workforce and operative capacity at district-level hospitals to reduce the burden of untreated VI among marginalized refugee populations and impoverished host communities.

Abbreviations

VI	Vision Impairment
SOSAS	Surgeons OverSeas Assessment of Surgical Needs
LMIC	Low- and Middle-Income Countries
OR	Odds Ratio
CI	Confidence Interval
NGO	Nongovernmental Organization
CHW	Community Health Worker

AMO-O	Assistant Medical Officer Ophthalmologist
HSSP	Health Sector Strategic Plan
TZS	Tanzanian Shilling
USD	United States Dollar
NSOAP	National Surgical, Obstetric, and Anesthesia Plan
SOA	Surgical, Obstetric, and Anesthesia

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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