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GRADUATE SURVEY ARTICLE

Knowledge and Awareness of Glaucoma and Their Associated Eye Care Practices in 3 Areas With Different Tiers in Khartoum State 2020-2021: A Cross-Sectional Study

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ABSTRACT

Primary open-angle glaucoma is the most prevalent type of glaucoma in Africa, in which the patient is usually asymptomatic early in the disease course; so early presentation is the only way to prevent blindness progression. This study is a community-based cross-sectional study in 3 different socioeconomic areas in Khartoum state among adults who were selected using systemic random sampling inside the area. Data were collected using an interviewing questionnaire after obtaining ethical approval from the Department of Community Medicine- University of Khartoum and a sample of 384 was collected. The overall level of awareness was 62%, which differed significantly with: tier-level, educational level, diagnosis of refractive error, use of medical eyeglasses, family history of blindness, and attendance history of eye care services. The main source of knowledge and awareness of Glaucoma was the local community (57%) followed by ophthalmologists (23%). Among the aware population, the second socioeconomic area residents possessed higher knowledge of glaucoma than those in the first area (P=0.032). Ophthalmologists as a source of knowledge are associated positively with higher knowledge. Attendance of eye care services is associated positively with a family history of blindness and a university degree. The awareness of glaucoma is low in low socioeconomic area compared to the middle and high socioeconomic areas. Middle socioeconomic area residents possessed higher knowledge than the highest socioeconomic area. The high awareness in the population was not translated into good knowledge in most of the population so health education is recommended.

Keywords: Glaucoma, Knowledge, Socioeconomics

1 Introduction

Glaucoma is an optic neuropathy with characteristic structural damage to the optic nerve and visual field defect [1]. Worldwide, it affects 3.5% of those 40-80 years and it is expected to exceed 110 million in less than 20 years [2]. It is the leading cause of irreversible blindness and the second cause of overall blindness both worldwide and in Africa causing about 8% and 15% of blindness, respectively [3], [4]. The United States' glaucoma prevalence has exceeded 1.6 million, and half of them are asymptomatic [5]. The highest continent with POAG is Africa with a prevalence of 4.2% [2]. In Sudan the prevalence of glaucoma in Atbara locality, Nile state is 1.34% [6]. In 2013, blindness cost more than 139 billion dollars [7]. In the United States alone blindness costs $2.3 billion annually [8]. Glaucoma case detection increases by improving the attendance rate for eye examinations, especially among high-risk groups [9]. Treating self-referring patients with a hypothetical one-time laser surgery was highly cost-effective relative to WHO willingness to pay thresholds[10]. A recent recommendation from the United States Preventive Task Force stated that: "Screening tests can identify persons with glaucoma and treatment was associated with a lower risk of glaucoma progression, but evidence of improvement in visual outcomes, quality of life, and function remains lacking" [11]. Patients with POAG are asymptomatic early in the disease course, but with late presentation irreversible blindness is unavoidable [8].

Optometrists are an important source of referral systems for ophthalmologists. Moreover, the patients - who are referred by optometrists- present earlier in the glaucoma disease course four times more than patients of the same sex, ethnicity, and age who are referred from other sources [12]. Blindness causes physical limitations, psychological disturbances, and financial burdens [7]. Patients would present for adequate screening and possible treatment if they were aware of the disease thus reducing glaucoma's financial burden and risk of blindness [8], [13], [14]. Moreover, Poor glaucoma knowledge may be present in high-risk groups with limited access to eye care services [8]. African Americans have a higher risk of developing POAG, this group has poor knowledge about the disease and unfortunately, it is the leading cause of irreversible blindness [5], [15]. Low socioeconomic status is associated with late disease presentation and blindness [16]. Eye health education encourages individuals to participate in regular ophthalmologic checkups - as it increases the knowledge and awareness about the disease – so it is an important tool for detecting glaucoma early, thereby preventing needless visual impairment and preserving the quality of life [15]. Lack of glaucoma awareness in Nigeria was a risk factor for late presentation [17]. Several studies were conducted in Africa and revealed that glaucoma knowledge and understanding is generally low [18]. Another study showed that there is low awareness of surgery as a treatment option for glaucoma [19]. Low socioeconomic status is associated with poor vision, advanced disease at presentation, and poor quality of life among patients with glaucoma [20].

Healthcare professionals should establish education campaigns to increase the level of awareness and knowledge about the disease as it increases the awareness of the population significantly. Programs such as the National High Blood Pressure Education Program in the United States- which resulted in a progressive decline in age-adjusted mortality rates for stroke inspire us to implement similar programs but, in a country like Sudan with an economic crisis and limited resources; health education campaigns and screening programs should be more focused[21]. Moreover, if we know the attendance behavior of the community towards eye care services more focused glaucoma-screening programs in high-risk individuals can be established with areas of lower attendance rate, which is considered a cost-effective intervention to increase the catch-up of the cases early on [9]. Many studies about this topic were conducted outside Sudan and revealed variable level of knowledge and awareness levels and up to our knowledge, this is the first community-based study. This study aims to study glaucoma awareness and knowledge and their determinants among the 3 different areas with different socioeconomic status and the associated eye care services attendance level among the general population and among those who are at risk of blindness.

2 Methods

This is an analytical cross-sectional - community-based study to assess the Knowledge and awareness of glaucoma and its relation to attendance of eye care services among 3 areas with different tiers in Khartoum state 2020-2021. The data were collected from the seventh to the 26th of December 2020 from 3 areas in Khartoum state with different tiers which are Nile City, Alshati, and block 17 Alnasr-Mayo. Nile city is a first-tier area in Karari Locality; with most of the residents of a high education and of a high socioeconomic status and containing about 1000 families. Alshati district is a second-tier area, located in Karari Locality, and contains about 1100 families. The residents of this district are divided into two main categories the older residents -who most of them migrated from White Nile state- and the newcomers who migrated in the last few years after the advancement of the local services. The residents are divided between high, middle, and low socioeconomic status with the majority of upper middle status. Block 17- Alnasr- Mayo area is third tier area in Khartoum Locality; with most of the residents of low socioeconomic status, who came to Khartoum as internally displaced from conflict areas and famine due to dry up of the original areas in western parts of Sudan, containing about 1000 families. The sample size was calculated by using the formula $n = \frac{Z^2pq}{e^2}$ Where n =minimum sample size required, z = probability that e is not exceeded, (e score of 1.96 corresponds to 95% confidence level), p= expected prevalence (estimated as 0.5), and q=1-p. The sample size was 384, which then was divided equally between the 3 areas. systematic random sampling was used for data collection inside each area after calculation of the sampling interval the house was selected, and then all who met the inclusion criteria inside the house were interviewed till the sample size was completed.

All eligible Sudanese adults (more than 18 years) were interviewed and those who lived in the study area for less than 6 months, doctors, nurses and pharmacists were excluded. The data collector of "mayo" area knows Rutana (local language) which is used interchangeably with Arabic language there. Data were collected using an interviewing questionnaire, which was formed from previous studies[22], [23], then was approved by the department of community medicine - Faculty of Medicine - University of Khartoum. The questionnaire was translated into Arabic language with glaucoma used interchangeably with "almoia alsawdaa" or black water in Arabic which is the local term of glaucoma in Sudan. The questionnaire contained the following sections: sociodemographic section (11 questions), some blindness risk factors in Sudan according to a previous study (2 questions included in the previous section)[7], awareness section (2 questions), attendance to eye care services section (2 questions) and glaucoma knowledge assessment section (16 questions). Only those who were aware about glaucoma were further assessed about the degree of glaucoma knowledge in definition, risk factors, symptoms, treatment options and complications aspects with, 16 questions with answers "yes" "no" or "I don't know". The correct answer was given one, other than that zero, then glaucoma knowledge score was calculated out of 16. Data were coded, given sequential numbers, entered, and analyzed using the Statistical Package for Social Sciences (SPSS) program version 24. The results were presented in the form of numbers, percentages, tables, figures, and charts. The chi-square test, independent sample t-test, and multinomial logistic regression were used to analyze the data. Glaucoma awareness referred to a respondent having heard of the condition. Eye care services in our study are any optometric or ophthalmologic checkup area either center, clinic, campaign, or hospital. Any participant who scored eight or more in glaucoma knowledge score out of 16 was considered to have good knowledge.

3 Results

3.1 Sociodemographic characteristics

Three hundred eighty-four adults participated in the study with a mean age (±SD) of 37.3 (±16.2) years, with the mean ages (±SD) of Nile city, Alshati, and Mayo-Alnasr participants were 38.2(±15.2), 40.4(±16.3) and 33.3(±16.2) years respectively. 89(68%) of Nile city sample, 81(63%) of Alshati sample,

and 109(87%) of Mayo-Alnasr sample did not suffer from any chronic disease. Diabetes Mellitus, Hypertension, or both are the most common chronic diseases (Table 1).

Table 1: *Sociodemographic characteristics of adults living in 3 areas in Khartoum State 2020(n=384) :n(%)*

Characteristic	Nile city(1st)	Alshati(2nd)	Mayo-Alnasr(3rd)
Number	131(34%)	128(33%)	125(33%)
Age (in years) *			
< 30	52(40%)	45(35%)	77(61%)
30-45	40(30%)	38(30%)	27(22%)
>45-60	25(19%)	27(21%)	12(10%)
>60	14(11%)	18(14%)	9(7%)
Gender:			
Male	69(53%)	72(56%)	67(54%)
Female	62(47%)	56(44%)	58(46%)
Monthly income (in thousand SDG): *			
<5	25(44%)	67(55%)	47(38%)
5-20	23(18%)	35(29%)	54(43%)
21-35	24(19%)	12(10%)	17(14%)
>35	24(19%)	9(7%)	7(6%)
Marital status:			
Single	54(41%)	41(32%)	60(48%)
Married	69(53%)	81(63%)	55(44%)
Divorced	2(2%)	1(1%)	4(3%)
Widow	6(5%)	5(4%)	6(5%)
Educational level: *			
No formal education	6(5%)	7(6%)	48(38%)
Primary education	2(2%)	29(23%)	35(28%)
Secondary education	17(13%)	36(28%)	22(18%)
University and above	106(81%)	56(44%)	20(16%)
Diagnosis with Diabetes or hypertension: *			
Yes	29(22%)	28(22%)	6(5%)
No	102(78%)	100(78%)	119(95%)
Using of Medical eyeglasses: *			
Yes	58(44%)	51(40%)	11(9%)
No	73(56%)	77(60%)	114(91%)

Diagnosis of refractive error: *			
Yes	58(44%)	52(41%)	9(7%)
No	73(56%)	76(59%)	116(93%)
Family history of blindness*:			
Yes	9(5%)	25(19%)	16(13%)
No	125(95%)	103(81%)	109(87%)

*P<0.05 Chi-square test

The means of the income of adults in the three areas (in SDG) were 20000, 10300, and 13400 respectively. 5%, 6%, and 38% of the residents of the first, second, and third-tier, respectively did not receive a formal education, While 81%, 44%, and 16% respectively have university degrees. Family history of blindness was significantly low in the high socioeconomic area in comparison with the second and third areas (AOR=0.20, P<0.01, AOR=0.29, P=0.02, respectively). Other sociodemographic data are described in Table (1). The comparison of the 3 areas' residents' glaucoma awareness and knowledge and eye care services attendance are in Table No. (2).

Table 2: *awareness and attendance of eye care services among adults living in 3 areas in Khartoum state 2020 (n=384): n(%)*

Characteristic	Nile city(1st)	Alshati(2nd)	Mayo-Alnasr(3rd)
Attend ophthalmologist: *			
Yes	58(65%)	51(40%)	40(32%)
No	46(35%)	77(60%)	85(68%)
Attend optometric service: *			
Yes	82(63%)	71(56%)	29(23%)
No	49(37%)	57(44%)	96(77%)
Awareness of glaucoma: *			
Yes	104(79%)	94(73%)	39(31%)
No	27(21%)	34(27%)	86(69%)
Glaucoma knowledge score: (out of 16)			
<4	19(18%)	8(9%)	7(15%)
4-7	46(44%)	35(38%)	8(38%)
8-11	31(30%)	39(42%)	18(47%)
>11	8(8%)	11(12%)	5(13%)

*P<0.05 Chi-square test

3.2 Awareness of glaucoma and its determinants

Multinomial logistic regression of awareness variable showed statistically significant association between glaucoma awareness and residential area, educational level, diagnosis of refractive error, using of medical eyeglasses, family history of blindness, and attendance history of either an ophthalmologist or optometrist- after adjustment of age and monthly income. Diagnosis of Diabetes Mellitus, hypertension, or both showed no statistically significant association with awareness, after adjusting age as a confounding factor. Details of

the determinants of awareness of glaucoma among the participants of the study are in Table (3). The odds of being aware of glaucoma among adults residing in the 1st (AOR=8.0, P<0.01) and 2nd (AOR=5.3, P<0.01) tier areas was eight and five times greater than adults residing in the 3rd tier area. Similarly, the odds of being aware of glaucoma among adults who had secondary (AOR=5.4, P<0.01), college, and above (AOR=10.6, P<0.01) education exceeds five and ten times than those with no formal education. Using medical eyeglasses, diagnosis of refractive error, family history of blindness, and attending to either an ophthalmologic or optometric service increase glaucoma awareness by 4.2, 4.5, 2.0, 4.5, and 5.7 (P<0.05) times, respectively than their counterparts. The age group <30 was associated negatively with glaucoma awareness in comparison with >60 years (AOR=0.26, P<0.01).

Table 3: *determinants of awareness of glaucoma among the participants of the study in Khartoum state (n=384)*

	Awareness			
Variable	**Yes**	**No*** **	**COR**	**AOR**
Residency				
Nile city (1st)	104(44%)	27(18%)	8.5**	8.0**
Alshati (2nd)	94(40%)	34(23%)	6.1**	5.3**
Mayo-Alnasr (3rd)	39(16%)	86(59%)		
Age (in years)				
< 30	87(37%)	87(59%)	0.26**	
30-45	66(28%)	39(27%)	0.42	
46-60	51(21%)	13(9%)	0.91	
>61	33(14%)	8(5%)		
Gender:				
Male	127(54%)	81(55%)	1	0.9
Female	110(46%)	66(45%)		
Monthly income (in thousand SDG):				
<5	109(47%)	60(42%)	0.8	1.2
5-20	60(26%)	52(36%)	0.5	0.7
20-35	33(14%)	20(14%)	0.7	1.1
>35	28(12%)	12(8%)		
Marital status:				
Single	85 (36%)	70(48%)		
Married	138(58%)	67(46%)		
Divorced	3(1%)	4(3%)	0.4	1.0
Widow	11(5%)	6(4%)	1.6	0.2*
Educational level:				
No formal education	26(11%)	35(24%)		
Primary education	24(10%)	42(29%)	0.8	1.2

Secondary education	47(20%)	28(19%)	2.3	5.4**
University and above	140(59%)	42(29%)	4.5**	10.6**
Diagnosis with Diabetes or hypertension:				
Yes	53(22%)	10(7%)		
No	184(78%)	137(93%)	0.25**	0.5
Using Medical eyeglass:				
Yes	102(43%)	18(12%)	5.4**	4.2**
No	135(57%)	129(88%)		
Diagnosis of refractive error:				
Yes	102(43%)	17(12%)	5.8**	4.5**
No	135(57%)	130(88%)		
Family history of blindness:				
Yes	36(15%)	11(8%)	2.6*	2.0*
No	201(85%)	136(93%)		
Attend ophthalmology:				
Yes	93(39%)	115(78%)		
No	144(61%)	32(22%)	0.18*	0.22*
Attend optometric service:				
Yes	85(36%)	117(80%)		
No	152(64%)	30(20%)	0.14**	0.18**

* 0.05 <P value >0.01 AOR adjusted odd ratio (for age)

** P value <0.01 COR crude odd ratio

*** used as reference for calculation of odd ratio

3.3 Glaucoma knowledge and its determinants:

Two hundred thirty-seven (62%) of the participants were aware of glaucoma. About half (45%) of them knew that glaucoma affects the retina and optic nerve. Only 31% ticked the right answer to the glaucoma pathophysiology question. 52% of the award population said that glaucoma has no cure. 133(57%) knew that genetic factors play a role in the disease. 50(21%) stated that severe anemia is a risk factor for glaucoma. The least known treatment modality was Laser (92, 39%) followed by eye drops (130, 55%) then surgery (134, 57%). Only 84(36%) answered correctly that glaucoma patients may be completely asymptomatic. Only 59(25%) answered correctly that glaucoma doesn't cause acute blindness, for the rest of the Glaucoma knowledge individual question scores refer to Table (4).

Table 4: *Glaucoma knowledge questions score descriptive data (n=235):*

Question	Number who scored 1*	Number who scored 0**
Glaucoma is a group of eye diseases affecting the optic nerve, leading to retinal cell damage.	106(45%)	129(55%)
Glaucoma occurs due to an imbalance between aqueous humour production and the capacity of the eye to drain it.	74(31%)	161(69%)

One of Glaucoma's risk factors is aging.	161(69%)	74(31%)
One of Glaucoma's risk factors is genetic factors.	133(57%)	102(43%)
One of Glaucoma's risk factors is Myopia.	61(26%)	174(74%)
One of Glaucoma risk factors is severe Anemia.	50(21%)	185(79%)
There is no current treatment for Glaucoma.	122(52%)	113(48%)
Laser is considered one option for the treatment of Glaucoma.	92(39%)	143(61%)
Surgery is considered one option for the treatment of Glaucoma.	134(57%)	101(43%)
Eye lowering Pressure eye-drop is considered one option for the treatment of Glaucoma.	130(55%)	105(45%)
Glaucomatous patients can be asymptomatic.	84(36%)	151(64%)
Headache is one of the glaucoma symptoms.	110(47%)	125(53%)
The red eye is one of the glaucoma symptoms.	106(45%)	129(55%)
Treatment can preserve Vision in the late stages of glaucoma.	82(35%)	153(65%)
Glaucoma causes optic nerve damage	149(63%)	86(37%)
Glaucoma causes acute onset blindness	59(25%)	176(75%)

*right answer ** wrong answer or "I don't know"

The main source of information mentioned by them was the local community (57.4%), followed by ophthalmologist (23.1%), internet (20%), Television (19%), Radio (8%) and books (2%), for the sources of Glaucoma knowledge and awareness refer to figure (1).

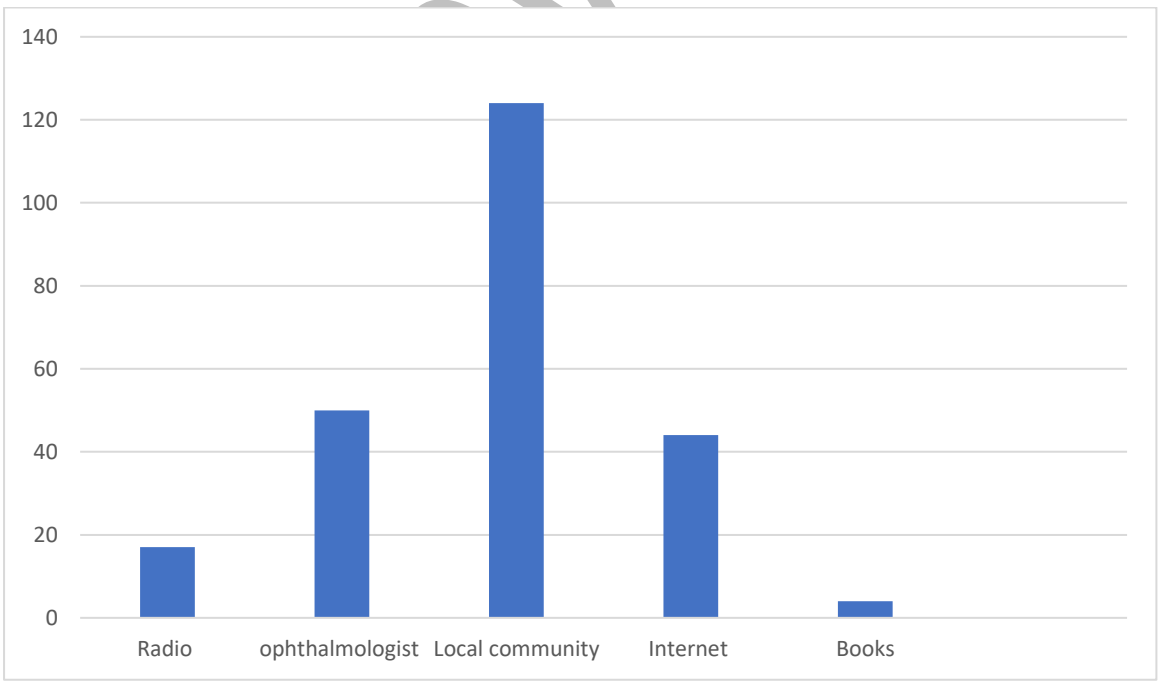

Figure 1: *Sources of Glaucoma knowledge and awareness among the residents of the three socioeconomic areas in Khartoum state, Sudan 2020 (n=384)*

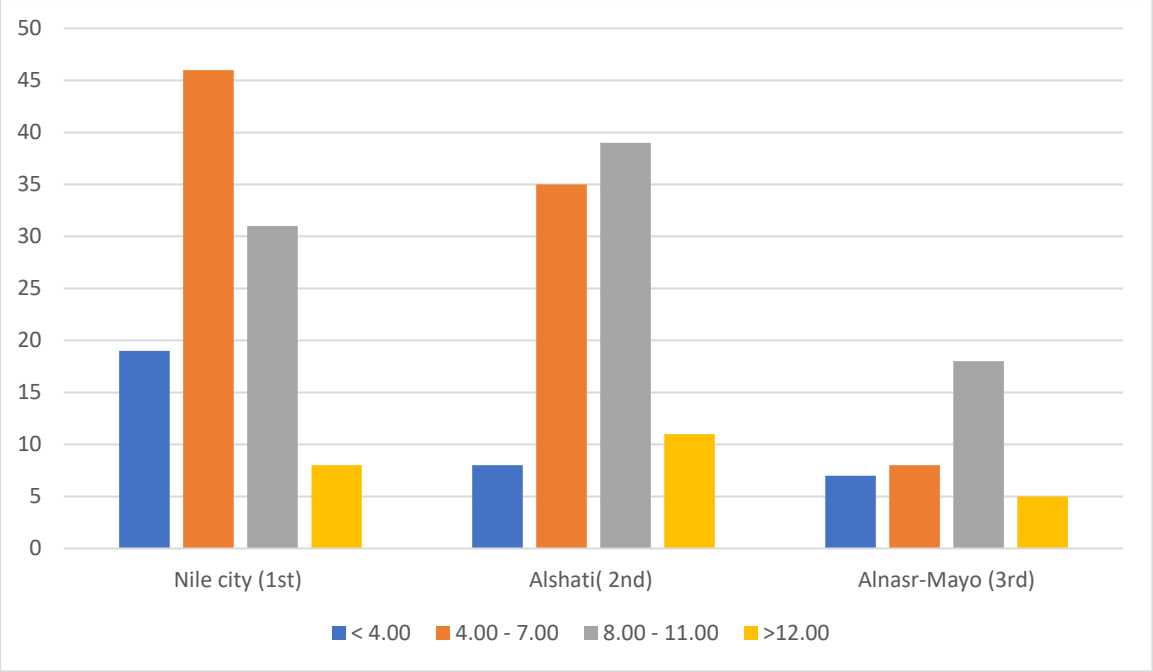

Figure 2: *Glaucoma knowledge score (out of 16) among residents of the three areas in Khartoum state, Sudan 2020 (n=235)*

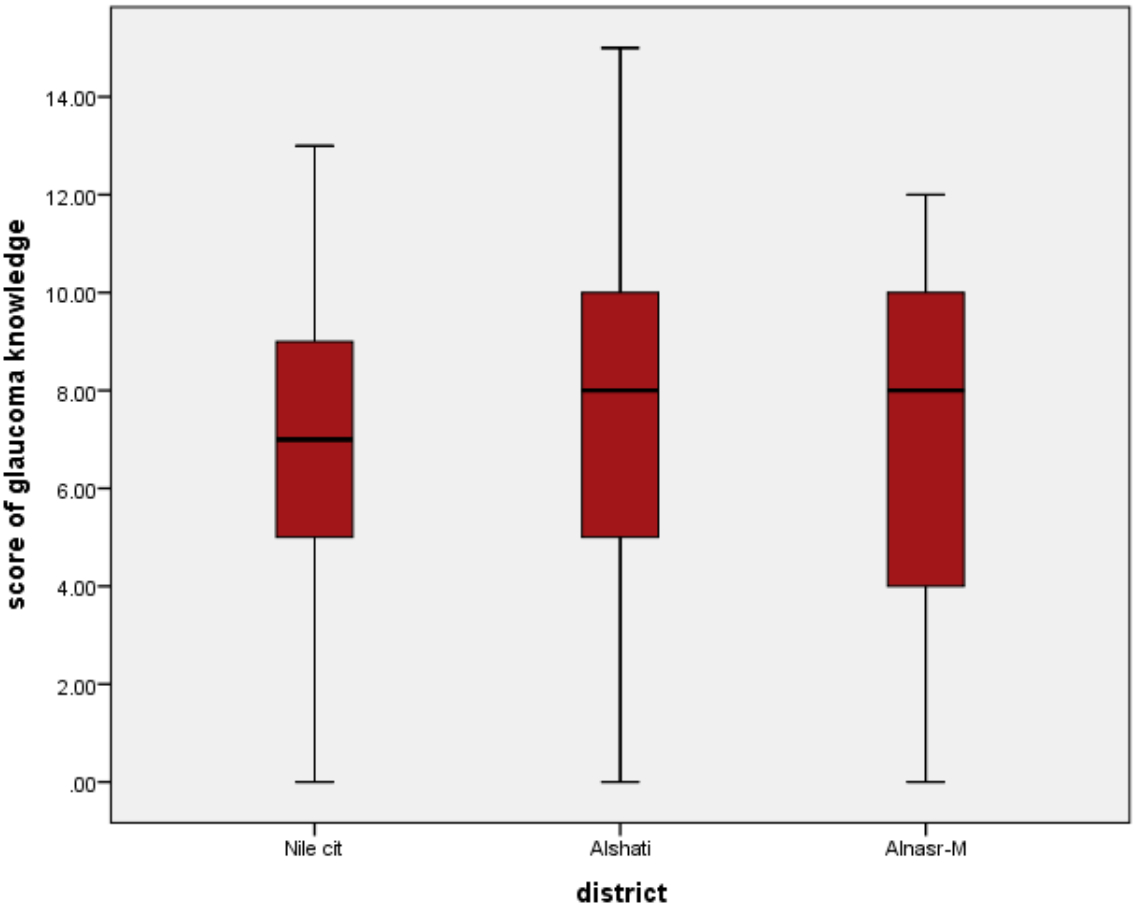

Figure 3: *Boxplot showing the difference in knowledge score among the residents of the three areas with 3 different socioeconomic areas, Khartoum state 2020 (n=235)*

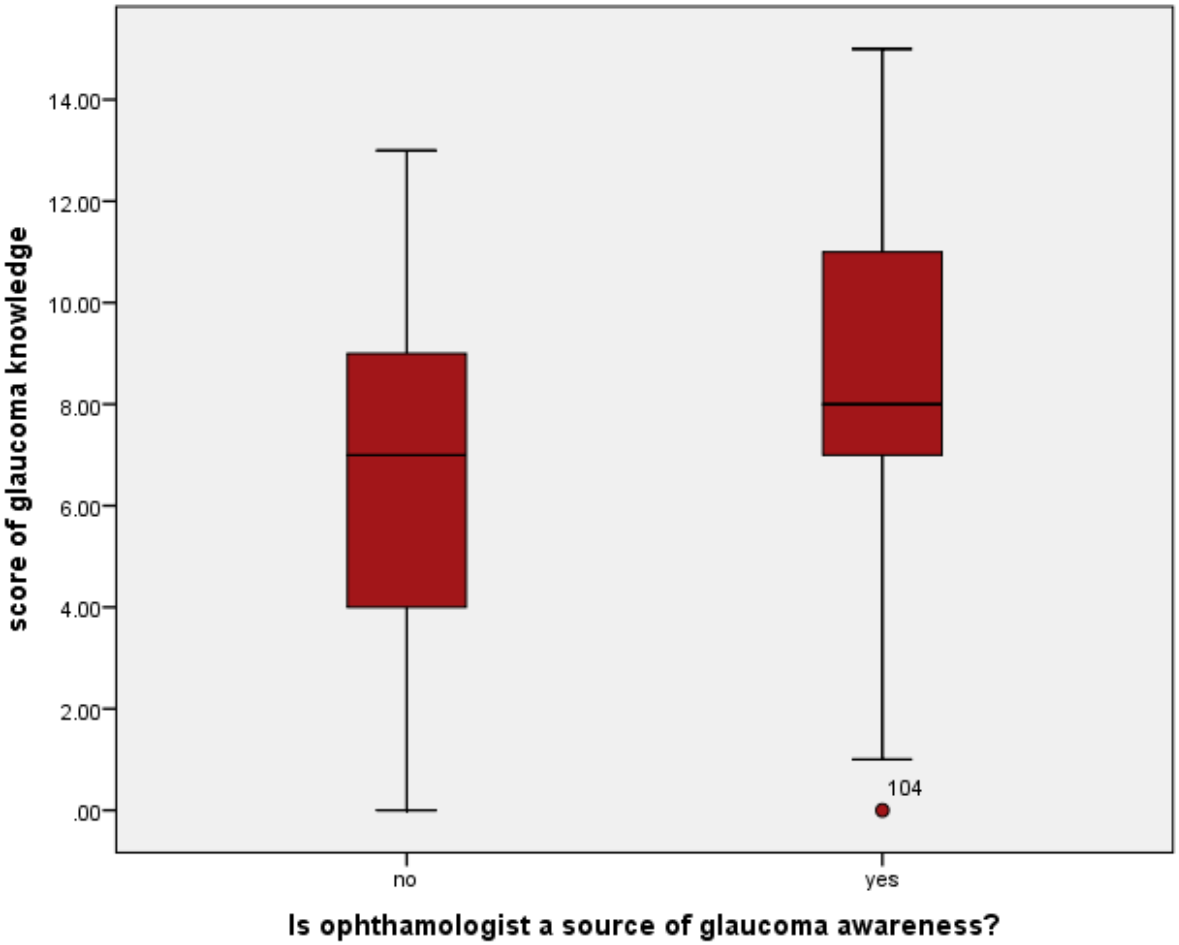

Figure 4: *Boxplot showing the difference in knowledge score between those who had ophthalmologist as a source of knowledge among the residents of the three areas with 3 different socioeconomic areas, Khartoum state 2020. (n=384)*

The overall mean of glaucoma knowledge score (±SD) was 7.1(±3.4). Nile city, Alshati and Mayo-Alnasr participants scored means of 6.6(±3.3), 7.6(±3.3), and 7.0(±4.1), respectively. Independent sample T test showed that the mean of the first area was significantly lower than the mean of the second area (T= -2.159, P=0.032); figure No. (3) is showing the difference in knowledge score among the residents of the three areas. Ophthalmologist as a source of knowledge associated with increase the level of knowledge in the community (t= 3.102, P<0.01), see figure (4). Table (5) is showing the determinants of glaucoma knowledge. Out of the total number or residents in the specific area; those who had good knowledge (scored ≥8) were 29.8%, 39.1% and 18.4% in the first, second- and third-class areas respectively, refer to figure (2) which is showing Glaucoma knowledge score (out of 16) among residents of the three areas.

Table 5: *independent sample T-test of the mean glaucoma knowledge score*

		Mean glaucoma knowledge score			
Variable	**First outcome**	**Mean (±SD) of the first outcome**	**Second outcome**	**Mean (±SD) of the second outcome**	**t**
Residency	Nile city (1st)	6.6 (±3.3)	Alshati (2nd)	7.6 (±3.2)	-2.159*
	Nile city (1st)	6.6 (±3.3)	Mayo-Alnasr (3rd)	7.0 (±4.1)	-.589

	Alshati (2nd)	7.6 (±3.2)	Mayo-Alnasr (3rd)	7.0 (±4.1)	.911
Gender	Male	7.0	Female	7.1	-.279
Marital status	Single	7.1	Married	7.1	-0.051
Educational level	No formal education	6.2 (±4.4)	University and above	7.0 (±3.3)	-1.053
	No formal education	6.2 (±4.4)	Secondary education	7.6 (±3.2)	-1.538
	No formal education	6.2 (±4.4)	Primary education	7.6 (±3.4)	-1.276
	University and above	7.0 (±3.3)	Primary education	7.6 (±3.4)	-.850
	University and above	7.0 (±3.3)	Secondary education	7.6 (±3.2)	-1.069
Diagnosed with Diabetes or hypertension	Yes	7.2(±2.8)	No	7.1(±3.6)	.264
Use Medical eyeglass	Yes	7.6(±3.3)	No	6.7(±3.5)	1.894
Diagnosed with refractive error	Yes	7.6(±3.3)	No	6.7(±3.5)	1.816
Family history of blindness	Yes	7.5(±3.9)	No	7.0(±3.4)	.762
Attend ophthalmology	Yes	7.1(±3.2)	No	7.0(±3.7)	.191
Attend optometric service	Yes	7.4(±3.3)	No	6.6(±3.6)	1.558
Is TV a source of knowledge?	Yes	6.9(±3.4)	No	7.2(±3.5)	-.586
Is radio a source of knowledge?	Yes	7.4(±3.5)	No	7.3(±3.6)	.233
Is ophthalmologist a source of knowledge?	Yes	8.5(±3.2)	No	6.7(±3.5)	3.102**
Is local community a source of knowledge?	Yes	7.2(±3.3)	No	6.9(±3.8)	.614
Is internet a source of knowledge?	Yes	7.8(±3.4)	No	7.0(±3.5)	1.422
Are books sources of knowledge?	Yes	10.0(±2.4)	No	7.0(±3.4)	1.711

* 0.05 <P-value >0.01 ** P-value <0.01 no* P-value >0.05

3.4 Eye care services attendance

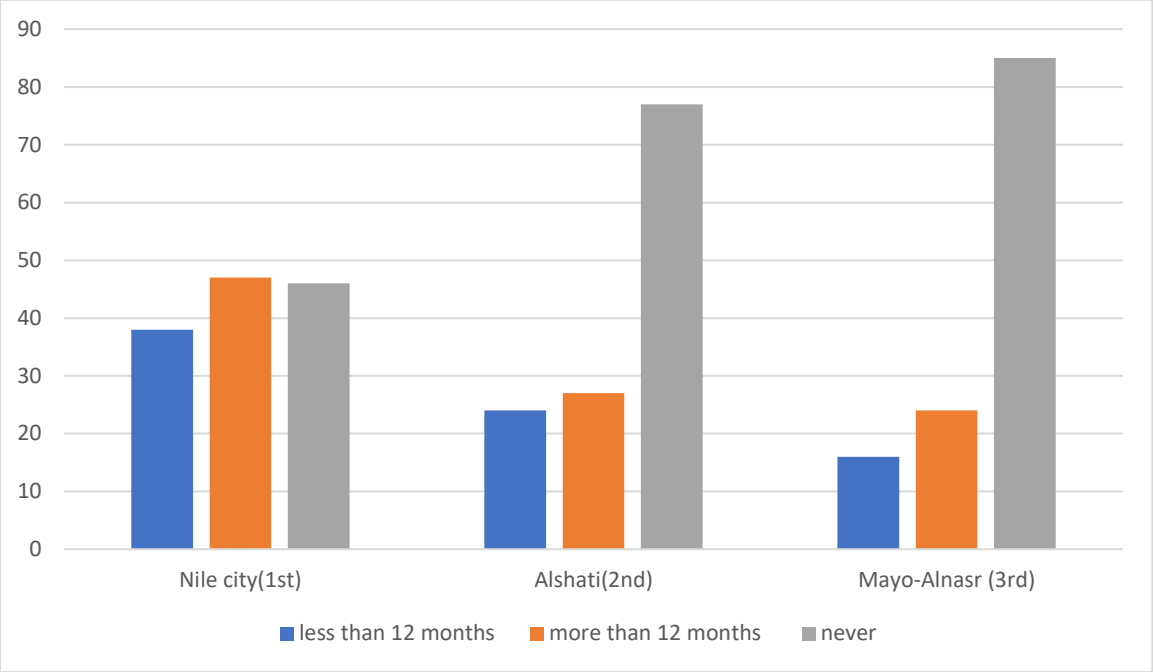

Figure 5: *Timing of the last ophthalmologist visit among adults in the three areas with different socioeconomic status in Khartoum state 2020 (n=384)*

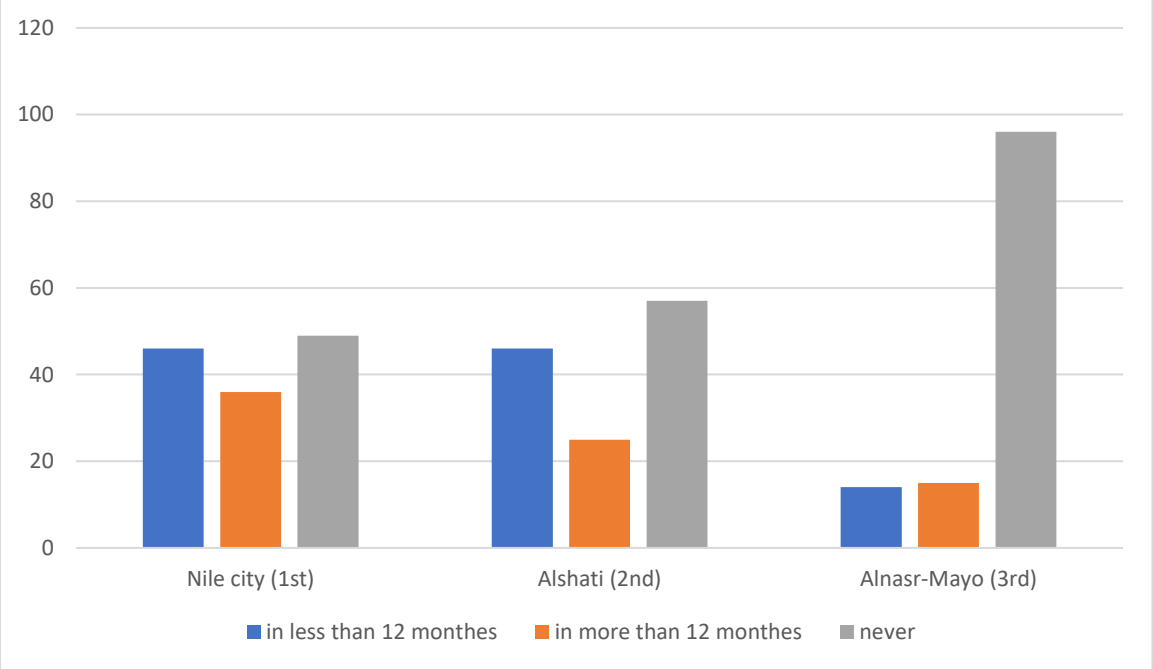

Figure 6: *Timing of the last optometrist visit among adults in the three areas with different socioeconomic status in Khartoum state 2020 (n=384)*

Figure No. (5) And (6) show ophthalmologist and optometrist services use among the three areas, respectively. Nine out of 41 (22%) of those above 61 years didn't attended an ophthalmologist before, (24%) of this group attended in more than 12 months, refer to figure (7) which shows ophthalmologist service attendance across the different age groups. Out of 64 who were 46-60 years, 35.9% of them never attended an optometrist before 40.6% of them attended in more than 12 months. 12 out 41 (29%) of those

above 61 years didn't attend an optometrist before, 7 (17%) of this group attended in more than 12 months. Out of 64 who were 46-60 years 28% of them never attend an optometrist before, and 30% of this age group attended in more than 12 months, refer to figure (8) which shows optometrist service attendance across the different age groups.

Attendance of ophthalmologic services was associated positively with having a positive family history of blindness (AOR = 2.4, P=0.02) but, negatively associated with no formal education (AOR =0.2, P<0.01), primary education (AOR= 0.2, P<0.01) and secondary education (AOR =0.3, P<0.01) in comparison with university education level and above, see table (6). Residing in Nile city (1st) was associated strongly positive with attending an ophthalmologist service (AOR=3.6, P<0.01) in comparison with Mayo-Alnasr (3rd) and Alshati (2nd) (AOR=3.4, P=.0 <0.01). females were more likely to attend than men (AOR=1.8, P=0.03). diagnosis of diabetes Mellitus, hypertension, or both increased the chances to attend an ophthalmology service by more than two times (AOR=2.5, P=0.02). Marital status had no effect on attendance of ophthalmology services in this study.

Table 6: *Ophthalmologist attendance of high-risk groups of blindness in the three areas in Khartoum state(n=384). n(%)*

Have you attended an ophthalmologist?	Attend***	Never attend	AOR
Family history of blindness:			
Yes	30(17%)	17(8%)	
No	146(83%)	191(92%)	0.46*
Educational level:			
No formal education	24(14%)	37(19%)	4.13**
Primary education	20(11%)	46(22%)	4.29**
Secondary education	25(14%)	50(24%)	2.95**
University and above	107(61%)	75(36%)	

*P<0.05 **P<0.01 ***reference category

Attendance of optometric services was associated positively with a positive family history of blindness (AOR=2.3, P=0.02) in comparison with those who have a negative family history of blindness but, negatively with no formal education (AOR=0.1, P<0.01), primary education (AOR=0.2, P<0.01) and secondary education (AOR=0.3, P<0.01) in comparison with university and above. Refer to Table (7). Residing in Nile City (1st) and Alshati (2nd) was strongly positive associated with attending an optometric service (AOR=5.2, P<0.01 and AOR=3.5, P<0.01 respectively) in comparison with Mayo-Alnasr (3rd) but there was no significant difference between the first and the second areas (P=0.14). females attended more than men (AOR=2.0 P=0.01). Diagnosis of either Diabetes Mellitus, hypertension, or both increases the chances of attending an optometric service (AOR=1.7, P=0.02).

Table 7: *optometrist attendance level of high-risk groups of blindness in the three areas in Khartoum state(n=384). N(%)*

Have you attended an optometrist?	Attend***	Never attend	AOR
Family history of blindness:			
Yes	31(17%)	16(8%)	
No	151(83%)	186(92%)	0.4*
Educational level:			
No formal education	20(11%)	41(20%)	7.9**
Primary education	20(11%)	46(23%)	5.4**
Secondary education	28(15%)	47(23%)	2.9**
University and above	114(63%)	68(34%)	

*P<0.05 **P<0.01 ***reference category

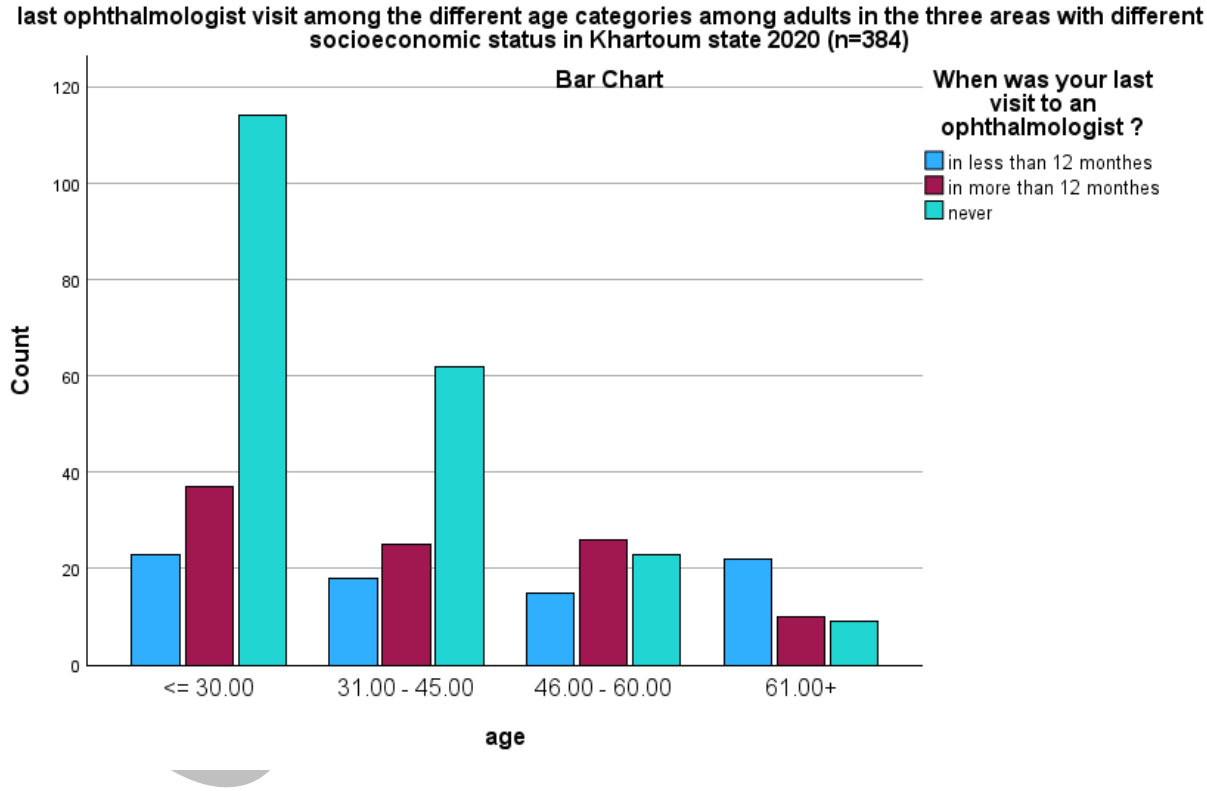

Figure 7: *Last ophthalmologist visit among the different age categories among adults in the three areas with different socioeconomic status in Khartoum state 2020 (n=384)*

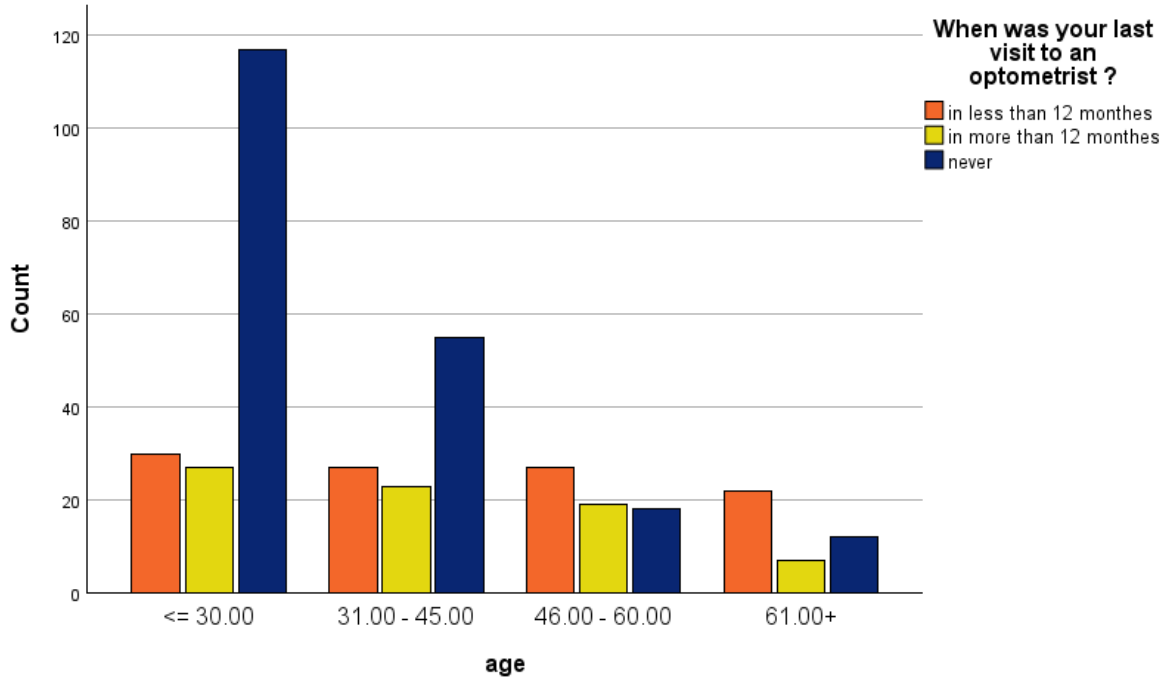

Figure 8: *Last optometrist visit among the different age categories among adults in the three areas with different socioeconomic status in Khartoum state 2020 (n=384)*

4 Discussion

Our study's overall level of awareness was 62%, which is higher than the studies of: Bangladesh (7%),[24] Gondar Town (35.1%),[25] Abokobi, Ghana (39 %),[26] Osun State (15.8%),[27] Gish-Abay Town, Northwest Ethiopia (24.4%),[28] Urban Puducherry (45.45%),[29] Tehran study (46.6%) [30]. The awareness level in the current study was nearly similar to Kumasi, Ghana (60%) [31] but, lower than the studies Abha (77.1%) and Hong Kong (86.94%)[32], [33]. In the Gondar study[25] only 17% had college and above education and those with no formal education were 32.7%; this study showed that the first-tier residents are more than ten times more aware than the third area. The probability that the residents of the first and second-tier areas were aware was eight and five times more than the third-tier area after adjusting age and income as confounding factors to guard against the fact that the population of the third-tier area were younger than the other groups. This difference in awareness level can be explained by the difference in educational level among the residents; residing in the high and middle socioeconomic areas associated with 42 and 19 times more chance to have a university degree in comparison to no formal education; in comparison with the low socioeconomic area. Obtaining Secondary and University and above degrees increased glaucoma awareness by 6 and 11 times, respectively; in contrast to having no formal education; this could explain why our study has a higher awareness level in comparison to Agaro town, Southwestern Ethiopia study as about half of the participants there were illiterate [34], [35]. This study found that younger tend to have less knowledge about the disease, and this is comparable with other studies [25]. This is logical because the most important source of awareness in my study is the local community who are either relatives, friends, or neighbors of those who have glaucoma- who are classically elderly. Wearing medical eyeglasses and diagnosis of refractive error increases the awareness of glaucoma and this is similar to another study [37]. This study showed no statistical difference between gender and awareness this is dissimilar to other studies, which showed male gender as a determinant for low awareness [38], [39], [40], [41]. The history of attending an ophthalmological clinic for examination is associated with better glaucoma awareness and this is similar to the findings of 2 old studies in the USA and Melbourne [18]. The leading source of awareness in this study was the local community- followed by ophthalmologists. This study shows that:

ophthalmologists are not just a major source of awareness, but also associated with increasing the knowledge of the community. This is consistent with the findings of the study on the urban population in southern India in 2001 and the study in Riyadh city [25]. Ophthalmologists were found to be the most important source of information in Pakistan study [23]. The major source of information was the TV in Rural Population of Southern India 2005, Glaucoma patient and their Normal First-Degree Relatives Turkey, the study on Ethiopians in a Tertiary Eye Care Center and Kumasi, Ghana [22]. Friends were the major source in the German survey [8]. Books in this study constituted just 2% of the sources of awareness, which is lower than the Riyadh study (29%) [44].

Good glaucoma knowledge was present in 29% of the total population (48% of the aware population) which is comparable to the Tehran study. Our study showed that good knowledge didn't have an association with: gender, family history of blindness, attendance of optometric service, attendance of ophthalmologic service, refractive error, educational level, monthly income, or marital status and this result is different from the study in Australia[37] where education was associated with better knowledge about the disease. Interestingly, those who were aware of glaucoma in the first-class area appeared to have poorer knowledge than those who were aware and living in the third-class area. This difference was most likely due to the fact that: a large proportion of the residents in the first area had just heard about glaucoma without acquiring sufficient knowledge about it in comparison to those in the third area with a larger proportion of no awareness from the start. Moreover, residents of the second-class area have relatively better knowledge, this is most likely because the local community was the most important source of information and there may be differences in societies between the groups but still this is an area for more research; because other factors rather than the socioeconomic status may affect the knowledge. Forty-five percent (28% of the total population) of those who were aware recognized the glaucoma definition and this is similar to the result of the Philadelphia study[45], but there is a difference in the variable measurement methodology between the studies. This study used closed-ended questions with "yes" and "No" answers whereas the American study used more strict criteria, i.e., open-ended questions. This study result is higher than the Population-Based Survey Tehran [30] (19.2%)and the German survey (8.4%)[8] but is lower than the Gondar study [25].

Our study found that educational level is associated with awareness but plays no role in glaucoma knowledge difference and this is similar to the study of Abokobi Ghana [26]. In our study, 52% of those who were aware (32% of the total sample) realized that glaucoma is treatable. This is higher than what was in the Tehran study (23% of the total) but, lower than the study in a tertiary center in Ethiopia (94.7%) because the study area of the latter research was hospital-based in which more knowledgeable about the disease. The most known therapeutic measures of glaucoma in this study were Surgery (134 i.e. 57% among the aware, 35% among the total), medical (130 i.e. 55% among the aware, 34% among the total), and laser (92) i.e. 39% among the aware group, 24% among the total). This study found that 84 (36% of those who were aware, 22% of the total population) of the participants knew that glaucoma patients can be asymptomatic and this is higher than the results of the Tehran study (7.1%)[30] and lower than the Ethiopian study in a Tertiary Eye Care Center (78.6%) [46]. This study found that 133(57% of the aware, 35% of the total sample) knew that genetic factors are risk factors for glaucoma. This result is nearly similar to the study in the Eye Clinic of a Secondary Health Care Facility in South-East, Nigeria 2010[27] which found that 31.5% knew that glaucoma may be familial. However, the Nigerian study was in glaucomatous patients my study showed slightly higher results. Forty-six percent of the participants of the Nigerian study [27] knew that glaucoma leads to progressive blindness this is in contrast to 59(25% of the aware, 15.4% of the total population) in my study. When residents obtain information about glaucoma from ophthalmologists, they retain better information about the disease and this is consistent with the findings of a Jordanian study [47]. We recommend that the ophthalmologists should conduct health education campaigns in all areas of Khartoum state and Sudan in general, with special consideration to the population with low education to address the gap between awareness and knowledge [48], [49].

In our study, 176(45.8%) had a history of attendance to an ophthalmological service and this is higher than what was found in the Abokobi, Ghana study [26]. Twenty percent of the adult population attended an ophthalmologic clinic in the last year and this is higher than the results of Bangladesh population-based diabetes and eye study (BPDES)[24]. In our study, residents of the first-tier areas had a four-time chance to attend than the third-tier area and this may explain why those who live in the low-ranking area residents presents more likely with severe glaucoma [50]. Residents of the third-tier area are associated with less attendance to optometrists who are considered an important source for referral of glaucoma patients with the privilege especially early in the disease course [12]. Therefore, we could conclude that residents of the third tier area have another risk factor to present late during the disease course; so we recommend that: screening programs should target these areas because of the low socioeconomic status, educational level, and attendance pattern of eye care services [51]. Low education and a family history of blindness are risk factors for blindness in Sudan [7]. This study found that having no formal, primary, or secondary education decreases the chances of attending optometric services 9,6, or 3 times less than those with university or above level, respectively. Similarly, having no formal, primary, or secondary education decreases chances of attending ophthalmological services 3-4 times less than those with university or above level. Nevertheless, interestingly those with a family history of blindness have higher chances of attending both ophthalmological and optometric services more than two times. This may be due to shared genetic or environmental factors that predispose to an eye disease that requires attending these services. We recommend future research to determine whether this is due to secondary or tertiary prevention. Family history of blindness is significantly low in the high-tier area compared with the other areas. This may reflect the better attendance of eye care services, which promotes eye health by increasing secondary or even tertiary prevention of blindness. We recommend health education programs targeting family members of those who are blind to increase their level of knowledge about glaucoma and other eye diseases. This study links residing in the high-tier area positively with attendance of ophthalmological services and obtaining a university degree and -interestingly- negatively with the family history of blindness; we recommend more studies involving this area in the future. We recommend further studies about the risk factors of blindness among the different socioeconomic areas in Sudan and its correlation with the findings of this study. We also recommend studies to explore the reasons for attendance of eye care services for those with a positive family history of blindness whether this is for secondary or tertiary preventive motives.

5 Conclusion

This study reflects that the awareness of glaucoma is low in low socioeconomic areas. Diabetic, hypertensive, using medical eyeglasses, having secondary and university educational level, diagnosed with refractive error, positive family history of blindness, history of attending eye care services are determinants of glaucoma awareness. The high awareness in the population was not translated into good knowledge. The most important source of information was the local community, but ophthalmologists as a source were associated with better knowledge. Attendance of eye care services associates positively with family history of blindness and residing in the first socioeconomic area but negatively with educational level other than university level.

6 Declarations

6.1 Study Limitations

Data collection was at the time of the COVID-19 pandemic so many problems were faced during data collection because of the risk of acquiring or transmitting the infection. the study area was limited to only 3 areas in Khartoum state but sampling inside the same area was randomized. Access to the female population during data collection was harder due to social reasons in some communities in this study. The researcher faced financial constraints, which limited the achievement of more widespread and better-quality cluster sampling at the level of the whole state.

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6.3 Informed consent

Informed consent was taken from each of the participants of the study.

6.4 Competing interests

The authors declare no competing interests.

6.5 Publisher's Note

AIJR remains neutral with regard to jurisdictional claims in published institutional affiliations.

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