

# Impact of Sociodemographic and Psychological Factors on Adherence to Glaucoma Treatment - A Cross-Sectional Study

Katarzyna Malewicz<sup>1</sup>, Aleksandra Pender<sup>2</sup>, Mariusz Chabowski<sup>3,4</sup>, Beata Jankowska-Polańska<sup>5,6</sup>

<sup>1</sup>Division of Family and Pediatric Nursing, Department of Nursing and Obstetrics, Faculty of Health Science, Wrocław Medical University, Wrocław, Poland; <sup>2</sup>Student Research Group No. 180, Faculty of Medicine, Wrocław Medical University, Wrocław, Poland; <sup>3</sup>Department of Surgery, 4th Military Clinical Hospital, Wrocław, Poland; <sup>4</sup>Department of Clinical Surgical Sciences, Faculty of Medicine, Wrocław University of Science and Technology, Wrocław, Poland; <sup>5</sup>Department of Preclinical Sciences, Pharmacology and Medical Diagnostics, Faculty of Medicine, Wrocław University of Science and Technology, Wrocław, Poland; <sup>6</sup>Center for Research and Innovation, 4th Military Clinical Hospital, Wrocław, 50-981, Poland

Correspondence: Mariusz Chabowski, Email [mariusz.chabowski@gmail.com](mailto:mariusz.chabowski@gmail.com)

**Introduction:** Glaucoma is a group of eye diseases characterized by progressive and irreversible damage to the optic nerve. The aim of the study was to examine the impact of sociodemographic and psychological factors on adherence to glaucoma therapy.

**Methods:** The study was carried out among 190 adults treated for glaucoma at the Ophthalmology Outpatient Clinic of the University Teaching Hospital in Wrocław between January 2019 and September 2019. Treatment adherence was measured using the Adherence to Refills and Medications Scale (ARMS). We used the Acceptance of Illness Scale (AIS), the Revised Life Orientation Test (LOT-R) and the Satisfaction with Life Scale (SWLS).

**Results:** 58.9% patients reported low treatment adherence. Educated females aged 68 or under living in cities had higher adherence. The regression analysis showed an association between dispositional optimism and glaucoma treatment adherence. The higher the level of dispositional optimism, the better the adherence. Higher dispositional optimism is directly associated with a sense of self-esteem and self-efficacy and a feeling of internal control. Patients reporting a high level of illness acceptance were found to have 2.5 times higher odds of adhering to glaucoma therapy. Illness acceptance is an indicator of the degree of adaptation to an illness and is positively correlated with a sense of self-esteem and self-efficacy and engagement in healthy behavior.

**Conclusion:** More than half of patients with glaucoma have low adherence. Sociodemographic characteristics (female gender, age 68 or under, tertiary education and living in an urban area) and psychological characteristics (high level of illness acceptance, dispositional optimism and satisfaction with life) are significant predictors of high adherence.

**Keywords:** glaucoma, adherence, LOT-R, acceptance, SWLS

## Introduction

Glaucoma is a group of eye diseases characterized by progressive and irreversible damage to the optic nerve. The main risk factor for glaucoma is raised intraocular pressure (IOP), which leads to the loss of retinal ganglion cells (GCs) and retinal nerve fiber layer (RNFL) thickness. The damage to the optic nerve results in loss of peripheral and then central vision, leading to significant limitations in daily living. There are two main types of glaucoma, which have different pathological mechanisms: primary open-angle glaucoma (POAG) and primary angle-closure glaucoma (PACG). Glaucoma can also develop secondary to other eye disorders.<sup>1</sup>

Glaucoma is the second most common cause of blindness, following cataract, and the fourth most common cause of moderate and severe vision impairment globally in people over the age of 50. It is also the leading cause of irreversible blindness, because unlike cataract, which is effectively treated with surgery, there is no known method of regeneration of the damaged optical nerve.<sup>2,3</sup>

The number of people affected by glaucoma is growing. It is estimated that 60.5 million adults over the age of 40 had glaucoma in 2010. This number increased to 79.6 million in 2020.<sup>4</sup> By 2040, an estimated 111.8 million people older than 40 years will have glaucoma worldwide.<sup>5</sup> The prevalence of glaucoma increases with age, which is particularly important in the context of the ageing of populations.<sup>6</sup>

The criteria for diagnosing glaucoma typically include a combination of clinical assessments and tests, focusing on the examination of visual acuity, IOP, and the anterior and posterior segments of the eye. Visual acuity tests, such as the Snellen Chart and LogMAR Chart, measure the clarity or sharpness of vision and are vital for determining how well a person can see details at various distances. Near vision tests and automated refraction also contribute to this assessment.<sup>7</sup> Measuring IOP is crucial for diagnosing and managing glaucoma, with methods including Goldmann applanation tonometry (the gold standard), non-contact tonometry (air-puff tonometry), Tonopen, and rebound tonometry.<sup>8,9</sup> Elevated IOP (above 21 mmHg) is a significant risk factor, although glaucoma can occur with normal IOP (normal-tension glaucoma).<sup>10</sup> Examination of the anterior segment involves the use of slit-lamp examination to assess the front part of the eye, including the cornea, iris, and lens. Gonioscopy, pachymetry, and anterior segment optical coherence tomography (AS-OCT) are essential for visualizing the drainage angle, measuring corneal thickness, and providing detailed images of the anterior segment, respectively. Examination of the posterior segment focuses on the retina, optic nerve, and vitreous using techniques such as direct and indirect ophthalmoscopy, fundus photography, optical coherence tomography (OCT), and visual field testing (perimetry). Signs of the optic nerve damage include increased cupping (cup-to-disc ratio greater than 0.5), thinning of the neuroretinal rim, and notching.<sup>6</sup>

According to current medical knowledge, glaucoma is an irreversible condition and the aim of treatment is to slow, as much as possible, the progression of damage to the optic nerve and preserve vision. The only proven treatment is to lower intraocular pressure using medications, lasers or surgery. Medical treatment of glaucoma involves topical drugs delivered as eye drops.<sup>1</sup> Given the irreversible and progressive nature of glaucoma, patient-doctor cooperation and patient adherence to therapy play a key role, affecting the effectiveness of treatment and prognosis.<sup>11</sup>

Since glaucoma is often asymptomatic and requires life-long treatment, which does not result in subjective improvement, individuals with glaucoma are at increased risk of non-adherence to treatment.<sup>12,13</sup>

Treatment adherence is defined as active and voluntary cooperation between the patient and the doctor or other healthcare professional which requires their commitment and acceptance of the course of treatment.<sup>14</sup> Non-adherence means not taking medications as prescribed, skipping doses or failing to attend follow-up appointments. In the literature the percentage of the patients adherent to their glaucoma treatment varies from 5% to 80%.<sup>15</sup> The difference in results is likely due to different inclusion criteria and various methods of measuring adherence. The most common methods used by researchers include self-reported questionnaires, rate of refilling prescriptions and electronic medication monitoring.<sup>16</sup>

Adherence to treatment in chronic diseases is influenced by a multifaceted set of factors that can be broadly categorized into four general groups: patient-related, disease-related, provider-related and socio-economic factors. Patient-related factors include, among others, age, gender, education, place of residence and psychological characteristics.<sup>17</sup>

The aim of the study was to examine the impact of sociodemographic and psychological factors on adherence to glaucoma therapy.

## Materials and Methods

### Material

The study was carried out among 190 adults treated for glaucoma at the Ophthalmology Outpatient Clinic of the University Teaching Hospital in Wrocław between January 2019 and September 2019.

The inclusion criteria were as follows: patients were aged 18 years or over; at least 6 months after the diagnosis of glaucoma; receiving pharmacological treatment; able to complete a questionnaire independently; able and willing to give consent to participate in the study.

The exclusion criteria were as follows: age under 18 years; glaucoma diagnosed less than 6 months prior to inclusion in the study; lack of consent to participate in the study; cognitive function impairment (MMSE score <24); lack of the

manual dexterity required to correctly instill glaucoma eye drops independently (reliance on others); significant exacerbation of a chronic condition. Exacerbation, that is: noticeable worsening of symptoms or need for medical intervention, such as a change in medication, hospitalization or other medical procedures that were not previously necessary, in the 3 months prior to this study.

The study was approved by the Bioethics Committee of the Wrocław Medical University (KB 305/2018). All the patients included in the study received written information about the aim of the study and provided written informed consent to participate. Each patient was surveyed during one of their follow-up visits to the ophthalmology clinic.

## Methods

All the patients completed a self-administered questionnaire including standardized research measures.

Treatment adherence was measured using the Adherence to Refills and Medications Scale (ARMS).<sup>18</sup> It consists of 12 questions about, among other things: remembering to take medications, taking medications at the prescribed dose and timing, filling prescriptions as well as planning ahead and refilling medications before they run out to avoid treatment interruptions. Respondents are asked to rate each item on a four-point Likert scale (1 - none of the time, 2 - some of the time, 3 - most of the time, 4 - all of the time). The total score ranges from 12 (optimum level of adherence) to 48 (complete non-adherence to medications). A Polish language version of the questionnaire was used in the study. Its satisfactory psychometric properties were confirmed in a study among patients with hypertension.<sup>19</sup> The patients included in the present study were divided into two groups according to the level of treatment adherence: group I – low adherence (score of 16–48), and group II – high adherence (score of 12–15). For the purpose of this study, we examined the psychometric properties of the questionnaire among glaucoma patients. Results confirmed that the instrument has appropriate psychometric properties among individuals with glaucoma (Cronbach's alpha  $\alpha=0.726$ , mean inter-item correlation  $r=0.187$ ).

We used the Acceptance of Illness Scale (AIS) developed by Felton et al to measure the patients' mental adjustment to their illness.<sup>20</sup> The scale consists of eight statements concerning the perceived limitations imposed by the illness, lack of independence, perceived dependence on others and reduction in self-esteem. Respondents are asked to rate each statement on a scale from 1 ("strongly agree") to 5 ("strongly disagree"). The total score ranges from 8 to 40, with higher scores indicating a higher level of illness acceptance. The patients included in the study were categorized into three groups according to the level of illness acceptance: score of 8–18 – lack of illness acceptance (strong feeling of mental discomfort); score of 19–29 – moderate level of acceptance; score of 30–40 – good illness acceptance (absence of negative emotions relating to the illness). The Polish adaptation of the AIS by Juczyński was used in the study.<sup>21</sup>

We used the Revised Life Orientation Test (LOT-R) developed by Scheier and Carver, adapted into Polish by Poprawa and Juczyński, to measure dispositional optimism and life orientation in the patients included in the study.<sup>22</sup> Dispositional optimism is considered a stable personality trait characterized by a tendency to anticipate positive outcomes across various life situations.<sup>23,24</sup> The test consists of 10 statements, six of which are diagnostic. Respondents are asked to rate each statement on a 5-point Likert scale, where 0 = "strongly agree" and 4 = "strongly disagree". The total score ranges from 0 to 24. The higher the score, the higher the level of optimism. For easier interpretation, raw scores can be converted to Standard Ten Scores (sten scores) ranging from 1 to 10. The patients included in the study were classified into three groups according to their scores on the LOT-R: patients with low dispositional optimism (stens 1–4), those with a moderate level of dispositional optimism (stens 5–6) and those with high dispositional optimism (stens 7–10).

The Satisfaction with Life Scale (SWLS) developed by Diener et al, adapted into Polish by Juczyński, was also used in the present study.<sup>25</sup> The scale consists of five items scored on a scale from 1 ("strongly disagree") to 7 ("strongly agree"). The total score, which is calculated as the sum of all item scores, indicates the respondent's level of satisfaction with life and ranges from 5 to 35. The higher the score, the higher the level of satisfaction with life. Raw scores on the scale can be converted to sten scores. Sten scores of 1–4 were deemed to indicate a low level of satisfaction, sten scores of 5–6 were deemed to indicate a moderate level satisfaction and sten scores of 7–10 were deemed to indicate a high level of satisfaction with life.

# Statistical methods

The results of the survey were analyzed statistically. The normality of distribution of all quantitative variables (age, duration of glaucoma, scores on psychometric measures, etc.) was tested using the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Quantitative variables were reported as means (M), standard deviations (SD), medians (Me), lower (Q1) and upper (Q3) quartiles and minimum (Min), and maximum (Max) values. The significance of differences between mean values in two groups for parameters showing distributions significantly different from normality or showing heterogeneous variance was tested using the Mann–Whitney *U*-test. Hypotheses about the lack of correlations between qualitative variables were tested using the Pearson’s chi-squared test or the Fisher’s exact test. Cut-offs for continuous variables (eg age) and discrete variables (scores on psychometric measures) were determined using ROC (Receiver Operating Characteristic) curves and Youden’s index. The diagnostic (classification) ability of the parameters analyzed was evaluated using the Area Under the ROC Curve (AUC). In addition, sensitivity and specificity were estimated for cut-offs for dichotomous variables. In order to identify independent predictors of an acceptable level of adherence, multiple logistic regression analysis (using backward elimination) was carried out. Statistical significance was set at  $p < 0.05$  for all statistical tests. Statistical analysis was carried out using STATISTICA v.13.3 (TIBCO Software Inc).

# Results

## Sociodemographic Characteristics of the Study Group

The study included 190 glaucoma patients: 124 women (65.3%) and 66 men (34.7%) aged between 25 and 88 ( $M = 69$ ,  $SD = 11.2$ ). The majority of the patients had secondary (36.3%) or vocational education (32.1%) and were retired at the time of the study (77.9%). Most patients were in a relationship (65.8%) and living with a partner (45.3%) or family (44.2%). A total of 68.4% of the patients lived in urban areas. 75% of the patients had other systemic co-morbidities, such as hypertension, diabetes, asthma, osteoporosis and kidney failure. Patients’ characteristics are shown in [Table 1](#).

**Table 1** General Characteristics of the Patients Studied

Feature (Variable)	Total N = 190	
Sex:	<i>n</i>	%
Males	66	34.7
Females	124	65.3
Age (years)		
<i>M</i> ± <i>SD</i>	69.0 ± 11.2	
<i>Me</i> [Q1; Q3]	70 [63; 77]	
<i>Min.</i> - <i>Max.</i>	25–88	
Education:	<i>n</i>	%
Primary	32	16.8
Vocational	61	32.1
Secondary	69	36.3
Tertiary	28	14.7
Relationship status:	<i>n</i>	%
Single	65	34.2
In a relationship	125	65.8
Employment status:	<i>n</i>	%
Employed	31	16.3
Student	1	0.5
Disability pensioner	6	3.2
Old-age pensioner	148	77.9
Unemployed	4	2.1

(Continued)

**Table 1** (Continued).

Feature (Variable)	Total N = 190	
Place of residence:	<i>n</i>	%
Rural area	60	31.6
Urban area	130	68.4
Living arrangement status:	<i>n</i>	%
Lives with a spouse/partner	86	45.3
Lives with family	84	44.2
Lives alone	20	10.5
Systemic co-morbidities	<i>n</i>	%
Hypertension	89	46.8
Diabetes	40	21.1
Asthma	5	2.6
Osteoporosis	5	2.6
Kidney failure	4	2.1
No other systemic co-morbidities	47	24.7

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; *n*, number; %, percentage.

## Clinical Characteristics of the Study Group

The largest proportion of the patients studied (44.7%) had been diagnosed with glaucoma more than 10 years prior to inclusion in the study. All patients were receiving pharmacological treatment. Some patients had also undergone laser treatment (10.5%) or surgery (12.1%). Most patients were using only one glaucoma eye drop (62.1%). The majority of patients (69.5%) were using their glaucoma eye drops twice daily. The data are shown in [Table 2](#).

**Table 2** Clinical Characteristics of the Glaucoma Patients Studied

Feature (Variable)	Total N = 190		Test Result <i>p</i>
Duration of glaucoma (years) <i>M</i> ± <i>SD</i> <i>Me</i> [Q1; Q3] <i>Min.</i> - <i>Max.</i>	11.3 ± 6.8 10 [5; 15] 1–40		0.211
Duration of glaucoma: 1–5 years 6–10 years > 10 years	<i>n</i> 48 57 85	% 25.3 30.0 44.7	0.660
Type of glaucoma treatment*: Medications Laser treatment Surgery	<i>n</i> 190 20 23	% 100.0 10.5 12.1	1.000 0.784 0.812
Number of glaucoma medications currently used: 1 2 3	<i>n</i> 118 62 10	% 62.1 32.6 5.3	0.811

(Continued)

**Table 2** (Continued).

Feature (Variable)	Total N = 190		Test Result <i>p</i>
How many times a day?:	<i>n</i>	%	0.141
1	51	26.8	
2	132	69.5	
3	7	3.7	

**Notes:** \*Percentages do not add to 100% as multiple responses were allowed.

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

## Results of the Assessment of Selected Psychological Characteristics in the Glaucoma Patients Studied

### Results of the Measurement of Dispositional Optimism Using the LOT-R

The mean score on the LOT-R was  $14.8 \pm 3.0$ , which corresponds to a sten score of  $5.6 \pm 1.5$ . Most patients (44.7%) reported a moderate level of optimism. The results are shown in [Table 3](#).

### Results of the Measurement of Life Satisfaction Using the SWLS

The mean score on the SWLS was  $21.8 \pm 4.0$ , which corresponds to a sten score of  $5.9 \pm 1.4$ . Most patients reported a moderate (54.2%) or high (34.7%) level of satisfaction with life. The results are shown in [Table 4](#).

### Results of the Measurement of the Level of Illness Acceptance Using the AIS

The mean score on the AIS was  $33.6 \pm 6.4$ . The vast majority of the patients (74.2%) reported a high level of illness acceptance. The results are shown in [Table 5](#).

**Table 3** Results of the Measurement of Dispositional Optimism (LOT-R)

LOT-R	M ± SD	Me (Q1; Q3)	Min. - Max.
Total score	14.8 ± 3.0	15 (12, 17)	7–23
Sten score	5.6 ± 1.5	6 (4, 7)	2–10
Level of dispositional optimism:	N (%)		
Low (stens 1–4)	51 (26.9%)		
Moderate (stens 5–6)	85 (44.7%)		
High (stens 7–10)	54 (28.4%)		

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

**Table 4** Results of the Measurement of Life Satisfaction (SWLS)

SWLS	M ± SD	Me (Q1; Q3)	Min. - Max.
Total score	21.8 ± 4.0	22 (20, 25)	5–33
Sten score	5.9 ± 1.4	6 (5, 7)	1–10
Level of satisfaction with life:	N (%)		
Low (stens 1–4)	21 (11.1%)		
Moderate (stens 5–6)	103 (54.2%)		
High (stens 7–10)	66 (34.7%)		

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

**Table 5** Results of the Measurement of the Level of Illness Acceptance (AIS)

AIS	M ± SD	Me (Q1;Q3)	Min. - Max.
Total score	33.6 ± 6.4	36 (29, 39)	12–40
Level of illness acceptance:	N (%)		
Low (score of 8–18)	4 (2.1%)		
Moderate (score of 19–29)	45 (23.7%)		
High (score of 30–40)	141 (74.2%)		

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

## Results of the Measurement of Treatment Adherence

The mean score on the ARMS was  $16.3 \pm 2.7$ . More than half of the patients (58.9%) reported low adherence. The results are shown in Table 6.

## Analysis of the Impact of Selected Sociodemographic Characteristics on Treatment Adherence

The comparative analysis showed that female patients had better adherence than male patients ( $15.7 \pm 2.5$  vs  $17.3 \pm 2.7$ ). Our analysis showed that female sex is a statistically significant factor positively influencing adherence ( $p < 0.001$ ). The comparative analysis showed no statistically significant relationship between the level of treatment adherence and other analyzed sociodemographic factors. The results are shown in Table 7.

**Table 6** Results of the Measurement of Glaucoma Medication Adherence (ARMS)

	M ± SD	Me (Q1; Q3)	Min. - Max.
Total score	16.3 ± 2.7	16 (14, 18)	12–25
Level of adherence:	N (%)		
Low (score of 16–48)	112 (58.9%)		
High (score of 12–15)	78 (41.1%)		

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

**Table 7** Adherence to Treatment (ARMS) by Sociodemographic Characteristics

Patients	N	M ± SD	Me [Q1 – Q3]	Min. - Max.	p
All patients	190	16.3 ± 2.7	16 [14; 18]	12–25	-
Sex:					<0.001
Female	124	15.7 ± 2.5	15.5 [13; 17]	12–25	
Male	66	17.3 ± 2.7	17 [16; 19]	12–25	
Education					0.238
Primary	32	16.3 ± 2.4	16 [15; 18]	12–23	
Vocational	61	16.8 ± 2.8	17 [15; 18]	13–25	
Secondary	69	16.0 ± 2.7	16 [14; 18]	12–25	
Tertiary	28	15.8 ± 2.6	16 [14; 17]	12–23	

(Continued)

**Table 7** (Continued).

Patients	N	M ± SD	Me [Q1 – Q3]	Min. - Max.	p
Marital status					0.667
Single	65	16.1 ± 2.4	16 [14; 18]	12–25	
In a relationship	125	16.4 ± 2.8	16 [14; 18]	12–25	
Employment status					0.412
Employed	31	16.4 ± 3.6	16 [13; 18]	12–25	
Student	1	13	13	13–13	
Disability pensioner	6	17.8 ± 3.2	18 [16; 20]	13–22	
Old-age pensioner	148	16.2 ± 2.4	16 [14; 18]	12–25	
Unemployed	4	17.0 ± 4.0	15 [15; 19]	15–23	
Place of residence:					0.118
Rural area	60	16.6 ± 2.5	16 [16; 18]	12–23	
Urban area	130	16.1 ± 2.8	16 [14; 18]	12–25	
Living arrangement status:					0.804
Lives with a spouse/partner	86	16.4 ± 2.9	16 [14; 18]	12–25	
Lives with family	84	16.3 ± 2.7	16 [14; 18]	12–25	
Lives alone	20	15.8 ± 1.8	16 [15; 17]	12–19	

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number.

Univariate logistic regression analysis showed that female sex ( $b=1.14$ ;  $p < 0.001$ ), age  $\leq 68$  years ( $b=0.82$ ;  $p < 0.007$ ) and living in an urban area ( $b=1.04$ ;  $p < 0.003$ ) are factors positively influencing adherence.

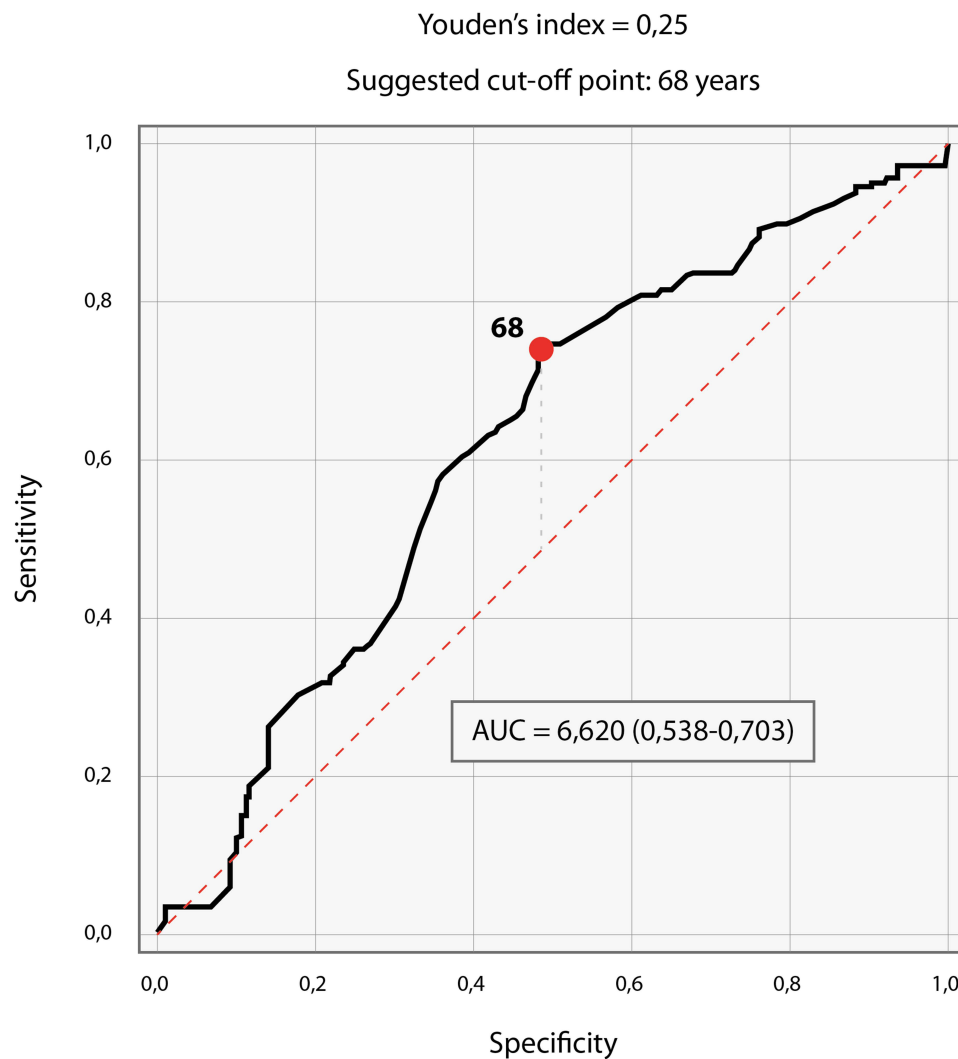
The multiple logistic regression analysis demonstrated that female sex ( $b=1.13$ ;  $p < 0.002$ ), age  $\leq 68$  years ( $b=0.89$ ;  $p < 0.008$ ) and living in an urban area ( $b=0.93$ ;  $p < 0.024$ ) were statistically significant independent predictors of adherence. Women had more than 3 times higher odds of adherence than men ( $OR=3.10$ ), patients living in an urban area had 2.5 times higher odds of adherence than patients living in a rural area ( $OR=2.53$ ), and patients aged 68 or under had nearly 2.5 times higher odds of adherence compared to older patients ( $OR=2.43$ ). The results are shown in Table 8.

A ROC curve was used to determine the cut-off value for age (Figure 1). For age  $\leq 68$  years, the sensitivity of the test was 74.1%, specificity was 51.3%, and the AUC was 0.620. The lower bound of the 95% confidence interval for the AUC was 0.538 and was greater than the acceptable value of 0.5, which is to be interpreted as meaning that a test based on patient age may be useful in classifying patients as adherent or not.

**Table 8** Logistic Regression Analysis of Adherence to Treatment by Sociodemographic Characteristics

Predictor	Univariate Regression Analysis			Multiple Regression Analysis		
	b	p	OR (95% CI)	beta	p	OR (95% CI)
Female sex	1.14	<b>&lt;0.001</b>	<b>3.12 (1.61–6.07)</b>	1.13	<b>0.002</b>	<b>3.10 (1.53–6.28)</b>
Age (years)	−0.03	<b>0.032</b>	<b>0.97 (0.95–0.99)</b>	–	>0.05	–
Age $\leq 68$ years	0.82	<b>0.007</b>	<b>2.27 (1.26–4.11)</b>	<b>0.89</b>	<b>0.008</b>	<b>2.43 (1.26–4.71)</b>
Secondary or tertiary education	0.72	<b>0.016</b>	<b>2.06 (1.14–3.71)</b>	–	>0.05	–
Not living alone	−0.18	0.705	0.84 (0.33–2.12)	–	>0.05	–
Old-age pensioner	−0.23	0.534	0.80 (0.39–1.64)	–	>0.05	–
Living in an urban area	<b>1.04</b>	<b>0.003</b>	<b>2.82 (1.43–5.56)</b>	<b>0.93</b>	<b>0.024</b>	<b>2.53 (1.13–5.66)</b>

**Notes:** Statistically significant ( $p < 0.05$ ) predictors of adherence are in bold.



**Figure 1** ROC curve and cut-off value for age ( $\leq 68$  years) differentiating between patients adherent and those not adherent to treatment.

High adherence was reported by 52.5% of patients aged 68 or under and 32.7% of older patients ( $p=0.010$ ). The results are shown in [Table 9](#).

High adherence was reported by 50.0% of women and only 24.3% of men ( $p<0.001$ ). The results are shown in [Table 10](#).

A statistically significant relationship was also found between the level of adherence and education. High adherence was reported by 49.5% of patients with secondary or tertiary education and only 32.3% of patients with primary or basic vocational education ( $p=0.023$ ). The results are shown in [Table 11](#).

**Table 9** Treatment Adherence by Age and the Result of the Test of Independence

Level of Adherence	Total N = 190		Age $\leq 68$ Years N = 80		Age $>68$ Years N = 110		Test Result p
	n	%	n	%	n	%	
High (ARMS score: 8–15)	78	41.0	42	52.5	36	32.7	<b>0.010</b>
Low (ARMS score: 16–48)	112	59.0	38	47.5	74	67.3	

**Abbreviations:** N, number; %, percentage.

**Table 10** Treatment Adherence by Sex and the Result of the Test of Independence

Level of Adherence	Female N = 124		Male N = 66		Test Result <i>p</i>
	<i>n</i>	%	<i>n</i>	%	
High (ARMS score: 8–15)	62	50.0	16	24.2	<b>&lt;0.001</b>
Low (ARMS score: 16–48)	62	50.0	50	75.8	

Abbreviations: N, number; %, percentage.

**Table 11** Treatment Adherence by Education Level and the Result of the Test of Independence

Level of Adherence	Secondary or Tertiary Education N = 97		Primary or Vocational Education N = 93		Test Result <i>p</i>
	<i>n</i>	%	<i>n</i>	%	
High (ARMS score: 8–15)	48	49.5	30	32.3	<b>0.023</b>
Low (ARMS score: 16–48)	49	50.5	63	67.7	

Abbreviations: N, number; %, percentage.

**Table 12** Level of Adherence by Place of Residence and the Result of the Test of Independence

Level of Adherence	Urban Area N = 130		Rural Area N = 60		Test Result <i>p</i>
	<i>n</i>	%	<i>n</i>	%	
High (ARMS score: 8–15)	63	48.5	15	25.0	<b>0.004</b>
Low (ARMS score: 16–48)	67	51.5	45	75.0	

Abbreviations: N, number; %, percentage.

There was also a statistically significant relationship between the level of adherence and place of residence. High adherence was reported by 48.5% of patients living in urban areas and only 25.0% of patients living in rural areas ( $p=0.004$ ). The results are shown in Table 12. Other sociodemographic characteristics did not significantly influence the level of adherence ( $p>0.05$ ).

## Analysis of the Impact of Psychological Characteristics on Adherence

### Impact of Life Orientation and Dispositional Optimism on Adherence to Glaucoma Treatment

Our comparative analysis showed that patients with low adherence (ARMS score  $>15$ ) reported significantly lower optimism compared to patients with high adherence (ARMS score  $\leq 15$ ) ( $14.2 \pm 2.8$  vs  $15.6 \pm 3.1$ ).

Most of the patients who reported high adherence (65.4%) had higher dispositional optimism (LOT-R score  $\geq 15$ ). More than half (57.1%) of patients with low adherence reported lower dispositional optimism (LOT-R score  $<15$ ). The analysis showed that a LOT-R score of 15 or higher was a statistically significant factor positively influencing adherence ( $p=0.004$ ). The results are shown in Table 13.

Univariate logistic regression analysis showed that both the level of dispositional optimism (LOT-R score) ( $b=0.172$ ;  $p=0.001$ ) and a cut-off LOT-R score of  $\geq 15$  ( $b=0.92$ ;  $p=0.002$ ) were significant factors positively influencing adherence. Patients with high dispositional optimism (LOT-R score  $\geq 15$ ) had 2.5 times higher odds of adherence than patients with low dispositional optimism (LOT-R score  $<15$ ). The results are shown in Table 14.

**Table 13** Level of Dispositional Optimism (LOT-R) by Level of Treatment Adherence

Feature (Variable)	Total N = 190		Level of Adherence (ARMS)				Test Result <i>p</i>
			Low		High		
Life orientation (LOT-R) <i>M</i> ± <i>SD</i> <i>Me</i> [Q1; Q3] <i>Min.</i> - <i>Max.</i>	14.8 ± 3.0 15 [12; 17] 7–23		14.2 ± 2.8 14 [12; 16] 7–21		15.6 ± 3.1 16 [13; 18] 8–23		0.001
LOT-R score:	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
15 or higher	99	52.1	48	42.9	51	65.4	0.004
Lower than 15	91	47.9	64	57.1	27	34.6	

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

**Table 14** Logistic Regression Analysis of Adherence (ARMS Score ≤15) by Level of Dispositional Optimism, as Well as Odds Ratios and Their 95% Confidence Intervals

Predictors of Adherence	Univariate Regression Analysis		
	b	p	OR (95% CI)
Level of dispositional optimism (LOT-R score)	<b>0.172</b>	<b>0.001</b>	<b>1.19 (1.07–1.32)</b>
LOT-R score ≥15	<b>0.92</b>	<b>0.002</b>	<b>2.52 (1.39–4.58)</b>

### Impact of Life Satisfaction on Adherence to Glaucoma Treatment

Our comparative analysis showed that patients with low adherence (ARMS score >15) had slightly lower life satisfaction compared to patients with high adherence (ARMS score ≤15) (21.3 ± 3.7 vs 22.5 ± 4.4). Slightly fewer than half (42%) of patients with high adherence (ARMS score ≤15) reported high satisfaction with life (SWLS score ≥22). One-third (33.3%) of patients with low adherence (ARMS score >15) reported low satisfaction with life (SWLS score <22). Our analysis showed that a score of 22 or higher on the SWLS was a statistically significant factor positively influencing adherence ( $p=0.001$ ). The results are shown in Table 15

Univariate logistic regression analysis showed that both the level of satisfaction with life (SWLS score) and a cut-off SWLS score of ≥22 were significant factors positively influencing adherence. Patients with a score of 22 or higher on the

**Table 15** Level of Satisfaction with Life (SWLS) by Level of Adherence

Feature (Variable)	Total N = 190		Level of Adherence (ARMS)				Test Result <i>p</i>
			Low		High		
Level of life satisfaction (SWLS score): <i>M</i> ± <i>SD</i> <i>Me</i> [Q1; Q3] <i>Min.</i> - <i>Max.</i>	21.8 ± 4.0 22 [20; 25] 5–33		21.3 ± 3.7 21 [20; 24] 10–32		22.5 ± 4.4 23 [20; 25] 5–33		<b>0.005</b>
SWLS score:	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
22 or higher	99	52.1	52	66.7	47	42.0	
Lower than 22	91	47.9	26	33.3	65	58.0	

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

**Table 16** Logistic Regression Analysis of Adherence (ARMS Score  $\leq 15$ ) by Level of Life Satisfaction, as Well as Odds Ratios and Their 95% Confidence Intervals

Predictors of Adherence	Univariate Regression Analysis		
	<i>b</i>	<i>p</i>	OR (95% CI)
Level of satisfaction with life (SWLS score)	0.082	0.037	1.09 (1.01–1.17)
SWLS score $\geq 22$	1.02	0.001	2.77 (1.52–5.05)

SWLS had 2.5 times higher odds of good adherence compared to patients with a score of less than 22 on the SWLS (OR=2.77). The results are shown in Table 16.

### Impact of Illness Acceptance on Adherence to Glaucoma Treatment

Our comparative analysis showed that patients with high adherence (ARMS score  $\leq 15$ ) were more accepting of their illness compared to patients with low adherence (ARMS score  $> 15$ ) ( $34.9 \pm 6.2$  vs  $32.8 \pm 6.4$ ). Almost three-quarters (73.1%) of patients with high adherence (ARMS score  $\leq 15$ ) reported a high level of illness acceptance (AIS score  $\geq 34$ ). Almost half (49.1%) of patients with low adherence (ARMS score  $> 15$ ) reported a low level of illness acceptance (AIS score  $< 34$ ). The analysis showed that illness acceptance, as measured using the AIS, was a statistically significant factor influencing adherence to treatment ( $p=0.014$ ). A score of 34 or higher on the AIS was also found to be a statistically significant factor influencing adherence ( $p=0.004$ ). The results are shown in Table 17.

The results of univariate logistic regression analysis showed that both the level of illness acceptance (AIS score) and a cut-off AIS score of  $\geq 34$  were significant factors positively influencing adherence. Patients with a score of 34 or higher on the AIS had 2.5 times higher odds of good adherence compared to patients with a score of less than 34 on the AIS (OR=2.62). The results are shown in Table 18.

**Table 17** Level of Illness Acceptance (AIS) by Level of Adherence

Feature (Variable)	Total N = 190		Level of adherence (ARMS)				Test Result <i>p</i>
			Low		High		
Acceptance of illness (AIS score): <i>M</i> ± <i>SD</i> <i>Me</i> [Q1; Q3] <i>Min.</i> - <i>Max.</i>	33.6 ± 6.4 36 [29; 39] 12–40		32.8 ± 6.4 34.5 [29; 39] 12–40		34.9 ± 6.2 37 [33; 40] 18–40		0.014
AIS score:	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	0.004
34 or higher	114	60.0	57	50.9	57	73.1	
Lower than 34	76	40.0	55	49.1	21	26.9	

**Abbreviations:** M, mean; SD, standard deviation; Me, median; Q1, lower quartile; Q3, upper quartile; Min., minimum value; Max., maximum value; n, number; %, percentage.

**Table 18** Logistic Regression Analysis of Adherence (ARMS Score  $\leq 15$ ) by Level of Illness Acceptance, as Well as Odds Ratios and Their 95% Confidence Intervals

Predictors of Adherence	Univariate Regression Analysis		
	<i>b</i>	<i>p</i>	OR (95% CI)
Acceptance of illness (AIS score)	0.054	0.030	1.06 (1.01–1.11)
AIS score $\geq 34$	0.96	0.002	2.62 (1.41–4.88)

## Discussion

Glaucoma, which is the leading cause of irreversible vision loss worldwide, poses a significant concern for public health and health systems.<sup>2,26</sup> It is an incurable disease, and the aim of treatment is to stop the progression of visual loss. Anti-glaucoma therapy is deemed effective if the individually set target intraocular pressure is achieved, damage to the optic nerve is halted and visual field tests are stable. First-line treatment usually involves topical glaucoma medications.<sup>1</sup>

If not treated appropriately, glaucoma leads to progressive and irreversible visual impairment. It seems that simply being aware of the possible consequences of the disease can have a significant impact on the patient's emotional state. In the Collaborative Initial Glaucoma Treatment Study, 34% of the glaucoma patients studied reported a moderate amount or a lot of fear of becoming blind after receiving a glaucoma diagnosis, at the beginning of treatment. The percentage decreased to 17% at 6 months after diagnosis and to 11% at 5 years after diagnosis.<sup>27</sup> It is possible that patients are able to, over time, overcome their initial anxiety generated by a diagnosis of glaucoma, especially when no new symptoms develop.

Regular and correct use of eye drops in accordance with the prescribed regimen is crucial for the effectiveness of the medical management of glaucoma. As glaucoma is a chronic and progressive disease, anti-glaucoma treatment is long term and requires the patient to be self-disciplined and strictly adhere to treatment recommendations. If glaucoma eye drop medications are used incorrectly, they may be incorrectly deemed as ineffective, which may lead to unnecessary prescription of additional eye drops or surgery.<sup>28</sup>

Chronic conditions are associated with an increased risk of mental disorders such as depression and anxiety. There have been numerous studies on depression and anxiety symptoms among individuals with glaucoma, showing high prevalence of anxiety and depression among glaucoma patients.<sup>29–31</sup> The prevalence and severity of anxiety and depressive symptoms in patients with glaucoma may differ significantly depending on the type of glaucoma. In a study by Cumurcu et al, patients with pseudoexfoliative glaucoma, which is associated with more rapid disease progression and worse treatment response, were found to have significantly more severe depressive symptoms compared to patients with POAG and controls without glaucoma.<sup>32</sup> In a study by Kong et al, patients with PACG, which is often associated with a sudden onset of symptoms and rapid progression of visual impairment, were found to have significantly higher levels of anxiety and depression compared to patients with POAG, which usually develops slowly and causes very few symptoms.<sup>33</sup>

The aim of this study was to examine the impact of sociodemographic and psychological factors on adherence to glaucoma treatment. While illness acceptance, satisfaction with life and optimism are highly subjective measures, an analysis of their role can help better understand the perspective of patients treated for a chronic condition.

More than half of the patients included in the present study (58.9%) reported low treatment adherence. Similar findings were reported by other authors. In their study among glaucoma patients, Tse et al estimated patient adherence with glaucoma medications using data on the number of prescriptions collected annually. The study showed that half (51.6%) of the patients studied demonstrated poor adherence.<sup>34</sup> In their study, Mehari et al measured adherence in patients with glaucoma using the Morisky Medication Adherence Scale (MMAS), which is a self-report measure. More than half (57.4%) of the patients included in the study reported low adherence.<sup>35</sup> The MMAS was also used in a study by Movahedinejad et al, which showed that only one-third (34.6%) of the glaucoma patients studied completely adhered to their therapy.<sup>36</sup> However, in study by Newman-Casey et al, who also used the MMAS, only 27% of the patients reported poor adherence.<sup>37</sup> Sayner et al compared the level of adherence to glaucoma medications as measured using a self-report questionnaire with data from Medication Event Monitoring Systems (MEMS) electronic monitors. The authors examined two types of MEMS-measured adherence: MEMS-measured percent adherence, ie, the percentage of the prescribed number of doses taken by the patient, and MEMS-measured timing adherence, ie, the percentage of doses taken on time. The study showed that 31% of the patients studied overestimated their adherence as compared with the MEMS-measured percent adherence and as many as 74% overestimated their adherence as compared with the MEMS-measured timing adherence.<sup>38</sup> Thus, it can be assumed that the proportion of glaucoma patients who do not adhere to treatment is even higher than that reported in studies based on self-report adherence measures.

The present study and the available literature show that individuals with glaucoma have low levels of treatment adherence. Given that the lack of, or inadequate, treatment of glaucoma can lead to irreversible damage to the optic nerve and blindness, it is crucial to identify factors influencing adherence to glaucoma therapy and develop a strategy to improve adherence among individuals with glaucoma.

A number of factors have been described in the literature that can influence adherence to glaucoma treatment. They may be classified into several groups. Our study identified key sociodemographic and psychological factors affecting glaucoma treatment adherence. Firstly, we discuss sociodemographic factors, such as age, gender, education, marital status, place of residence and employment status.

In the present study, univariate logistic regression analysis showed that age was a significant predictor of glaucoma treatment adherence. Patients aged 68 or under reported higher adherence than older patients. In our study patients aged 68 or under had nearly 2.5 times higher odds of adherence compared to older patients. The available publications on the subject report significantly divergent results as regards the impact of age on adherence to glaucoma treatment. Findings from the present study are consistent with those from studies by Movahedinejad et al, Khan et al, Tamrat et al, Alhusban et al and Singh et al, in which older age was found to be associated with significantly poorer adherence.<sup>23,39–42</sup> This finding may be due to the fact that older patients are more likely to have memory problems and problems with the manual dexterity required to instill eye drops independently. Newman-Casey et al, Alhusban et al, da Costa Andrade et al and Singh et al reported forgetfulness as one of the main barriers cited by non-adherent patients.<sup>35,38,42,43</sup> In a study by Tse et al, both the youngest patients (aged under 59) and the oldest patients (aged over 90) studied demonstrated poor adherence, with the youngest patients showing the poorest adherence.<sup>24</sup> Leading a more active work and family life may be a factor contributing to non-adherence. However, our study did not confirm such an association. In studies by Castel et al, Allison et al and Jang et al, older age was found to promote adherence.<sup>44–46</sup> Younger age was associated with poorer adherence in study by Firat et al.<sup>47</sup> There are also studies which did not find a significant relationship between age and adherence to glaucoma treatment.<sup>25,48,49</sup> Given that older individuals have the highest prevalence of glaucoma of any age group, experience limitations resulting from declines in motor and mental capacities and often suffer from multiple chronic conditions, ophthalmologists should pay particular attention to these patients and assess their risk of non-adherence.<sup>5</sup>

Another significant factor that can influence treatment adherence is gender. In the present study, female gender was found to be an independent predictor of better adherence to glaucoma treatment. The odds ratio for female gender was 3.10, which in practice means that female glaucoma patients have 3 times higher odds of adhering to treatment than male patients. Studies by Jones et al, Jang et al and Khan et al also found higher adherence among female patients than among male patients.<sup>28,40,50</sup> In contrast, in studies by Anbesse et al and Firat et al, male glaucoma patients were found to have better adherence.<sup>46,51</sup> Studies by Tamrat et al, Castel et al, Movahedinejad et al and Welge-Lussen et al did not find a significant difference between male and female glaucoma patients in treatment adherence.<sup>26,29,30,33</sup>

In the present study, education level was found to be significantly associated with adherence to glaucoma therapy. Patients with secondary or tertiary education had better adherence than patients with primary or vocational education. Similar findings were reported by Movahedinejad et al, Moore et al, Mehari et al, Melaku et al, Hwang et al and Salman et al.<sup>15,25,26,52–54</sup> It is likely that better educated patients have a better understanding of the chronic nature of the condition and are more aware of the consequences of non-adherence to treatment. In contrast, studies by Tamrat et al and Welge-Lussen et al did not find a significant relationship between education and glaucoma treatment adherence.<sup>29,33</sup> An interesting phenomenon is so-called “whitecoat adherence” describing patients’ tendency to improve their adherence in the few days prior to or after their follow-up visits. In their study, Poleon et al reported that lower educational level was associated with better glaucoma treatment adherence directly after the clinic visit.<sup>55</sup>

Place of residence was found to be a significant factor influencing adherence to glaucoma therapy in the patients included in the present study. High adherence was reported by half of patients living in urban areas and only 25% of patients living in rural areas. This may be due to the fact that patients living outside large urban centers have poorer access to health care. Studies by Melaku et al, Anbesse et al and Assem et al also reported higher adherence in patients living in urban areas.<sup>35,37,56</sup>

Our study did not demonstrate a statistically significant association between other sociodemographic factors (relationship status, employment status, living with a partner or not) and adherence to glaucoma treatment.

The main aspect of this study was to analyze the psychological characteristics of glaucoma patients.

Our regression analysis showed an association between dispositional optimism and glaucoma treatment adherence. The higher the level of dispositional optimism, the better the adherence. Higher dispositional optimism is directly associated with a sense of self-esteem and self-efficacy and a feeling of internal control.<sup>57</sup> These characteristics are reflected in an individual's health behavior and have a positive impact on coping with difficult situations. They may thus have a direct impact on a glaucoma patient's attitude to their chronic condition and adherence to therapy. A study by Spencer et al showed that poor self-rating of own motivation has a negative influence on adherence to topical glaucoma therapy.<sup>58</sup>

The present study showed that satisfaction with life is a significant determinant of high adherence to glaucoma therapy. Life satisfaction is an individual's sense of contentment with their achievements and living conditions. Satisfaction with life has an impact on a patient's sense of self-esteem and self-efficacy and results in the patient being less susceptible to the negative impact of stress. Therefore, patients who are satisfied with their lives are likely to better cope with their chronic condition and have better adherence. A study by Reis et al showed a positive correlation between treatment adherence and satisfaction with life in HIV/AIDS patients on antiretroviral therapy.<sup>59</sup>

In the literature, there is a paucity of analyses focusing on psychological factors, such as satisfaction with life and optimism, in glaucoma patients and their association with glaucoma treatment adherence. Findings from studies among patients with other medical conditions indicate that these factors can significantly influence treatment adherence. In a study by O'Brien et al, greater dispositional optimism was found to be associated with attendance at Phase III cardiac rehabilitation and, according to the authors, was a better predictor of adherence to phase III cardiac rehabilitation than other variables.<sup>60</sup> In a study by Nsamenang et al, optimism and future orientation were found to be positively associated with treatment adherence in primary care patients.<sup>61</sup>

The patients included in our study reported a high level of illness acceptance. Our analysis demonstrated an association between the level of adherence to glaucoma therapy and the level of illness acceptance. Patients reporting a high level of illness acceptance were found to have 2.5 times higher odds of adhering to glaucoma therapy compared to patients reporting a low level of illness acceptance. Illness acceptance is an indicator of the degree of adaptation to an illness and is positively correlated with a sense of self-esteem and self-efficacy and engagement in healthy behaviour.<sup>62</sup> It seems that these factors have a positive influence on a patient's attitude to therapy and treatment adherence. To the best of our knowledge, there are no studies in the available literature on the relationship between illness acceptance and adherence to glaucoma therapy. The available publications analyze the impact of illness acceptance on treatment adherence in patients with other chronic conditions. In a study by Martynow et al among patients with atrial fibrillation, high illness acceptance was found to be a determinant of better treatment adherence.<sup>63</sup> A significant positive correlation between illness acceptance and treatment adherence was also demonstrated in patients with type 2 diabetes.<sup>64</sup>

Our research highlights the need to consider these sociodemographic and psychological factors when developing strategies to improve adherence in glaucoma patients. Newman-Casey et al reported that 61% of patients cited multiple barriers to optimal adherence.<sup>37</sup> Therefore, it seems that personalized approach and management tailored to the patient's needs might be critical to addressing non-adherence and ensuring effective glaucoma management.

## Study Limitation

Our study was limited in that we used a self-report questionnaire to measure treatment adherence in the glaucoma patients studied, which might have resulted in overestimation of adherence. Further research on the role of psychological factors in individuals with glaucoma may provide important information regarding care planning, education and counselling for these patients.

## Conclusions

More than half of patients with glaucoma have low adherence. Sociodemographic characteristics (female gender, age 68 or under, tertiary education and living in an urban area) and psychological characteristics (high level of illness acceptance, dispositional optimism and satisfaction with life) are significant predictors of high adherence.

## Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Bioethics Committee at the Wrocław Medical University (no. KB-305/2018).

## Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Informed Consent Statement

Written informed consent was obtained from all the subjects involved in the study.

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## Disclosure

The authors declare no conflicts of interest in this work.

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