Published in final edited form as:
Am J Ophthalmol. 2012 September ; 154(3): 436–444.e2. doi:10.1016/j.ajo.2012.03.039.

Prevalence and predictors of depression among participants with glaucoma in a nationally representative population sample

Sophia Y. Wang[1], **Kuldev Singh, M.D., M.P.H**[2], and **Shan C Lin, M.D.**[1]

[1]Department of Ophthalmology; University of California, San Francisco; San Francisco, CA

[2]Department of Ophthalmology; Stanford University; Stanford, CA

Abstract

Purpose—To investigate the prevalence of and risk factors for depression among participants with glaucoma and the predictive value of glaucoma for depression.

Design—Cross-sectional study.

Methods—This study included 6760 participants in the National Health and Nutrition Examination Survey (NHANES) between 2005 and 2008, age ≥40 years, who reported a presence or absence of glaucoma. Demographic and disease-related information was obtained by interview. Self-reported measures of vision were ascertained via items from the Visual Function Questionnaire (VFQ-25). Participants underwent visual acuity examination, fundus photography, and visual field testing with screening frequency doubling technology (FDT N-30-5). The main outcome was presence of depression, as determined by a score ≥10 on the Patient Health Questionnaire-9 (PHQ-9).

Results—Prevalence of depression among participants with and without glaucoma was 10.9% (SEM 2.2%) and 6.9% (SEM 0.62%), respectively. While the presence of glaucoma was significantly associated with depression after adjustment for demographic factors (OR 1.80, 95% CI 1.16 - 2.79), this association was not significant after adjustment for self-reported general health condition (OR 1.35, 95% CI 0.822-2.23). Among participants with glaucoma, objective measures of glaucoma severity were not significant predictors for depression. However, several self-reported measures of visual function were significantly associated with depression.

Conclusions—Glaucoma is a significant predictor of depression after adjustment for demographic factors and multiple comorbidities, but not after adjustment for self-reported general

Corresponding Author: Shan Lin, M.D., 10 Koret Street, Room K301, San Francisco, CA 94143-0730, Phone: (415) 810-4448, lins@vision.ucsf.edu.

b) Financial disclosures

- Sophia Wang – no financial disclosures
- Kuldev Singh – consultant (Alcon, Allergan, Santen, Bausch and Lomb, Ivantis, iScience, Transcend)
- Shan Lin – grant to institution for other research (Genentech), payment for lectures (Allergan, Alcon)

C) Contributions Of Authors: Design Of Study (Syw, Scl); Analysis And Interpretation Of The Data (Syw, Ks, Scl); Preparation And Review Of Manuscript (Syw, Ks, Scl).

health condition. Among participants with glaucoma, self-reported measures of vision were significant risk factors for depression, whereas objective measures of vision were not.

Introduction

Glaucoma is a chronic, progressive, and irreversible disease which can result in severe visual disability[1,2]. Over the past two decades, interest has increased among physicians and other health professionals regarding patients' quality of life, which has led to a better understanding of glaucomatous disease burden and outcomes of treatment[3]. It has been postulated that mental health may impact clinical factors such as glaucoma medication adherence and persistence[4-6].

Previous studies have estimated a 10-12% prevalence of depressive symptomatology in subjects with glaucoma[7,8]. The prevalence of depression was found to be as high as 32.1% in patients with severe glaucomatous disease[9]. Furthermore, depression has been found to be associated with patients' perception of vision[10]; however, in contrast to subjective measures of visual perception, objective measures of function such as visual acuity or visual field results have not been linked to glaucoma diagnosis or depression severity[9,10]. Common limitations of prior analyses have included small sample size, enrollment of patients from clinic rather than population-based settings, and lack of sufficient normal controls, with the latter being particularly problematic in large studies of depression and glaucoma[7-10].

The National Health and Nutrition Examination Survey (NHANES)[11] is an annual national population-based study administered by the Centers for Disease Control and Prevention (CDC) designed to assess the health status of the U.S. population, sampling approximately 5000 persons per year. It not only includes an extensive interview questionnaire related to a variety of physical and mental health conditions, but also includes a physical exam component, with an assessment of visual acuity and objective refraction. From 2005-2008, NHANES also included fundus photography and visual field testing of participants over the age of 40. This extensive national database can be used to determine the prevalence of diseases such as glaucoma and depression, to investigate the predictive value of the presence of glaucoma for depression, and to discern the prevalence of risk factors for depression among individuals with glaucoma.

Methods

Sample and population

We used publicly available data from the 2005-2008 administrations of the National Health and Nutrition Examination Survey (NHANES)[11], a cross-sectional series of interviews and exams of the civilian, non-institutionalized population of the United States. NHANES is administered by the Centers for Disease Control and Prevention (CDC) for the purpose of providing U.S. health statistics and uses a stratified multistage sampling design that requires a weighting scheme to most accurately estimate disease prevalence in the U.S. population.

Our analysis included 6760 subjects consisting of all survey participants aged 40 years and older who underwent both the interview and exam phases of the survey between 2005 and 2008. Thirty-five participants were excluded for not knowing whether or not they had glaucoma, and 2 participants were excluded for not answering the glaucoma question.

Measures

The primary predictor variable was the presence of self-reported glaucoma (N=453). The main outcome was the presence or absence of depression, as determined by score on the Patient Health Questionnaire (PHQ)-9, a self-administered version of the depression module

of the Primary Care Evaluation of Mental Disorders Questionnaire (PRIME-MD). For each of the nine DSM-IV criteria for the diagnosis of depression, participants reported how often they were bothered by that symptom over the preceding 2 weeks, with scores on each question ranging from 0 (not at all) to 3 (nearly every day) for a total score range from 0 to 27. A prior validation study found that a score ≥10 achieved 88% sensitivity and 88% specificity for major depression[12]. The range may be further subdivided into scores of 5, 10, 15, and 20, representing mild, moderate, moderately severe, and severe depression, respectively[12].

Potential confounders in our analysis included age, sex, ethnicity, annual household income, and education; comorbid medical conditions such as self-reported history of stroke, thyroid disease, emphysema, liver disease, cancer, congestive heart failure (CHF), diabetes, angina, coronary heart disease (CHD), myocardial infarction (MI), chronic bronchitis; comorbid eye conditions such as self-reported history of cataract extraction, diabetic retinopathy, macular degeneration; self-reported general health condition (self-rated as excellent or very good, fair, or poor or very poor); body mass index; and spherical equivalent on objective refraction.

Potential mediators in our analysis of the relationship between glaucoma and depression included several self-reported measures of vision and visual disability, as well as objective measures of visual function. All self-reported measures of vision were ascertained from a subset of questions from the National Eye Institute Visual Function Questionnaire (VFQ-25), a reliable and validated instrument for self-reporting visual disability[13]. These included a series of questions assessing the difficulty that participants experience in performing vision-related tasks, which include reading ordinary print in newspapers; doing work or hobbies that require seeing well close up; going down steps, stairs, or curbs in dim light or at night; noticing objects off to the side while walking; finding something on a crowded shelf; and driving during the daytime in familiar places. We rated each of these tasks on a scale from 0 (no difficulty) to 4 (unable to perform as a result of poor eyesight), for a total score range from 0 to 24. NHANES also ascertained whether or not participants had trouble seeing despite the aid of glasses or contact lenses; participants' self-assessment of their eyesight, ranging from excellent to very poor; how much time participants spent worrying about their eyesight and how often their vision limited the length of common daily activities, ranging from no time to all of the time.

Objective measures of visual function among participants with glaucoma included vertical cup-to-disk ratio (VCDR) as graded from fundus photos, best corrected visual acuity (BCVA) from objective refraction, and presence of visual field defects based on a N-30-5 frequency doubling technology (FDT) screening protocol, which is a 19-point supra-threshold visual field screening test. In NHANES, abnormal FDT status was defined by a 2-2-1 Algorithm: two fields in the first test below the 1% threshold level, at least two fields in the second test below the 1% threshold level, and at least one failed field in the same location on both tests. Exams were considered unreliable if either of the two tests on each eye had at least 2/3 false positive or blind spot errors, or the technician supervising the test noted lack of fixation[14].

The NHANES 2-2-1 Algorithm for FDT N-30-5 had a previously demonstrated sensitivity of 54.8% and specificity of 91.9% in detecting subjects with glaucoma[14]. In addition, we further stratified FDT results of the first visual field test administered for each eye into normal, early, moderate, or severe visual field defects based on the clinical classification scheme previously published and validated against the Glaucoma Staging System, which showed a Cohen Kappa agreement of .679 and specificity of 95%[15]. The classification of severe glaucoma was slightly modified for our study and defined as more than 9 P<1%

defects (same as the original criteria), or more than 12 abnormal points with more than 6 P<1% defects (modified from the original criteria where the cutoff was 0.5% rather than our 1%). This slight modification was necessary due to lack of P<0.5% threshold data in the NHANES dataset.

In addition, the use of topical glaucoma medications in the 30 days prior to the interview, including whether or not such medications included a topical beta blocker, was ascertained by self-report. Participants who reported using betaxolol, metipranolol, levobunolol, and timolol or timolol-containing combination medications were considered to be on topical beta blocker therapy.

Data Analysis

We compared the distribution of possible confounding and mediating variables between participants with and without self-reported glaucoma using design-adjusted Rao-Scott Pearson-type chi-square and Wald tests for categorical and continuous variables, respectively. Multivariate logistic regression models were used to examine the independent association of self-reported glaucoma with questionnaire-assessed depression as defined by a PHQ-9 score ≥10, with confounders added sequentially to the model. Confounding comorbidities not found to be significant at the P<0.1 level in multivariate models were excluded from the final model. These excluded confounders were body mass index; spherical equivalent on objective refraction; comorbid eye conditions including history of cataract extraction, diabetic retinopathy, macular degeneration; and medical conditions including congestive heart failure, diabetes mellitus, angina, coronary heart disease, myocardial infarction, and chronic bronchitis. Similar multivariate logistic regression models were constructed to examine the independent association between depression and objective measures of glaucoma severity including visual acuity, FDT results, cup-to-disk ratio, number of topical glaucoma medications used, as well as subjective measures of glaucoma severity, while adjusting for the same set of confounders. The subjective measures from the NEI-VFQ which assessed the difficulty which participants had in performing daily activities were analyzed with the “No difficulty” category as the reference. In order to most accurately calculate confidence intervals around estimates for the U.S. national population, all data analysis was performed in Stata 12.0 (StataCorp, College Station, Texas) using weighted data, and standard errors of population estimates were calculated using Taylor linearization methods.

Results

Population characteristics

The combined 2005-2008 NHANES data yielded 6760 participants over the age of 40 who underwent both the interview and the examination, and who were able to self-report glaucoma status. Of these, 453 participants self-reported glaucoma, representing 5.06% (standard error of the mean (SEM) 0.33%) of the sampled U.S. civilian non-institutionalized population.

Demographic and general health characteristics of participants self-reporting glaucoma are compared to the control group of those who self-reported not having glaucoma in Table 1. Unadjusted P values were calculated for a crude difference in means or proportions between these two groups. The mean ages of those self-reporting glaucoma and controls were 66.9 (SEM 1.03) and 56.5 (SEM 0.38) years, respectively (P<.001). All demographic variables and almost all general health characteristics differed significantly between the two groups. Notably, the self-reported variable “general health condition” differed significantly between

the two groups (P<.001), with 34.5% (SEM 3.2%) of the glaucoma group reporting poor or very poor general health, compared to 18.9% (SEM 0.91%) of the control group.

The unadjusted means and proportions relating to vision and depression in the glaucoma and control groups are presented in Table 2. Participants with glaucoma had significantly worse visual function and vision-related characteristics by objective measures, including worse LogMar BCVA in the worse eye (0.254 vs 0.176 in controls, P<.001), larger VCDR in the eye with the smaller VCDR (0.44 vs 0.36 in controls, P<.001), and higher proportion of subjects with visual field defects in one or both eyes (29.6% vs 6.0% in controls, P<.001). Furthermore, a higher proportion of subjects in the glaucoma group self-reported poor or very poor vision, worrying about their eyesight most or all of the time, and being limited by poor vision in the performance of activities most or all of the time relative to those in the control group. The prevalence of depression also significantly differed between the two groups, measuring 10.9% (SEM 2.2%) in the glaucoma group compared to 6.9% (SEM 0.62%) in the control group (P=0.02).

Glaucoma as a predictor of depression

To investigate whether or not glaucoma is an independent predictor of the presence of depression as determined by a PHQ-9 score ≥10, we created a multivariate logistic regression model and sequentially adjusted for potential confounders (Table 3). After adjusting for the demographic variables of age, sex, ethnicity, and socioeconomic status, the association between glaucoma and depression was stronger than in the unadjusted model (OR 1.80, 95% CI 1.16 - 2.79). Furthermore, after adjusting for the comorbidities of stroke, thyroid disease, emphysema, liver disease, and cancer, glaucoma remained a significant predictor of depression, although with a reduced odds ratio (OR 1.59, 95% CI 1.01 - 2.52).

However, after adjusting for self-reported general health condition, in which participants self-rated their health as excellent/very good, good, or poor/very poor, glaucoma was not found to be significantly associated with depression (OR 1.35, 95% CI 0.822-2.23) and this lack of an association persisted if general health condition was included in the model, regardless of whether or not other factors were present.

Predictors of depression among participants with glaucoma

We further investigated what characteristics of participants with glaucoma might be risk factors for major depression (Table 4), independent of the potential confounders of age, sex, race, education level, income, general health condition, and comorbidities of stroke, thyroid disease, emphysema, liver disease, and cancer. None of the objective measures of glaucoma severity or visual function, including BCVA, VCDR, presence of visual field defect, severity of visual field defect, number of topical glaucoma medications, or use of topical beta-blockers, were found to be significant predictors of depression in the multivariate logistic regression model. In contrast, many self-reported measures of visual function were significant predictors of depression. These measures were a subset of questions on the VFQ-25 and included whether or not participants reported having difficulty seeing despite glasses or contact lenses (P=0.008), how much time they spent worrying about eyesight (P=0.005) and how much their vision limited the length of time they could participate in activities (P=0.001). Furthermore, a series of six questions from the VFQ-25 gauged the difficulty participants had in performing certain daily activities due to poor vision. The total score on the vision difficulty questions was a significant predictor of depression (P=0.002), with each additional 1-point increase in score yielding an increased odds of depression by a factor of 1.15 (95% CI 1.06 - 1.26). Of the individual questions assessing difficulty with activities, significant predictors of depression included difficulty performing close work (P=0.005), difficulty with steps (P<0.001), difficulty with side vision (P=0.001), and

difficulty driving during the daytime (P=0.04). Those with extreme difficulty in performing activities had significantly higher odds of depression compared to those with no difficulty for each of these variables except driving, for which participants with moderate difficulty had the highest odds of being depressed. Additional adjustment for best corrected visual acuity for these VFQ-25 items did not change the results.

Discussion

Our study of a large U.S. national population-based sample of adults aged 40 years and older found that glaucoma was a significant predictor of depression after adjustment for demographic variables and certain comorbidities, but not after adjustment for self-reported general health condition. Among subjects with glaucoma, objective measures of disease and visual function such as visual acuity, VCDR, and visual field defects were not associated with depression, whereas most self-reported measures of visual disability were found to be associated with depression. The 10.9% prevalence of depression among glaucoma participants that we found is consistent with previous studies in various regions of the world, including 10.9% in a Japanese clinic study[7], 11.4-32.1% in an Australian clinic study[9], 9% in an U.S. health maintenance organization population[6], and 12.2% in a small U.S. clinic comprising older adults[8].

As NHANES included an abundant set of questions on all aspects of participants' health and background, a unique aspect of our model was the possibility of adjustment for a wide variety of demographic factors and comorbidities to assess the potential existence of an independent association between glaucoma and depression. Inclusion of self-reported general health condition in the model resulted in a lack of a significant association between glaucoma and depression (OR 1.35, 95% CI 0.822-2.23) and thus a true independent association was not found between these two diseases. Our findings corroborate those from a smaller case-control study in a clinic population which also did not find such an association[16]. Although no prior studies have examined the relationship between self-reported general health condition and glaucoma, one clinic study of depression and age-related macular degeneration suggested that self-reported general health condition may be linked to the causal pathway between eye disease and depression, with eye disease causing a perception of poor general health[17]. The question as to whether or not general health condition impacts such a potential causal pathway between glaucoma and depression will require further study.

As noted in prior studies, our work shows that objective measures of vision and glaucoma are not associated with depression. Skalicky et al found that only age and Glaucoma Quality of Life-15 (GQL-15) score were significant predictors of depression in a multivariate model[9]. Jampel et al found that among newly diagnosed glaucoma patients in the Collaborative Initial Glaucoma Treatment Study (CIGTS), visual acuity and visual field assessment were not associated with any items on the Center for Epidemiologic Studies Depression Scale (CES-D)[10]. Lundmark et al surprisingly found that among patients with mild visual field defects, those with field progression had lower odds of depressive symptoms relative to those with stable defects[18]. These prior findings are consistent with our results showing that common objective measures of glaucoma severity such as visual acuity, visual field status, and optic nerve appearance may not be as important to the mental health of glaucoma patients as the perception of illness and disability. Furthermore, our finding that topical beta blocker therapy was not associated with increased odds of depression among those who self-reported glaucoma corroborates the results of recent studies which also failed to find such an association[7,19].

Our findings suggest that it may be important to acknowledge that influencing a patient's perception of the disease may impact their sense of well-being. Counseling and prognostication from healthcare providers regarding the typically slow nature of glaucoma progression as well as the availability and effectiveness of treatments to retard progression should be assessed as a therapeutic option to help allay patient worries about visual decline, with the potential for such intervention to result in a decreased burden from depression. Extreme difficulty with several common activities assessed via items from the VFQ-25 was found to be independently associated with depression, suggesting that there may be an opportunity to decrease the symptoms of depression through interventions that improve the ability of patients to function in such activities. The finding that objective visual measures, including visual acuity, are not correlated with depression should alert providers to the possibility that a high prevalence of depression may exist even among patients in their practice who seem to be "doing well" with regard to objective measures of disease control, but may nonetheless suffer from functional disability.

We acknowledge that our study has several limitations, including reliance on self-reporting of medical conditions which may be subject to recall error and bias. In particular, the proportion of participants who concomitantly self-reported a diagnosis of glaucoma and the use of topical glaucoma medications was low (26.9%), which may reflect incomplete self-reporting of prescription medications or exaggerated reporting of glaucoma, particularly among those who truly carry the diagnoses of glaucoma suspect or ocular hypertension. It is noteworthy, however, that the prevalence of glaucoma found in this study is consistent with that reported in previous studies[20]. While the NHANES self-reported measures of visual function were derived from the previously validated VFQ-25 instrument[13], not all of the questions in the VFQ-25 were administered in this survey. Rather than using standard automated perimetry for visual field testing, NHANES used an FDT N-30-5 screening protocol with a scoring algorithm which is highly specific for detecting glaucomatous disease[14] but is unlikely to be the ideal tool for measuring glaucoma severity. Furthermore, these study results may not reflect true disease associations in smaller ethnic groups such as Asians and other minorities that were not oversampled in NHANES as were Mexican Americans and Hispanics. Finally, a cross-sectional study such as ours is useful in assessing disease associations, but cannot establish causation. While it is difficult to imagine a pathophysiologic mechanism that would lead from depression to glaucomatous disease, differences in recall between those with and without depression can certainly be postulated as influencing the reporting of visual disability.

In summary, we found that although glaucoma was a significant predictor of depression even after adjustment for demographic factors and comorbidities in this nationally representative sample of the U.S. population, adjustment for general health status led to a lack of statistical significance in the relationship between these two disease entities. Among participants with glaucoma, objective measures of visual function and glaucoma severity were not predictive of depression, whereas self-reported measures of decreased visual function and increased visual disability were found to be associated with depression. These results suggest that the association between glaucoma and depression reflects patients' perceptions and subjective experiences of their illness rather than conventional objective measures of glaucoma severity.

Acknowledgments

a) Funding/Support: This publication was made possible by core grant EY002162 from the National Eye Institute, That Man May See, Inc, Research to Prevent Blindness, and NIH/NCRR/OD UCSF-CTSI Grant Number TL1 RR024129. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the funding agencies.

d) Statement about Conformity with Author Information: This research utilized publicly available de-identified data, and as a result is not considered human subjects research. Therefore, it was exempted from review by the Committee on Human Research at the University of California, San Francisco (UCSF), which is the IRB at UCSF.

e) Other acknowledgements: none.

Biographies

Sophia Wang is currently a Clinical and Translational Research Fellow at the University of California, San Francisco (UCSF). She is a trainee in the Advanced Training in Clinical Research program at the UCSF Department of Epidemiology and Biostatistics. She earned her A.B. in Biochemistry from Harvard University, and will complete her medical degree at UCSF. Her research interests include modifiable risk factors for ophthalmologic illness, including glaucoma, and health disparities research.

Shan Lin is Professor and Co-Director of Glaucoma Service at the University of California, San Francisco and Director of Glaucoma Service at San Francisco General Hospital. His research interests include angle closure glaucoma and glaucoma among Asians. His leadership positions include Chair of the Glaucoma Section of the Ophthalmic Technology Assessment Committee and Chair of the American Glaucoma Society Documents Subcommittee. His special honors include the American Glaucoma Society and The Glaucoma Foundation’s Clinician-Scientist Awards.

References

1. Gutierrez P, Wilson MR, Johnson C, et al. Influence of glaucomatous visual field loss on health-related quality of life. Arch. Ophthalmol. 1997; 115(6):777–784. [PubMed: 9194730]
2. van Gestel A, Webers CAB, Beckers HJM, et al. The relationship between visual field loss in glaucoma and health-related quality-of-life. Eye (Lond). 2010; 24(12):1759–1769. [PubMed: 21057519]
3. Glen FC, Crabb DP, Garway-Heath DF. The direction of research into visual disability and quality of life in glaucoma. BMC Ophthalmol. 2011; 11(1):19. [PubMed: 21816060]

4. Friedman DS, Okeke CO, Jampel HD, et al. Risk factors for poor adherence to eyedrops in electronically monitored patients with glaucoma. Ophthalmology. 2009; 116(6):1097–1105. [PubMed: 19376591]
5. Holló G, Kóthy P, Géczy A, Vargha P. Personality Traits, Depression, and Objectively Measured Adherence to Once-daily Prostaglandin Analog Medication in Glaucoma. Journal of Glaucoma. 2009; 18(4):288–292. [PubMed: 19365193]
6. Jayawant SS, Bhosle MJ, Anderson RT, Balkrishnan R. Depressive symptomatology, medication persistence, and associated healthcare costs in older adults with glaucoma. J. Glaucoma. 2007; 16(6):513–520. [PubMed: 17873711]
7. Mabuchi F, Yoshimura K, Kashiwagi K, et al. High Prevalence of Anxiety and Depression in Patients With Primary Open-angle Glaucoma. Journal of Glaucoma. 2008; 17(7):552–557. [PubMed: 18854732]
8. Yochim BP, Mueller AE, Kane KD, Kahook MY. Prevalence of Cognitive Impairment, Depression, and Anxiety Symptoms Among Older Adults With Glaucoma. J Glaucoma. Feb 17.2011 Forthcoming, Epub ahead of print.
9. Skalicky S, Goldberg I. Depression and quality of life in patients with glaucoma: a cross-sectional analysis using the Geriatric Depression Scale-15, assessment of function related to vision, and the Glaucoma Quality of Life-15. J. Glaucoma. 2008; 17(7):546–551. [PubMed: 18854731]
10. Jampel HD, Frick KD, Janz NK, et al. Depression and mood indicators in newly diagnosed glaucoma patients. Am. J. Ophthalmol. 2007; 144(2):238–244. [PubMed: 17560843]
11. Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; Hyattsville, MD: 2005. Available at: http://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm.
12. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9. J Gen Intern Med. 2001; 16(9):606–613. [PubMed: 11556941]
13. Mangione CM, Lee PP, Gutierrez PR, et al. Development of the 25-item National Eye Institute Visual Function Questionnaire. Arch. Ophthalmol. 2001; 119(7):1050–1058. [PubMed: 11448327]
14. Terry AL, Paulose-Ram R, Tilert TJ, et al. The methodology of visual field testing with frequency doubling technology in the National Health and Nutrition Examination Survey, 2005-2006. Ophthalmic Epidemiol. 2010; 17(6):411–421. [PubMed: 21090914]
15. Brusini P, Tosoni C. Staging of functional damage in glaucoma using frequency doubling technology. J. Glaucoma. 2003; 12(5):417–426. [PubMed: 14520150]
16. Wilson MR, Coleman AL, Yu F, et al. Depression in patients with glaucoma as measured by self-report surveys. Ophthalmology. 2002; 109(5):1018–1022. [PubMed: 11986112]
17. Mathew RS, Delbaere K, Lord SR, et al. Depressive symptoms and quality of life in people with age- related macular degeneration. Ophthalmic Physiol Opt. 2011; 31(4):375–380. [PubMed: 21679317]
18. Lundmark PO, Trope GE, Shapiro CM, Flanagan JG. Depressive symptomatology in tertiary-care glaucoma patients. Can. J. Ophthalmol. 2009; 44(2):198–204. [PubMed: 19491956]
19. Kaiserman I, Kaiserman N, Elhayany A, Vinker S. Topical beta-blockers are not associated with an increased risk of treatment for depression. Ophthalmology. 2006; 113(7):1077–1080. [PubMed: 16815397]
20. Leske MC. Open-angle glaucoma -- an epidemiologic overview. Ophthalmic Epidemiol. 2007; 14(4):166–172. [PubMed: 17896292]

Table 1

Demographic and general health characteristics of participants with and without self-reported glaucoma

	Self-reported no glaucoma (N=6307) Mean or % [a] (Std Error)	Self-reported glaucoma (N=453) Mean or % [a] (Std Error)	P value [b]
Demographics			
Age, years	56.5 (0.38)	66.9 (1.03)	<.001
Female	53.0% (0.71%)	52.4% (3.2%)	0.03
Race			
Mexican	5.6% (0.72%)	4.0% (1.3%)	
Other Hispanic	3.2% (0.62%)	2.7% (1.1%)	
Non-Hispanic White	75.9% (2.1%)	72.5% (3.6%)	0.004
Non-Hispanic Black	10.1% (1.3%)	16.7% (2.6%)	
Other and multiracial	5.2% (0.61%)	4.2% (1.4%)	
Education			
<9th grade	7.45% (0.61%)	14.1% (2.6%)	
9th grade - less than high school graduate	11.6% (0.86%)	13.4% (1.6%)	
High school graduate or GED equivalent	26.1% (0.95%)	28.2% (2.9%)	<.001
Some college	27.8% (0.95%)	28.8% (3.1%)	
College graduate and beyond	27.2% (1.6%)	15.5% (2.1%)	
Annual household income			
<$20,000	14.8% (0.865)	23.4% (3.1%)	
$20,000 - $44,999	26.8% (1.3%)	35.5% (2.9%)	
$45,000 - $74,999	22.0% (0.99%)	21.0% (2.3%)	<.001
$75,000 and up	33.7% (1.8%)	16.9% (2.7%)	
>$20,000	2.8% (0.39%)	3.3% (1.0%)	
General health status and comorbidities			
General health condition			
Excellent or Good	42.4% (1.4%)	37.8% (3.3%)	
Fair	38.8% (0.78%)	27.7% (3.0%)	<.001
Poor or Very Poor	18.9% (0.91%)	34.5% (3.2%)	
Medical comorbidities			
Stroke	4.3% (0.43%)	10.2% (2.2%)	0.002
Emphysema	2.6% (0.23%)	7.4% (0.17%)	<.001
Thyroid problem	13.4% (0.65%)	18.5% (2.2%)	0.01
Liver condition	4.4% (0.31%)	4.1% (1.1%)	0.74
Cancer	12.2% (0.53%)	22.1% (2.5%)	0.001

[a] All means, proportions, and standard errors are weighted estimates of the US population characteristics, taking into account NHANES' complex sampling design

[b] All p values are unadjusted. P values were calculated using Wald test for continuous variables, and design-adjusted Rao-Scott Pearson chi-squared test for categorical variables

Table 2

Vision-related characteristics and PHQ-9 depression classification of participants with and without self-reported glaucoma

		Self-reported no glaucoma (N=6307) Mean or %[a] (Std Error)	Self-reported glaucoma (N=453) Mean or %[a] (Std Error)	P value[b]
Vision Exam				
LogMar BCVA, worse eye		0.176(0.0037)	0.254 (0.017)	<.001
VCDR, better eye		0.363 (0.0026)	0.449 (0.0122)	<.001
Any visual field defect, one or both eyes		6.0% (0.38%)	29.6% (3.2%)	<.001
Visual field defect classification, worse eye				
	Normal	74.4% (0.88%)	49.8% (3.8%)	
	Early	12.7% (0.53%)	10.4% (1.6%)	<.001
	Moderate	10.2% (0.57%)	24.9% (2.8%)	
	Severe	2.7% (0.23%)	15.0% (2.2%)	
Number of topical glaucoma medications				
	1	0.20% (0.00%)	17.0% (2.1%)	
	2	0% (0%)	7.2% (1.5%)	<.001
	3	0% (0%)	2.7% (0.64%)	
Self-reported vision-related status				
Has trouble seeing even with glasses or contacts		22.0% (0.94%)	40.9% (3.6%)	<.001
General condition of eyesight				
	Excellent or Good	82.1% (0.88%)	69.7% (3.3%)	
	Fair	14.4% (0.71%)	19.9% (3.2%)	<.001
	Poor or Very Poor	3.5% (0.31%)	10.5% (1.4%)	
Time worrying about eyesight				
	None of the time or a little of the time	77.0% (0.83%)	64.3% (2.6%)	
	Some of the time	15.78% (0.63%)	18.4% (2.1%)	<.001
	Most of the time or all of the time	7.2% (0.35%)	17.3% (2.5%)	
Vision limits how long a subject can perform activities				
	None of the time or a little of the time	95.4% (3.4%)	85.5% (2.0%)	
	Some of the time	3.1% (0.28%)	7.9% (1.9%)	<.001
	Most of the time or all of the time	1.5% (0.14%)	6.6% (1.1%)	
Total score on vision difficulty questions[c]		1.38 (0.053)	3.03 (0.263)	<.001
Prior cataract surgery		9.8% (0.51%)	34.3% (3.7%)	<.001
AMD		3.1% (0.21%)	8.1% (1.2%)	<.001
Diabetic retinopathy		2.3% (0.23%)	10.0% (1.2%)	<.001

		Self-reported no glaucoma (N=6307) Mean or %[a] (Std Error)	Self-reported glaucoma (N=453) Mean or %[a] (Std Error)	P value[b]
Depression				
Depression severity by PHQ-9				
	None	78.3% (1.1%)	74.0% (2.8%)	
	Mild	14.8% (0.70%)	15.2% (2.6%)	
	Moderate	4.6% (0.42%)	5.3% (1.4%)	0.03
	Moderately severe	1.6% (0.18%)	3.8% (1.6%)	
	Severe	0.64% (0.14%)	1.9% (0.59%)	
Depression presence (Score ≥10)		6.9% (0.62%)	10.9% (2.2%)	0.02

PHQ-9 = Patient Health Questionnaire 9, a self-administered version of the depression module of the Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic instrument; BCVA = best corrected visual acuity; VCDR = vertical cup to disk ratio; AMD = age-related macular degeneration

[a] AII means, proportions, and standard errors are weighted estimates of the US population characteristics, taking into account NHANES' complex sampling design

[b] All p values are unadjusted. P values were calculated using Wald test for continuous variables, and design-adjusted Rao-Scott Pearson chi-squared test for categorical variables

[c] Vision difficulty questions included the following: How much difficulty do you have in reading ordinary print in newspapers; how much difficulty do you have doing work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house, or using hand tools; how much difficulty do you have going down steps, stairs, or curbs in dim light or at night; how much difficulty do you have noticing objects off to the side while you are walking; how much difficulty do you have finding something on a crowded shelf; and how much difficulty do you have driving during the daytime in familiar places. Individual questions were scored on a 5-pt scale ranging from 0 - no difficulty to 4 - unable to do because of eyesight.

Table 3

Odds ratios for depression screener PHQ-9 score ≥10 among participants with self-reported glaucoma compared to participants without self-reported glaucoma, with successive addition of potential confounders

	Self-reported glaucoma OR[a] (95% CI)
Unadjusted	1.66 (1.09-2.53)
+Age	2.15 (1.42-3.25)
+Sex	2.19 (1.44-3.33)
+Ethnicity	2.12 (1.39-3.23)
+Socioeconomic status[b]	1.80 (1.16-2.79)
+Comorbidities[c]	1.59 (1.01-2.52)
+General health condition	1.35 (0.822 -2.23)

PHQ-9 = Patient Health Questionnaire 9, a self-administered version of the depression module of the Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic instrument.

[a] Reference group: participants without self-reported glaucoma

[b] Socioeconomic status variables included annual household income and education level.

[c] Comorbidities include stroke, thyroid disease, emphysema, liver disease, and cancer. Comorbidities which were not significant in the model and therefore not included were BMI, CHF, diabetes, angina, CHD, MI, chronic bronchitis, self-reported history of cataract operation, age-related macular degeneration, and diabetic retinopathy.

Table 4

Predictors for depression screener PHQ-9 score ≥10 among participants with self-reported glaucoma, adjusted for potential confounders[a]Objective measures

		OR (95% CI)	P value[b]
Objective measures			
LogMar BCVA, worse eye		13.5 (0.553-328.2)	0.11
VCDR, better eye		13.9 (0.281-686.6)	0.18
Any visual field defect		1.06 (0.660-1.70)	0.81
Binocular visual field defect		1.25 (0.671-2.35)	.465
Visual field defect classification, worst eye	Normal	1.00	
	Early	0.711 (0.474-1.07)	0.35
	Moderate	0.803 (0.554-.17)	
	Severe	1.06 (0.544-2.06)	
Number of topical glaucoma medications	0	1.00	
	1	1.29 (0.282-5.92)	0.94
	2	0.756 (0.083-6.85)	
	3	2.13 (0.120-37.9)	
Use of topical beta blockers		1.21 (0.305-4.78)	.782
General self-reported vision status			
General condition of eyesight	Excellent or Good	1.00	
	Fair	2.85 (0.899-9.03)	0.12
	Poor or Very Poor None of the time or a little of the	4.65 (0.663-32.6)	
Time spent worrying about eyesight	time	1.00	
	Some of the time	4.03 (1.51-10.8)	0.005
	Most of the time or all of the time	8.36 (2.44-28.7)	
Vision limits how long a subject can perform activities	None of the time or a little of the time	1.00	
	Some of the time	4.43 (0.772-25.4)	0.001
	Most of the time or all of the time	9.27 (3.23-26.6)	
Has trouble seeing even with glasses or contact	s	3.12 (1.38-7.06)	0.008
Self-reported vision-related difficulty			
Total score on vision difficulty questions		1.15 (1.06-1.26)	0.002
Difficulty reading ordinary newsprint	No difficulty	1.00	
	A little difficulty	1.94 (0.233-16.2)	
	Moderate difficulty	3.75 (0.762-18.4)	0.13
	Extreme difficulty	7.59 (1.42-40.5)	
	Unable to do because of eyesight	3.96 (0.601-26.1)	
Difficulty doing close work	No difficulty	1.00	
	A little difficulty	3.74 (0.742-18.9)	
	Moderate difficulty	2.30 (0.457-11.5)	0.005
	Extreme difficulty	17.3 (3.83-78.4)	

		OR (95% CI)	P value[b]
	Unable to do because of eyesight	1.95 (0.204-18.7)	
Difficulty with steps	No difficulty	1.00	
	A little difficulty	4.98 (1.44-17.2)	
	Moderate difficulty	10.1 (2.32-43.7)	<.001
	Extreme difficulty	41.7 (12.7-136.7)	
	Unable to do because of eyesight	3.31(0.169-64.6)	
Difficulty with side vision	No difficulty	1.00	
	A little difficulty	3.82 (1.11-13.2)	
	Moderate difficulty	2.14 (0.482-9.48)	0.001
	Extreme difficulty	8.29 (1.26-54.5)	
	Unable to do because of eyesight	12.8 (1.41-117.1)	
Difficulty finding things on crowded shelf	No difficulty	1.00	
	A little difficulty	1.92 (0.809-4.56)	
	Moderate difficulty	1.29 (0.312-5.34)	0.06
	Extreme difficulty	12.1 (2.15-68.7)	
	Unable to do because of eyesight	1.73 (0.140-21.2)	
Difficulty driving during the daytime	No difficulty	1.00	
	A little difficulty	5.64 (0.529-60.1)	
	Moderate difficulty	103.4 (7.16-1493.3)	0.04
	Extreme difficulty	17.8 (0.195-1617.9)	
	Unable to do because of eyesight	3.93 (0.148-104.0)	

PHQ-9 = Patient Health Questionnaire 9, a self-administered version of the depression module of the Primary Care Evaluation of Mental Disorders (PRIME-MD) diagnostic instrument; BCVA = best corrected visual acuity; VCDR = vertical cup to disk ratio

[a] All odds ratios are calculated from multivariate logistic regression models and are adjusted for the following confounders: age, sex, race, education level, income, general health condition, and comorbidities of stroke, thyroid disease, emphysema, liver disease, and cancer.

[b] P values are from design-adjusted Wald test.