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Health Literacy and Success with Glaucoma Drop Administration

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Purpose: To assess the relationship between health literacy and successful glaucoma drop administration.

Design: Substudy of a single-site interventional randomized controlled trial.

Participants: Veterans receiving care at the Durham Veterans Affairs Eye Clinic who had a diagnosis of open-angle glaucoma were recruited if they endorsed poor drop adherence.

Methods: Participants underwent a health literacy evaluation using the Rapid Estimate of Adult Literacy in Medicine (REALM) as well as a qualitative assessment of eye drop administration technique using 3 different criteria: (1) the drop was instilled in the eye, (2) only 1 drop was dispensed, and (3) the bottle was not potentially contaminated. A multivariate logistic regression model was used to assess the association of REALM score and successful drop administration, adjusting for age, disease severity, and Veterans Administration Care Assessment Needs (CAN) score.

Main Outcome Measures: Successful drop administration.

Results: Of the 179 participants with REALM scores and observed drop administration, 78% read at a high school level (HSL) or more and 22% read at less than HSL. Of the 179 participants, 87% (n = 156) successfully instilled the drop into the eye (criterion 1). A greater proportion of participants who read at HSL or more successfully instilled the drop in the eye compared with those reading at less than HSL (90.6% vs. 75.0%; $P = 0.02$). Rates of success with criterion 1 were similar across different levels of visual field severity. Care Assessment Needs scores were not statistically significant between those who did and those did not have successful overall drop technique.

Conclusions: Poor health literacy may be associated with decreased successful drop instillation in the eye in patients with glaucoma. Screening for and considering health literacy in developing interventions to improve glaucoma self-management may improve treatment adherence in a vulnerable population. *Ophthalmology Glaucoma 2022;5:26-31 Published by Elsevier Inc. on behalf of the American Academy of Ophthalmology*

Supplemental material available at www.ophthalmologyglaucoma.org.

Treatment with ocular hypotensive agents reduces the risk of progressive vision loss resulting from glaucoma.[1] However, nonadherence with glaucoma medications is a significant concern, with rates of nonadherence ranging from 23% to 59%.[2–6] In a study evaluating barriers to medication adherence, 1 in 5 participants reported difficulty using drops.[7] Self-reported difficulty with drop instillation also likely underestimates the problem, because other studies have demonstrated that many patients have poor insight into their relative inability to instill drops.[8] Even among those who reported "never" missing the eye when instilling drops, 35% actually missed the eye when observed directly.[9,10]

Prior studies have suggested that advanced age, lower level of education, arthritis, female gender, and more severe glaucoma may be risk factors for unsuccessful drop administration.[9,11–13] Although many of these factors are nonmodifiable, level of education provides an avenue for the development of targeted intervention and improvement in drop administration. Health literacy may provide a better measure than education level alone as a potential predictor (or screening measure), because prior studies have shown that education level may overestimate health literacy levels.[14] The purpose of this study was to assess the relationship between health literacy, a known risk factor for poor self-management of multiple chronic diseases,[15,16] and success with glaucoma drop administration.[14]

Methods

A sample of 200 participants with open-angle glaucoma (OAG) treated at the Durham Veterans Affairs (VA) Eye Clinic were enrolled in this cross-sectional study. This is a substudy of a larger clinical trial under the approval of the institutional review board of the Durham VA (clinicaltrials.gov identifier, NCT03052257). This study adheres to the tenets of the Declaration of Helsinki, and informed consent was obtained from all participants.

Potential participants were identified for recruitment if they met inclusion and exclusion criteria. Patients were asked the following preliminary screening questions: (1) How confident are you that you always remember to use your glaucoma medications? (not at all confident, somewhat confident, very confident) and (2) In the

Published by Elsevier Inc. on behalf of the American Academy of Ophthalmology
https://doi.org/10.1016/j.ogla.2021.05.004
ISSN 2589-4196/21

past 4 weeks, did you ever forget to take your medicine? Veterans were considered for enrollment if they reported being "not at all confident" or "somewhat confident" to question 1 and "yes" to question 2. Inclusion criteria were as follows: upcoming scheduled appointment in the Durham VA Eye Clinic, diagnosis of OAG (primary OAG, pigment dispersion glaucoma, pseudoexfoliation glaucoma, combined mechanism glaucoma, low-tension glaucoma) or OAG suspect record in the medical record, prescribed glaucoma drops, and visual field (VF) testing performed within the last 18 months. Exclusion criteria included intraocular surgery in the past 3 months or anticipated in the next 3 months, active uveitis or eye infection, visual acuity less than 20/70 in the better-seeing eye, lack of English proficiency, and lack of cell phone or landline phone.

Baseline information, including patient demographics, comorbidities, visual acuity, ophthalmic diagnoses, and history of ophthalmic surgery or laser therapy, were recorded as part of the larger clinical trial. The 1-year VA Care Assessment Needs (CAN) score also was recorded. The CAN score uses demographic data, clinical data, and health care use to determine automatically a patient's risk of hospitalization or morbidity.[17] A veteran is compared with other individuals receiving care at the VA center and is given a percentile rank from 0 (low risk) to 99 (high risk). Participants also underwent a baseline health literacy evaluation using the previously validated Rapid Estimate of Adult Literacy in Medicine (REALM) score as well as a qualitative assessment of their eye drop administration technique.[18] The REALM measures the patient's ability to pronounce commonly used lay medical terms. The REALM score was validated based on correlations with the raw scores of 3 standardized reading tests used with adults.[18] A score of 61 or more is estimated to be a literacy level of high school or more.

Patients were asked whether they themselves or a companion instilled their drops at home. If the patient instilled their own drops, drop technique was observed directly by 1 of 3 study staff (all trained by K.J.M.) by asking the patient to demonstrate drop administration using a cylindrical artificial tear bottle. Patients instilled drops in whatever position most comfortable to them (e.g., standing, sitting) and were provided a mirror if desired. Drop technique was observed and graded according to the following 3 criteria: (1) successful instillation of the drop into the eye (i.e., the drop actually reaches the eye), (2) dispensing only 1 drop (regardless of whether the drop reached the eye), and (3) avoiding bottle potential contamination (regardless of whether the drop reached the eye). For the purposes of this article, successful overall drop technique refers to success with all 3 criteria, whereas as successful drop instillation in the eye refers to success only with criterion 1.

Visual field analysis included 24-2 Swedish interactive threshold algorithm tests with size III white stimulus. Each VF result was graded using International Classification of Diseases, Tenth Revision, staging criteria in which mild glaucoma is defined as no glaucomatous VF abnormalities, moderate glaucoma is defined as glaucomatous VF abnormalities in 1 hemifield but not within 5° of fixation, and severe glaucoma is defined as glaucomatous VF abnormalities in both hemifields, loss within 5° of fixation in 1 hemifield, or both. Visual field results were deemed indeterminate if they were unreliable or uninterpretable.

The study sample size was based on power calculations for the larger clinical trial to determine drop adherence with and without an intervention. To detect a mean difference of 10% between the 2 groups with 80% power, it was calculated that 90 patients would be needed per patient arm. After accounting for 10% attrition, it was decided to recruit 200 patients in total.

Descriptive statistics were derived for baseline characteristics. The associations between REALM category and the different criteria of successful overall drop technique, as well as a composite measure of the drop criteria, were examined with the Fisher exact test. A multivariate logistic regression model was used to assess the association of REALM score and successful drop technique, adjusted for age, disease severity, and CAN score. SAS software version 9.4 (SAS Institute) was used for all analyses, with $P < 0.05$ considered statistically significant.

Results

Baseline Characteristics

Of the 200 patients enrolled in the study, 179 had REALM scores and underwent evaluation of drop technique. Of the 14 patients who did not have drop observation data, 6 did not give permission to administer the REALM evaluation and 1 had neither. No patients reported having their companions instill their drops for them. Missing drop observation data were the result of artificial tears being unavailable for demonstration. The study population was predominantly male (93.3%), 69.3% identified as Black, and the mean age ± standard deviation was 67.4 ± 8.29 years (Table 1). The average ± standard deviation 1-year CAN score was 67.7 ± 24.4, with higher numbers representing higher risk (Table 1). Of the 179 participants, 139 read at a high school level or more (REALM score, ≥61), and 40 read at less than a high school level (REALM score, <61; Table 1). Participants were using an average ± standard deviation of 1.81 ± 0.77 drops based on pharmacy refill data, and most patients (90.5%) had received a diagnosis of glaucoma at least 1 year previously based on self-reporting (Table 2). Visual field data demonstrated 28.9%, 28.3%, and 34.9% of patients had mild, moderate, and severe defects, respectively, and 7.8% of patients had VF results that were of indeterminate severity (Table 2). Most participants were observed successfully instilling 1 drop in the eye (87.2%; 156 participants met criterion 1), but only 33.5% (60 participants) met all 3 drop criteria: (1) successful instillation of the drop in the eye, (2) dispensing only 1 drop, and (3) avoiding bottle potential contamination (Table 2).

Health Literacy and Drop Administration

A greater proportion of participants with a REALM score of high school reading level or more met drop criterion 1 (drop instilled) compared with those reading at less than the high school level (90.6% vs. 75.0%; $P = 0.02$; Table 3). This relationship remained statistically significant when adjusting for age, CAN score, and VF severity. The odds of a patient successfully instilling the drop in the eye were 3.8 higher for those with a REALM score at high school reading level or more compared with those with less than a high school reading level ($P = 0.01$; Table 4). Health literacy level was not associated with successful completion of drop criterion 2 (only 1 drop) or 3 (without contamination). However, in the multivariate analysis, health literacy level was associated with simultaneously meeting criteria 1 and 2 (odds ratio, 2.4-; $P = 0.03$; Table 4).

Visual Field Results and Drop Administration

Participants who had VF data, REALM scores, and observed drop administration (166 of 179) showed similar rates of success with drop criterion 1 (drop instilled) across the different VF severity groups (mild, 87.5% [42/48]; moderate, 85.1% [40/47]; severe, 89.7% [52/58]; and indeterminate, 92.3% [12/13]). Rates of success with all 3 drop criteria also were similar among the VF

Table 1. Baseline Demographics

Category	Data (n = 179)
Age at consent, yrs	67.4 ± 8.29
Male sex	167 (93.3)
Race	
Black	124 (69.3)
White	47 (26.3)
Other	6 (3.4)
CAN score	67.7 ± 24.4
REALM score	61.4 ± 8.95
REALM category	
≥ 61	139 (77.7)
< 61	40 (22.3)
Employment status	
Employed	42 (23.5)
Unemployed	11 (6.1)
Disabled	34 (19.0)
Retired	86 (48.0)
Other	6 (3.4)
Marital status	
Married/living together/committed relationship	117 (65.4)
Divorced/separated/widowed/single/missing	62 (34.6)
Annual income ($)	
< 30 000	38 (21.2)
30 000–70 000	88 (49.2)
> 70 000	34 (19.0)
Missing	19 (10.6)

CAN = Care Assessment Needs; REALM = Rapid Estimate of Adult Literacy in Medicine.
Data are presented as no. (%) or mean ± standard deviation.

severity groups (mild, 33.3% [16/48]; moderate, 36.2% [17/47]; and severe 34.5% [20/58]; Table S5, available at www.ophthalmologyglaucoma.org).

Risk of Morbidity and Drop Administration

The 1-year CAN score was not statistically significant between patients who did versus did not demonstrate successful overall drop technique for all criteria or the composite of criterion 1 (drop instilled) and 2 (only 1 drop; Table S6, available at www.ophthalmologyglaucoma.org).

Table 2. Baseline Characteristics of Patients with Glaucoma

Category	Data (n = 179)
History of glaucoma	
6 mos–<1 yr	6 (3.4)
1–2 yrs	18 (10.1)
>2 yrs–<5 yrs	46 (25.7)
≥5 yrs	98 (54.7)
Don't know	11 (6.1)
No. of glaucoma medications	1.81 ± 0.77
Visual field severity	
Mild	48 (28.9)
Moderate	47 (28.3)
Severe	58 (34.9)
Indeterminate/NA	13 (7.8)
Successful drop technique	
Criterion 1: drop instilled	156 (87.2)
Criterion 2: only 1 drop	117 (65.4)
Criterion 3: without contamination	99 (55.3)
All criteria	60 (33.5)

N/A = not available.
Data are presented as no. (%) or mean ± standard deviation.

Table 3. Proportion with Successful Drop Technique in Participants with Rapid Estimate of Adult Literacy in Medicine Scores of Less Than or More Than High School Level

	Rapid Estimate of Adult Literacy in Medicine Score < 61 (n = 40)	Rapid Estimate of Adult Literacy in Medicine Score ≥ 61 (n = 139)	P Value
Criterion 1: drop instilled	75.0%	90.6%	0.02*
Criterion 2: only 1 drop	60.0%	66.9%	0.45
Criterion 3: without contamination	52.5%	56.1%	0.72
All 3 criteria	22.5%	36.7%	0.13

*$P < 0.05$.

Discussion

This study demonstrates the novel finding that health literacy may be associated with the physical ability to instill ophthalmic drops properly in the eye. Health literacy is defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate heath decisions."[19] It previously was demonstrated that in patients with primary OAG, poor health literacy is associated with less understanding of the disease, less adherence with glaucoma medications, and greater disease progression.[14,20] In addition to these factors that may disadvantage patients with poor health literacy in glaucoma management, this study demonstrated that health literacy also may be associated with a poorer ability to instill a drop in the eye successfully.

Proper drop administration is a crucial element of medical management in glaucoma, and even experienced drop users can struggle to administer drops successfully.[8] Most previously identified risk factors for inability to administer drops correctly are factors that may help to identify at-risk patients, but are not modifiable, including age, gender, or concurrent disease such as

Table 4. Odds Ratio of Successful Drop Administration in Participants with Rapid Estimate of Adult Literacy in Medicine Scores of More Than High School Level, Adjusting for Visual Field Severity, Age, and Care Assessment Needs Score

	Odds Ratio	95% Confidence Interval	P Value
Criterion 1: drop instilled	3.8	1.3–10.8	0.01*
Criterion 2: only 1 drop	1.8	0.8–4.0	0.18
Criterion 3: without contamination	1.1	0.5–2.5	0.78
Criteria 1 and 2	2.4	1.1–5.5	0.03*
All 3 criteria	2.4	0.9–6.5	0.08

*$P < 0.05$.

arthritis. However, education and health literacy levels may identify when a more targeted and patient-centered intervention may be of use. Prior studies have shown that a history of receiving education regarding drop technique was associated with an 8.17-fold increased odds of good observed drop technique, controlling for age.[21] Patients may also benefit from drop administration aids, which have been shown to improve rates of successful drop administration.[22]

It is not immediately intuitive that level of health literacy be associated with a physical ability. Factors such as overall risk of morbidity, age, and disease severity may be expected to impact the ability to have proper drop technique, but no such associations were found in this study. Poor health literacy measured by REALM scores previously was shown to be associated with decreased ability for patients to open their prescription medication containers properly in addition to less intent to take medications as prescribed.[23] Although 2 prior studies found an association between level and education and the ability to administer drops, only 1 of these also measured health literacy, and no relationship to drop administration was found.[11,13] The difference in findings from the present study may be the result of the difference in recruitment and study population. Unlike the present study, both of these studies were not in a VA-based population, and neither screened patients for their self-perception of medication adherence before enrollment.

This study has several limitations, including the generalizability of the findings. The present study recruited patients who endorsed being "not at all confident" or "somewhat confident" to the screening question "How confident are you that you always remember to use your glaucoma medications?" and answered "yes" to the question "In the past 4 weeks, did you ever forget to take your medicine?" Therefore, these findings may not be applicable to all-comers in a glaucoma clinic who do not endorse difficulty with drop adherence.

The study also may not be generalizable to settings outside of the VA health care system. The cost of medications within the VA health care system typically is either covered or lower than with other types of health insurance.

The patient population also was predominantly male. In a prior study, women were less likely to administer a single drop in the eye and more likely to contaminate the tip of the bottle.[11] Most patients also identified as Black, and although most studies have not found an association with race, one study found that Black participants were less likely to contaminate the tip of the bottle.[24]

Although we used CAN scores and visual fields to assess how both systemic and glaucoma disease severity may impact a patient's ability to administer drops properly, the measures we used have some limitations. The CAN score incorporates systemic comorbidities that may affect a patient's motor skills, but conditions such as Parkinson disease or arthritis are not included specifically in the measure. However, the CAN score has been shown to be correlated with frailty scores, which include measures such as needing help taking medications, feeding, and dressing, as well as history of arthritis.[25] As such, we believe the CAN score is an easily accessible and reasonable variable to represent a patient's overall systemic condition. When assessing glaucoma disease severity, we used International Classification of Diseases, Tenth Revision, staging criteria. Although the criteria do account for the effect of central vision loss as severe, we did not specifically analyze patients with and without central vision loss separately. It is possible that those with severe glaucoma, but with preserved central vision, would not have the same difficulties with proper drop technique as a patient with central defects.

Another limitation of the study is that drop observation in the study may not have mimicked drop instillation of patients at home adequately. The VA provides only generic cylindrical bottles, and all patients in the study received drops from the VA pharmacy. However, the patient may use a different sized bottle at home compared with the artificial tear bottle provided for the drop observation session. Drop technique also was graded by 1 of 3 different study coordinators without video recording. Although having different graders may introduce a source of bias, all study coordinators received the same training from one of the authors (K.J.M.).

Additionally, health literacy was measured using the REALM score, which is derived from the proportion of a list of medical terms that the participant pronounces correctly. In this study, we did not have data regarding the patient's actual years of education and therefore were unable to compare this with the REALM-estimated level of health literacy. Critics have noted that the REALM test does not directly evaluate components of health literacy such as reading comprehension or fluency.[26] However, given that prior studies have shown associations between REALM scores and health outcomes suggests that it remains a clinically relevant proxy for health literacy. The REALM score is one of the most commonly used tests to assess for health literacy and has been shown to be associated with various health outcomes such as worse medication adherence.[16]

Poor health literacy is a known risk factor for worse outcomes in many chronic diseases and also may be associated with decreased success with drop administration for people with glaucoma. Screening for health literacy and considering health literacy in the development of interventions to improve glaucoma self-management may improve visual outcomes in a vulnerable population.

Footnotes and Disclosures

Originally received: February 2, 2021.
Final revision: May 19, 2021.
Accepted: May 21, 2021.
Available online: May 28, 2021. Manuscript no. D-20-00392.

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Presented at: American Academy of Ophthalmology Annual Meeting, November 2020.

Disclosure(s):
All authors have completed and submitted the ICMJE disclosures form.

The author(s) have made the following disclosure(s):

A.C.: Equity owner — Aerie Pharmaceuticals

H.B.B.: Consultant — Sanofi, Novartis, Otsuka, Medscape, Preventric Diagnostics, VIDYA, Medicines Company; Financial support — Otsuka, Novo Nordisk, Sanofi, Improved Patient Outcomes, Boehringer Ingelheim, NIH, Department of Veterans Affairs

Supported by the VA Health Services Research & Development (grant nos.: IIR 15-113-3 [K.W.M.] and 08-027 [H.B.B.]); and the Durham Center of Innovation to Accelerate Discovery and Practice Transformation, Durham VA Health Care System, Durham, North Carolina (grant no.: CIN 13-410).

HUMAN SUBJECTS: Human subjects were included in this study. The Institutional Review Board of the Durham VA approved the study. All research adhered to the tenets of the Declaration of Helsinki. All participants provided informed consent.

No animal subjects were included in this study.

Author Contributions:

Conception and design: Kang, Chatterjee, Rosdahl, Bosworth, Woolson, Olsen, Sexton, Kirshner, Muir

Analysis and interpretation: Kang, Chatterjee, Rosdahl, Bosworth, Woolson, Olsen, Sexton, Kirshner, Muir

Data collection: Kang, Chatterjee, Rosdahl, Bosworth, Woolson, Olsen, Sexton, Kirshner, Muir

Obtained funding: Bosworth, Muir; Study was performed as part of the authors' regular employment duties. No additional funding was provided.

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Abbreviations and Acronyms:
CAN = Care Assessment Needs; **HSL** = high school level; **OAG** = open-angle glaucoma; **REALM** = Rapid Estimate of Adult Literacy in Medicine; **SITA** = Swedish Interactive Threshold Algorithm; **VA** = Veterans Affairs; **VF** = visual field.

Keywords:
Drop administration, Glaucoma medical treatment, Health literacy, Patient adherence.

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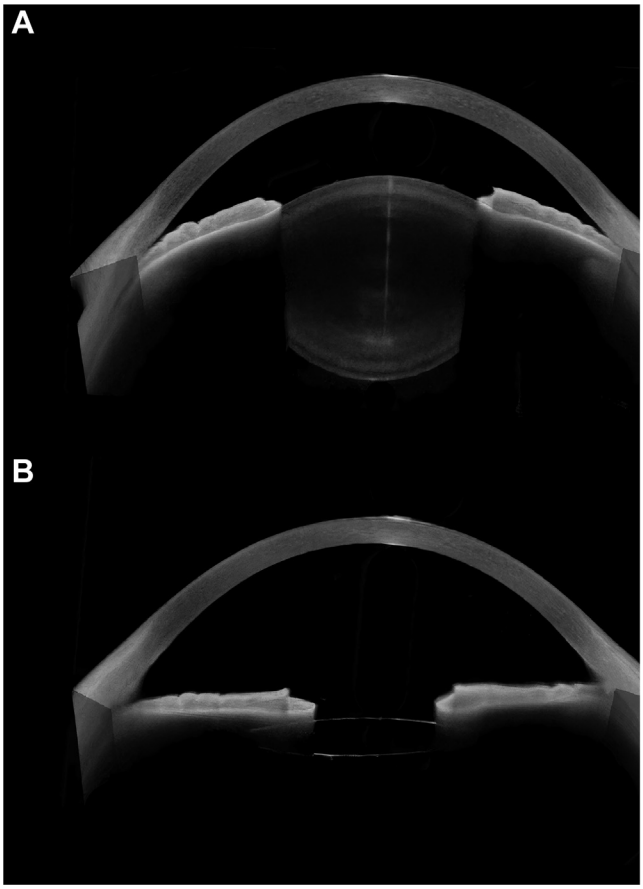
Pictures & Perspectives



Pre- and Post-Surgical Microspherophakia Anterior-Segment OCT

A 13-year-old myopic patient presented with decreased vision and increased intraocular pressure of 35 mmHg in both eyes. Anterior-segment OCT (Fig **A**) revealed bilateral microspherophakia causing iridocorneal angle closure with severe shallow chambers. The unusually spherical shape of the lens and increased 2.1-mm lens vault were easily observed on OCT. Clear lens extraction with implantation of a 3-piece intraocular lens allowed a significant reduction in intraocular pressure. A consequent deepening of the anterior chamber, 1.6 to 4.1 mm, was observed (Fig **B**). The main complication of microspherophakia is the onset of a severe chronic or acute glaucoma caused by angle closure (Magnified version of Fig **A**-**B** is available online at www.ophthalmologyglaucoma.org).

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